

# MASTERARBEIT | MASTER'S THESIS

Titel | Title

Multilevel Logistic Analysis of Social Determinants of Birth  
Certificate Ownership Among Children Aged 0–5 Across 27 Low-  
and Middle-Income Countries: Evidence from UNICEF MICS Data  
(2013–2023)

verfasst von | submitted by  
Tierney Michelle McCue

angestrebter akademischer Grad | in partial fulfilment of the requirements for the degree of  
Master of Science (MSc)

Wien | Vienna, 2025

Studienkennzahl lt. Studienblatt | Degree  
programme code as it appears on the  
student record sheet:

UA 066 945

Studienrichtung lt. Studienblatt | Degree  
programme as it appears on the student  
record sheet:

Masterstudium Global Demography

Betreut von | Supervisor:

Assoz. Prof. Dr. Eva Beaujouan

## Abstrakt

In der vorliegenden Studie wird die Beziehung zwischen sozialen Determinanten auf Haushalts- und Länderebene untersucht, die den Besitz von Geburtsurkunden bei Kindern unter fünf Jahren in Ländern mit niedrigem und mittlerem Einkommen (LMICs) beeinflussen. Dazu werden Daten aus den zwischen 2013 und 2023 durchgeführten Multiple Indicator Cluster Surveys (MICS) von UNICEF verwendet. Die Analyse gliedert sich in zwei Teile. Zunächst werden logistische Mehrebenen-Regressionsmodelle auf fünf Länderdatensätze angewandt, um zu untersuchen, wie Merkmale auf Haushaltsebene die Geburtenregistrierung beeinflussen. Dabei werden Clustereffekte berücksichtigt. In einem zweiten Schritt wurde eine länderübergreifende Analyse von 27 LMICs durchgeführt, um die Rolle von Faktoren auf Länderebene zu bewerten. Zu diesen Faktoren gehörten die Ergebnisse des Systems für zivile Registrierung und Vitalstatistik (CRVS), statistische Leistungsindikatoren, geschlechtsspezifische und Gleichstellungsaspekte sowie nationale Gesundheitsausgaben in Kombination mit den Indikatoren auf Haushaltsebene.

Der analytische Rahmen basiert auf dem Modell der sozialen Determinanten von Gesundheit auf Haushaltsebene von Chen et al. (2020) und baut auf weiteren Beiträgen aus der Forschung von Ebbers und Smits (2022) sowie Mohanty und Gebremedhin (2018) auf. Die wichtigsten Ergebnisse der Studie zeigen, dass das Alter des Kindes, der Wohlstand des Haushalts, ein städtischer Wohnsitz, das Bildungsniveau der Mutter und die Unterstützung durch Fachkräfte bei der Geburt signifikante Prädiktoren für den Besitz einer Geburtsurkunde sind. Das Ausmaß und die Richtung der Auswirkungen variieren jedoch von Kontext zu Kontext. Auf Länderebene weisen die Indikatoren eine geringere Korrelation auf. Dies lässt vermuten, dass die beobachteten strukturellen Unterschiede nicht allein für die Unterschiede bei der Geburtenregistrierung verantwortlich sind. Diese Ergebnisse unterstreichen die Bedeutung von Maßnahmen auf Haushaltsebene sowie von umfassenderen systemischen Reformen, um eine universelle Geburtenregistrierung in fragilen und ressourcenbeschränkten Kontexten zu gewährleisten.

## Abstract

The present study investigates the relationship between household- and country-level social determinants of reported birth certificate ownership among children under five in low- and middle-income countries (LMICs), using data from UNICEF's Multiple Indicator Cluster Surveys (MICS) conducted between 2013 and 2023. The analysis is structured in two parts. Firstly, multilevel logistic regression models are applied to five country datasets in order to examine how household-level characteristics influence birth registration, accounting for clustering effects. Secondly, a cross-national analysis of 27 LMICs was conducted to assess the role of country-level factors. These factors included Civil Registration and Vital Statistics (CRVS) system scores, Statistical Performance Indicators, gender and equity scores, and national health expenditures along with the household-level indicators.

The analytical framework utilises Chen et al.'s (2020) model of social determinants of health at the household level, with further contributions from research by Ebbers and Smits (2022) and Mohanty and Gebremedhin (2018). The study's key findings indicate that a child's age, household wealth, urban residence, maternal educational attainment, and skilled assistance at birth are significant predictors of birth certificate ownership. However, the magnitude and direction of effects vary across contexts. At the country level, indicators demonstrate a more limited correlation, thereby suggesting that structural capacity alone does not fully account for variation in birth registration outcomes. These findings underscore the importance of both household-level interventions and broader systemic reforms to ensure universal birth registration in fragile and resource-constrained settings.

## Table of Contents

|                                                                                                                          |           |
|--------------------------------------------------------------------------------------------------------------------------|-----------|
| ACKNOWLEDGEMENTS.....                                                                                                    | 4         |
| LIST OF ABBREVIATIONS.....                                                                                               | 5         |
| <b>CHAPTER 1: INTRODUCTION.....</b>                                                                                      | <b>6</b>  |
| 1.1 SETTING .....                                                                                                        | 6         |
| 1.2 PROBLEM STATEMENT.....                                                                                               | 7         |
| 1.3 PURPOSE STATEMENT AND AIM OF THE STUDY .....                                                                         | 11        |
| 1.4 RESEARCH QUESTIONS .....                                                                                             | 12        |
| 1.5 ANALYTICAL APPROACH .....                                                                                            | 12        |
| 1.6 STRUCTURE OF THE THESIS.....                                                                                         | 13        |
| <b>CHAPTER 2: LITERATURE REVIEW.....</b>                                                                                 | <b>15</b> |
| 2.1 AN OVERVIEW OF CONTEXTUAL SCHOLARSHIP .....                                                                          | 15        |
| 2.2 BIRTH REGISTRATION PROCESS AND CRITICAL GAPS.....                                                                    | 17        |
| 2.3 DATA SOURCES.....                                                                                                    | 21        |
| 2.4 METHODOLOGICAL CONSIDERATIONS IN BIRTH REGISTRATION AND MATERNAL HEALTH<br>RESEARCH .....                            | 22        |
| 2.5 THE INTERSECTION BETWEEN THE SOCIAL DETERMINANTS OF HEALTH AND THE SOCIAL<br>DETERMINANTS OF BR.....                 | 23        |
| 2.6 SOCIOECONOMIC AND CONTEXTUAL DETERMINANTS OF BC: HOUSEHOLD AND COUNTRY-<br>LEVEL.....                                | 25        |
| 2.7 COUNTRY-LEVEL INDICATORS OF HEALTH EXPENDITURE.....                                                                  | 30        |
| 2.8 CIVIL REGISTRATION AND VITAL STATISTICS (CRVS) SYSTEMS IN LOW- OR MIDDLE-INCOME<br>COUNTRIES (LMIC).....             | 33        |
| 2.9 FIVE CASE STUDIES FROM CONFLICT-AFFECTED AND DEVELOPING COUNTRIES:<br>GOVERNMENT POLICIES AND LEGAL FRAMEWORKS ..... | 37        |
| 2.9.1 AFGHANISTAN 2022 .....                                                                                             | 38        |
| 2.9.2 DEMOCRATIC PEOPLE’S REPUBLIC OF THE CONGO 2017.....                                                                | 39        |
| 2.9.3 MADAGASCAR 2018.....                                                                                               | 40        |
| 2.9.4 LAO PEOPLE’S DEMOCRATIC REPUBLIC 2017.....                                                                         | 41        |
| 2.9.5 SUDAN 2014.....                                                                                                    | 43        |
| 2.10 RISKS AND IMPLICATIONS.....                                                                                         | 44        |
| 2.11 RESEARCH GAPS AND OBJECTIVES.....                                                                                   | 44        |
| 2.12 HYPOTHESES.....                                                                                                     | 46        |

|                                                                                                                                                                                                                                                           |           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| <b>CHAPTER 3: DATA STRUCTURE AND METHODOLOGICAL FRAMEWORK .....</b>                                                                                                                                                                                       | <b>47</b> |
| 3.1 MICS SELECTION .....                                                                                                                                                                                                                                  | 47        |
| 3.2 MICS WOMEN AND CHILDREN'S SURVEY: SURVEY DESIGN, WEIGHTS .....                                                                                                                                                                                        | 47        |
| 3.3 MICS SURVEYS MERGED .....                                                                                                                                                                                                                             | 48        |
| 3.4 BR QUESTIONS ACROSS MICS QUESTIONNAIRES .....                                                                                                                                                                                                         | 49        |
| 3.5 BIRTH CERTIFICATE BINARY OUTCOME LOGIC .....                                                                                                                                                                                                          | 51        |
| 3.6 SECTION ONE: MICS HOUSEHOLD VARIABLES USED IN THE MELOGIT ANALYSIS ACROSS THE FIVE CASE STUDIES: AFGHANISTAN (2022–2023), DEMOCRATIC REPUBLIC OF THE CONGO (2017), MADAGASCAR (2017), LAO PEOPLE'S DEMOCRATIC REPUBLIC (2017), AND SUDAN (2014) ..... | 52        |
| 3.7 SECTION TWO: WORLD BANK COUNTRY-LEVEL VARIABLES USED IN THE MELOGIT ANALYSIS OF THE 27 LOW- AND MIDDLE-INCOME COUNTRIES (LMICs) .....                                                                                                                 | 56        |
| 3.8 LIMITATIONS OF SELF-REPORTED BR COMPLETENESS IN THE MICS .....                                                                                                                                                                                        | 59        |
| 3.9 THEORETICAL JUSTIFICATION: MOHANTY AND GEBREMEDHIN (2018) AND EBBERS AND SMITS (2022).....                                                                                                                                                            | 61        |
| 3.10 ME-LOGIT APPLICATION.....                                                                                                                                                                                                                            | 62        |
| 3.11 CONCLUSION.....                                                                                                                                                                                                                                      | 64        |
| <b>CHAPTER 4: STATISTICAL MODELS AND METHODOLOGY .....</b>                                                                                                                                                                                                | <b>65</b> |
| 4.1 RESEARCH DESIGN AND SCOPE: SECTION ONE (5 UNICEF REGIONAL CASE STUDIES).....                                                                                                                                                                          | 65        |
| 4.2 ANALYTICAL FRAMEWORK (5 UNICEF CASE STUDIES) .....                                                                                                                                                                                                    | 66        |
| 4.3 SECTION ONE: KEY ANALYTICAL STEPS, DATA CLEANING PROCEDURES AND HANDLING MISSING DATA (5 UNICEF COUNTRY CASE STUDIES).....                                                                                                                            | 70        |
| 4.4 MULTICOLLINEARITY CHECK, VARIATION INFLATION FACTOR .....                                                                                                                                                                                             | 73        |
| 4.5 INTRAClass CORRELATION COEFFICIENT (ICC) AS JUSTIFICATION FOR MULTILEVEL LOGISTIC REGRESSION MODELS .....                                                                                                                                             | 74        |
| 4.6 RESEARCH DESIGN AND SCOPE: SECTION TWO (UNICEF GLOBAL-27 MICS SURVEYS) .....                                                                                                                                                                          | 76        |
| 4.7 SECTION TWO: KEY ANALYTICAL STEPS, DATA CLEANING PROCEDURES (UNICEF GLOBAL ANALYSIS) .....                                                                                                                                                            | 79        |
| <b>CHAPTER 5: RESULTS AND SUMMARY OF KEY FINDINGS.....</b>                                                                                                                                                                                                | <b>81</b> |
| 5.1 OVERVIEW OF FINDINGS.....                                                                                                                                                                                                                             | 81        |
| 5.2 THE 5 UNICEF CASE STUDIES MULTILEVEL REGRESSION RESULTS .....                                                                                                                                                                                         | 81        |
| 5.3 SUMMARY OF ANALYSIS ONE: KEY RESULTS.....                                                                                                                                                                                                             | 88        |
| 5.4 LIMITATIONS AND OVERALL MODEL IMPROVEMENTS (5 UNICEF CASE STUDIES).....                                                                                                                                                                               | 90        |
| 5.5 SECTION TWO: GLOBAL MULTILEVEL REGRESSION RESULTS .....                                                                                                                                                                                               | 90        |
| 5.6 SUMMARY OF SECTION TWO: KEY RESULTS .....                                                                                                                                                                                                             | 91        |

|                                                                                                |           |
|------------------------------------------------------------------------------------------------|-----------|
| 5.7 LIMITATIONS AND OVERALL MODEL IMPROVEMENTS (GLOBAL) .....                                  | 92        |
| <b>CHAPTER 6: CONCLUSION.....</b>                                                              | <b>94</b> |
| 6.1 SUMMARY OF KEY FINDINGS .....                                                              | 94        |
| 6.2 CONCLUDING REMARKS .....                                                                   | 95        |
| 6.3 TOWARD UNIVERSAL BIRTH REGISTRATION: CONFRONTING STRUCTURAL BARRIERS<br>THROUGH DATA ..... | 95        |
| 6.4 LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH .....                                       | 96        |
| 6.5 CONTRIBUTIONS TO SCHOLARSHIP .....                                                         | 97        |
| BIBLIOGRAPHY .....                                                                             | 99        |

## ACKNOWLEDGEMENTS

I would like to express my gratitude to Daniel Köckerbauer, Taryn McCue, and Taylor McCue. Thank you all so much for your endless support, encouragement, and kindness over the years. You have been a constant source of strength and motivation. I truly could not have navigated these past few years without you. To put it simply, you are the best!

I am also sincerely thankful to Gloria Romero, James McCue, Angela Poppe, and the Köckerbauers for their continued support, as well as to my communities in Austria and New Mexico.

This project would not have been possible without my formative experience at the United Nations Population Fund, where I worked with the Census Team in the Population Division Branch. I'm especially grateful to my supervisor, Dr. Alessio Cangiano, and the team (Elsa and Tapiwa) for generously welcoming me. You all have imparted invaluable insights into the vital role of population data in the field of demography. Lastly, your mentorship has left a lasting impact on both my intellectual and professional journey.

My window into the world of the United Nations reaffirmed the importance of institutions like the UN and WHO. The beginning of 2025 marked a devastating period of cuts to global foreign aid. Among all the lessons drawn from this research, the most profound was the central role that population data plays in advancing the Sustainable Development Goals (SDGs) and how such data enhances humanitarian efforts and policy programming. With the uncertain future of the Demographic and Health Surveys (DHS) Program and possible funding cuts to the Multiple Indicator Cluster Surveys (MICS), the need for sustained support and investment in global data infrastructure has never been more urgent.

I would also like to thank the Demography Department and my thesis supervisor, Dr. Éva Beaujouan, at Universität Wien. Thank you all for taking the time and dedication to teach us! There was always support both inside and outside the classroom.

## **LIST OF ABBREVIATIONS**

**BC** – Birth Certificate

**BR** – Birth Registration

**CR** – Civil Registration

**CRVS** – Civil Registration and Vital Statistics

**DHS** – Demographic Health Surveys

**GDP** – Gross Domestic Product

**IPUMS** – Integrated Public Use Microdata Series

**LMICs** – Low- and Middle-Income Countries

**LDCs** – Least Developed Countries

**ME-Logit** – Multilevel Mixed-Effects Logistic Regression

**MICS** – Multiple Index Cluster Survey

**MICS Weight** – Survey weight for household and children's responses

**SES** – Socioeconomic Status

**STATA** – Statistical Software for Data Analysis

**UNFPA** – United Nations Population Fund

**UNICEF** – United Nations Children's Fund

**UNSD** – United Nations Statistics Division

**Cluster** – Sampling unit in survey design, often a geographic region or community

**hhno** – Household Number

**linemc** – Line Number of the Mother of Each Child (children's dataset)

**linewm** – Line Number of the Woman (women's dataset)

# CHAPTER 1: INTRODUCTION

## 1.1 SETTING

Birth registration (BR) is a binding obligation under international law, particularly as articulated in Article 7 of the 1989 United Nations Convention on the Rights of the Child (CRC). As such, it must be treated as a policy and administrative priority to ensure every child's legal identity and access to the rights they are entitled to under national and international law. Article 7 of the CRC affirms: *“The child shall be registered immediately after birth and shall have the right from birth to a name, the right to acquire a nationality, and, as far as possible, the right to know and be cared for by his or her parents”* (United Nations, 1989). As of December 2024, over 150 million children under five are unregistered, highlighting the significant gap in establishing their legal identity after birth (UNICEF, 2024). The initial event documented in an individual's life course should begin with their BR.

The United Nations Children's Fund (UNICEF) defines BR as the official recording of the occurrence and characteristics of a birth by the civil registrar within the civil registry, in accordance with a country's legal requirements (UNICEF, 2019). Typically, this registration process occurs at local civil registration offices, where a birth notification is submitted by parents, guardians, or other authorised individuals such as medical professionals (e.g., doctors or midwives) who attended the birth, or representatives from institutions like hospitals or clinics. Following this, a birth certificate (BC) is issued, formally recognising the child's identity and serving as a crucial document for accessing various legal rights and services in the context. The primary function of the BR system is twofold: firstly, the provision of essential legal documentation, and secondly, the generation of statistical demographic data. This data is fundamental in establishing legal identity and ensuring accurate demographic records within Civil Registration and Vital Statistics systems (CRVS). BR is the inaugural entry point to vital statistics in the life course (UNICEF, 2005).

The term 'CRVS' refers to a government-led mechanism for the continuous, permanent, compulsory, and universal recording of vital events, including births, deaths, fetal deaths,

marriages, and divorces. CRVS systems operate through local civil registration offices, where these events are legally registered, certificates are issued, and data is aggregated to create official statistics for governance, planning, and the protection of human rights (UNSD, 2014; WHO, 2023).

Despite the foundational importance, the effectiveness of national CRVS systems in capturing births is frequently compromised by household and country-level challenges, including incomplete registration, lack of awareness, inadequate infrastructure, and insufficient legal frameworks. These issues may result in substantial segments of the population, especially those residing in low-income or rural areas, marginalised and excluded from public provisions. This exclusion restricts their access to essential services, including but not limited to entry, education, healthcare, social protection, nationality or citizenship, legal recognition, and civil and economic participation. Moreover, the absence of identification documents such as national ID cards and passports is often a prerequisite for further documentation. It is a cyclical exclusion.

The timely completion of BR at the household and country level also matters; this issue extends beyond childhood (0-5). According to the World Bank (2022), the total scope of those worldwide who lacked official proof of identity as of 2021 was approximately 850 million, with most identified residing in low-income countries in South Asia and Africa. The lack of identity for these adult populations can also have repercussions that result in delays or gaps in data, which can have a significant impact on the accuracy of demographic vital statistics, including fertility and maternal/fetal mortality rates. While these unregistered populations face a high risk of exclusion from essential services and economic opportunities, the lack of demographic existence removes them from the population estimates that policy frameworks are built on, whether humanitarian or local government planning. This is a global issue.

## **1.2 PROBLEM STATEMENT**

Notwithstanding global commitments to universal birth registration, significant disparities persist across and within UNICEF regions. The United Nations uses the Sustainable Development Goal (SDG) Indicator 16.9.1 (Tier 1) to understand current global trends, which measures the

proportion of children under five whose births are registered with a civil authority. This indicator involves calculating the percentage of registered births using national civil registration systems, censuses, and household surveys such as Multiple Indicator Cluster Surveys (MICS) and Demographic and Health Surveys (DHS).<sup>1</sup>

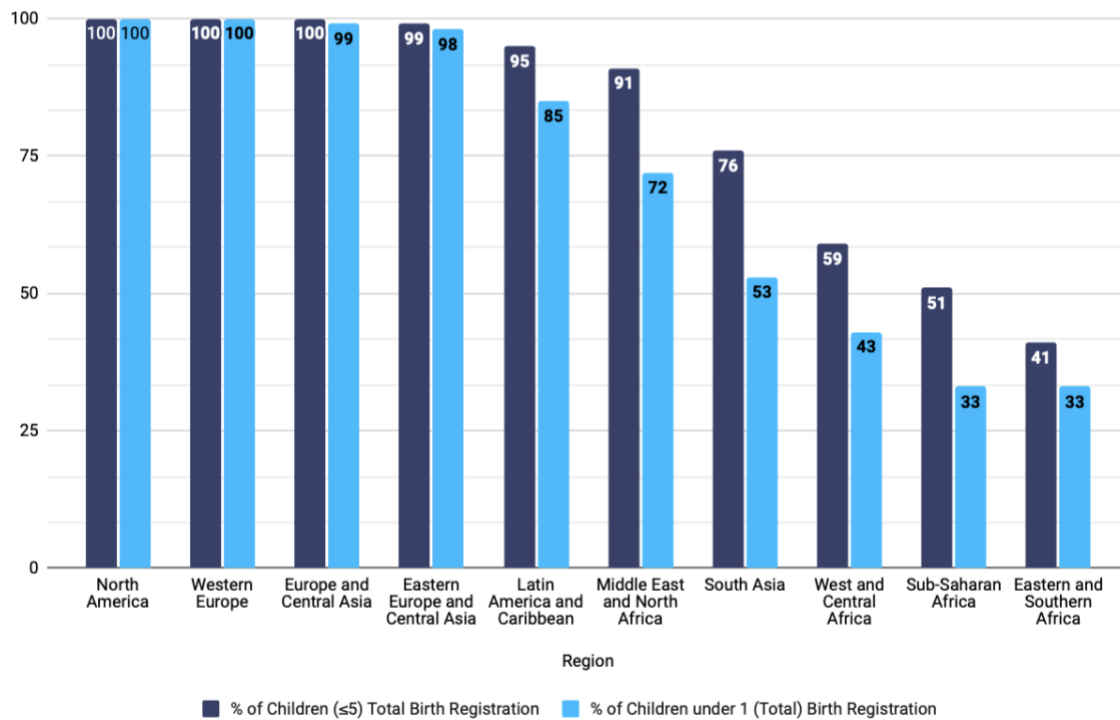
According to Indicator 16.9.1, with the 2023 published data shown in Figure 1, global BR rates for children under one year of age approach 100% in UNICEF regions such as North America, Western Europe, Eastern Europe and Central Asia. These rates decline markedly in other UNICEF regions, falling to 85% in Latin America and the Caribbean (LAC), 72% in the Middle East and North Africa (MENA), 53% in South Asia, and just 33% in both Sub-Saharan Africa and Eastern and Southern Africa. This age-based trend is particularly evident in low-resource settings, where the probability of registration increases as children grow older. However, by age five, significant regional disparities remain: over 90% BR coverage is recorded in high-performing statistical regions, compared to 76% in South Asia, 59% in West and Central Africa, 51% in Sub-Saharan Africa, and only 41% in Eastern and Southern Africa. LDCS report an average BR rate of just 47% for children under five (UNICEF, 2023). These disparities are shaped by numerous interrelated factors, including the mother's education, household income, geographic location, administrative reach, and enabling infrastructure (Musizvingova et al., 2023; Castle et al., 2020; UNICEF, 2005; UNICEF, 2024).

---

<sup>1</sup> It should be noted that 16.9.1 data is currently available for approximately 167 countries.

**Figure 1, UNICEF: Percentage of Children  $\leq 5$  Total Birth Registration and Percentage of Children  $\leq 1$  Total Birth Registration as of 2023**

Source: UNICEF Global Database. Accessed March 2024. Graph created by Tierney McCue.



The extent, coverage, types of data, and use of systems for collecting BR vary considerably, and are highly dependent on several local enabling factors (i.e. infrastructure, administrative capacity, financing, access to the general population, and data management technology) (S. Castle et al., 2020; UNICEF, 2005; UNICEF, 2024). While regional trend BR data provides insight, an equally important exploration occurs at the country and household levels, like Ebbers and Smits (2022), through multilevel logistic regression modelling with the birth registration as the outcome variable.

In countries grappling with substantial resource constraints, registration and the establishment of harmonised data systems may be relegated to a lower priority through the countries' infrastructures and the household infrastructures. This is often attributable to limitations in technical capacity and the allocation of financial resources. In particular, in these UNICEF regions, countries such as Afghanistan, the Democratic People's Republic of the Congo, Madagascar, the Lao People's Democratic Republic, and Sudan report low and uneven

registration rates, leaving millions of children without legal identity or access to essential services.

For example, in Afghanistan, the last reported birth registration completeness was only 42% of children under five were registered in 2018, with conflict, limited state capacity, and reliance on informal documentation like the *taskera* hindering formal registration (UNICEF, 2023). In the Democratic Republic of the Congo (DRC), the birth registration rate has drastically fluctuated. In 2014, it was 25%, and by 2018, fewer than 40% of births (UNICEF, 2025) were registered within the legal timeframe, prompting reliance on mobile registration units in remote and conflict-affected areas in Madagascar. However, the law mandates registration within 12 days, many families must pursue delayed court-based procedures due to geographic isolation and bureaucratic inefficiencies, often at considerable cost (UNICEF, 2021). By contrast, Laos has achieved over 75% BR coverage through integration with maternal and child health services, allowing health facilities to register births directly with civil authorities (UNESCAP, 2020). The last reported birth registration completeness rate in Sudan was in 2014, looking retrospectively at 2010 data, with about 59% of children under five registered (UNICEF, 2023). These patterns underscore the need for context-sensitive strategies that strengthen institutional capacity and remove barriers to timely and equitable birth registration.

While research into the social determinants of birth registration, including studies by Ebbers and Smits (2022) and Mohanty and Gebremedhin (2018), has highlighted the significance of household-level determinants, such as parental education, socioeconomic status, and access to health services, in influencing registration outcomes, these factors alone do not sufficiently explain the enduring gaps in birth registration coverage observed in many low-resource and capacity-affected settings. Hence, a critical gap remains in understanding how country contextual elements interact with household characteristics to influence birth registration practices. These contextual elements include the institutional structure of civil registration systems, the quality and reach of health infrastructure, the presence of conflict, and the decentralisation of governance. Without this systemic perspective, endeavours to address registration disparities may fail to consider fundamental structural determinants.

### **1.3 PURPOSE STATEMENT AND AIM OF THE STUDY**

The present study aims to address this gap by employing a multilevel analytical approach across the five diverse UNICEF regions with the lowest birth registration rates at the household and country levels. The research aims to generate evidence for more targeted and context-specific research to advance progress towards universal birth registration. This study is grounded in the theoretical frameworks of Ebbers and Smits (2022) and Mohanty and Gebremedhin (2018) and aims to achieve two primary objectives.

The first objective is to assess which socio determinants are statistically significant and how they correspond with the likelihood of self-reported BC ownership of children (ages 0-5) within households between 2013 and 2023 in Afghanistan, the Democratic People's Republic of the Congo, Madagascar, the Lao People's Democratic Republic, and Sudan using the MICS survey data. This is to fill in the research gap, as no individual studies have been done regarding the sociodeterminants of birth registration utilising the perspective of MICS surveys for the countries mentioned earlier. Furthermore, they were chosen because they exhibit persistently low birth registration rates, and each represents one country from the diverse UNICEF regions with historically weak civil registration systems: South Asia, East Asia and the Pacific, and the Middle East, which enables a comparative analysis of context-specific barriers to birth certificate ownership across some of the most affected areas globally. This will be achieved by disentangling the relative influence of household—and country-level factors.

The second objective is to examine cross-country variation in self-reported birth certificate (BC) ownership among children aged 0–5 years across 27 Low- and Middle-Income Countries (LMICS) over the period 2013–2023, using data from Multiple Indicator Cluster Surveys (MICS). Rather than treating countries as homogenous or solely as contextual units, this analysis applies a fully nested multilevel logistic regression framework, incorporating household-, cluster-, and country-level predictors. This approach enables the decomposition of residual variance across levels. It provides statistically robust estimates of the independent associations between institutional capacity which is proxied by national civil registration and vital statistics (CRVS) systems scores, statistical performance scores, gender equality ratings, and per capita

health expenditure (all collected from the World Bank Data portal), and individual and household characteristics (from the MICS surveys), including maternal education, household wealth, delivery assistance, and urban–rural residence. The model accounts for complex survey design using population-adjusted weights and cluster-robust standard errors. By estimating the additive effects of structural and proximal factors on BC ownership, the analysis offers empirical insight into the multilevel drivers of legal identity acquisition across LMICS.

## **1.4 RESEARCH QUESTIONS**

In response to the aims of this study, the following research questions will be examined:

1. To what extent do household-level social determinants of health, derived from Chen et al.'s (2020) framework, including economic stability, maternal education, healthcare access, housing and environment, social context, information access, and discrimination, independently predict the likelihood of birth certification ownership among children under five in five conflict-affected, low- and lower-middle-income countries with limited statistical capacity, using MICS data from Afghanistan (2022–2023), the Democratic Republic of the Congo (2017), Lao PDR (2017), Madagascar (2018), and Sudan (2013–2014)?
2. Within a multilevel logistic regression framework informed by Ebberts and Smits (2022) and Mohanty and Gebremedhin (2018), to what extent do country-level structural factors such as public health expenditure, governance quality and urban–rural population distribution independently and interactively influence the likelihood of birth certificate ownership among children under five across 27 low- and middle-income countries between 2013 and 2023?

## **1.5 ANALYTICAL APPROACH**

To address the two research questions, this study uses the Multilevel Mixed-Effects Logistic Regression (ME-Logit) framework in two sections of analysis, following the methodology used by Mohanty and Gebremedhin (2018), Ebberts and Smits (2022) and operationalised using Sommet (2017). The first section looks independently controls for the household and cluster levels within the individual MICS surveys of Afghanistan, DRC, Lao PDR, Madagascar, and Sudan. The countries selected for this research are based on five key metrics: (1) They are classified as one of the LDCs in FY2014, the year the first MICS5 concluded. (2) They have at least one survey in MICS5 or MICS6 and one survey in MICS 1-4; this was done for future research objectives. (3) The country falls under one of the UNICEF umbrella offices in East Asia

and Pacific, Eastern and Southern Africa, Middle East and North Africa, South Asia, and West and Central Africa. (4) Each country has faced prolonged political instability, authoritarian rule, or violent conflict, while weakening state institutions and hindering sustainable development. (5) and each country faces significant environmental challenges, which further exacerbate poverty and instability.

The second section of analysis uses the examines the socio-demographic determinants influencing self-reported BC ownership among children aged 0-5, with a framework of combined data from 55 surveys across 27 countries in the MICS5 and MICS6 rounds (2013–2023). It controls for the household, cluster, and country level effects. The aforementioned surveys include (1) the MICS Women’s survey and (2) the MICS Children’s survey, which have been merged for each country according to the *Guidelines for Merging Data Files of a MICS Survey* (UNICEF, n.d.). These two analyses are not causal; instead, they measure the approximation of associations between the independent variables and the likelihood of the child having a birth certificate.

## **1.6 STRUCTURE OF THE THESIS**

The following chapters systematically map out the analyses. Chapter 2 presents a literature review that situates the study within existing research, providing context for birth registration systems and how they are nestled within complex countrywide civil registration systems, and identifies key social determinants within household and country contexts. It provides a detailed description of the five selected countries in which to situate the work. Chapter 3 outlines the data structure and methodological framework, applying theories that define the relationship between social determinants and BC. This section also includes an explanation of UNICEF's MICS programme, survey design, data collection methods, and the application of survey weights to the merged Children's and Women's Surveys for each country. Chapter 4 presents the statistical models and methodology in two sections: the case studies and the global analysis. It explains the ME-Logit regressions at both the national and global levels. Chapter 5 presents the results of the data analysis. Finally, Chapter 6 offers a conclusion summarising the shortcomings of the key

findings and outlines the outcomes in response to the two research questions, concluding with reflections for future research. The thesis includes a reference section and an appendix.

## CHAPTER 2: LITERATURE REVIEW

### 2.1 AN OVERVIEW OF CONTEXTUAL SCHOLARSHIP

Before 1995, research on ‘birth registrations’ was primarily limited in scope to upper-middle and high-income countries<sup>2</sup> (Ebberts & Smits, 2022). While it was heavily quantitative, it lacked contextual depth, critical theory, and qualitative insight. The statistical methods employed were largely inferential or demographic and focused on estimation and modelling rather than investigating the barriers and social determinants of completed BR outcomes resulting in a birth certificate (Sekar & Deming, 1949; Gourbin & Mausy-Stroobant, 1995; Teperi, 1993).

This body of work lacked an analysis of household behaviour. Early research failed to engage with the micro-level factors that shape birth registration decisions within families. Specifically, there was no systematic inquiry into how parents’ knowledge, beliefs, or attitudes about the value of registration influenced their behaviour (Setel et al., 2007). The assumption that non-registration resulted purely from institutional failure obscured the complex interplay between awareness, perceived utility, and social norms within households.

Additionally, these studies neglected the role of social hierarchies in mediating access to registration systems. There was also a virtual neglect of social stratification. Little to no attention was given to how wealth class and gender equality norms shaped disparities in registration coverage. As a result, the literature failed to identify which groups were structurally excluded or why registration outcomes were stratified along socio-cultural lines.

Similarly, little attention was given to the bureaucratic complexities of healthcare-based birth assistance and subsequent birth registration, or lack thereof, with home birth or non-birth assistance. Early research inadequately addressed the procedural challenges faced by individuals seeking to register births, particularly in settings where trained healthcare professionals were involved in the birthing process or no healthcare staff assisted. Scholarly discussions often

---

<sup>2</sup> According to the World Bank country classifications by income level; The World Bank Group classifies economies into four income groups—low, lower-middle, upper-middle, and high—based on GNI per capita. These classifications, updated annually on July 1, use Atlas method conversion factors in U.S. dollars. This system, introduced in 1989, helps reflect a country's development level.

overlooked the administrative burdens imposed on families, such as the requirement to present marriage certificates, parental identification or third-party attestations, frequently prerequisites for official certification.

Regarding the interconnection between healthcare access and economic well-being, the crucial role of health vulnerability in defining individuals' vulnerability to hazards and reduced coping capacity is clear (Hoffmann, 2023). Individuals with poorer health and limited financial stability are more likely to be excluded from formal registration, and without data to capture these populations, it is difficult to raise their profile. Furthermore, informal costs, systemic inefficiencies and corrupt practices, which are now recognised as significant barriers to registration, remained under-explored in foundational studies.

In terms of regional coverage prior to 2000, the scholarly discourse on birth registration was heavily dominated by high-income countries in North America and Western Europe, often sidelining the complex realities and structural barriers faced by low- and middle-income countries, particularly in Sub-Saharan Africa and South Asia. This led to a lack of local perspective, limited understanding of contextual constraints, and the production of knowledge that was often normative, rather than empirically grounded in lived realities.

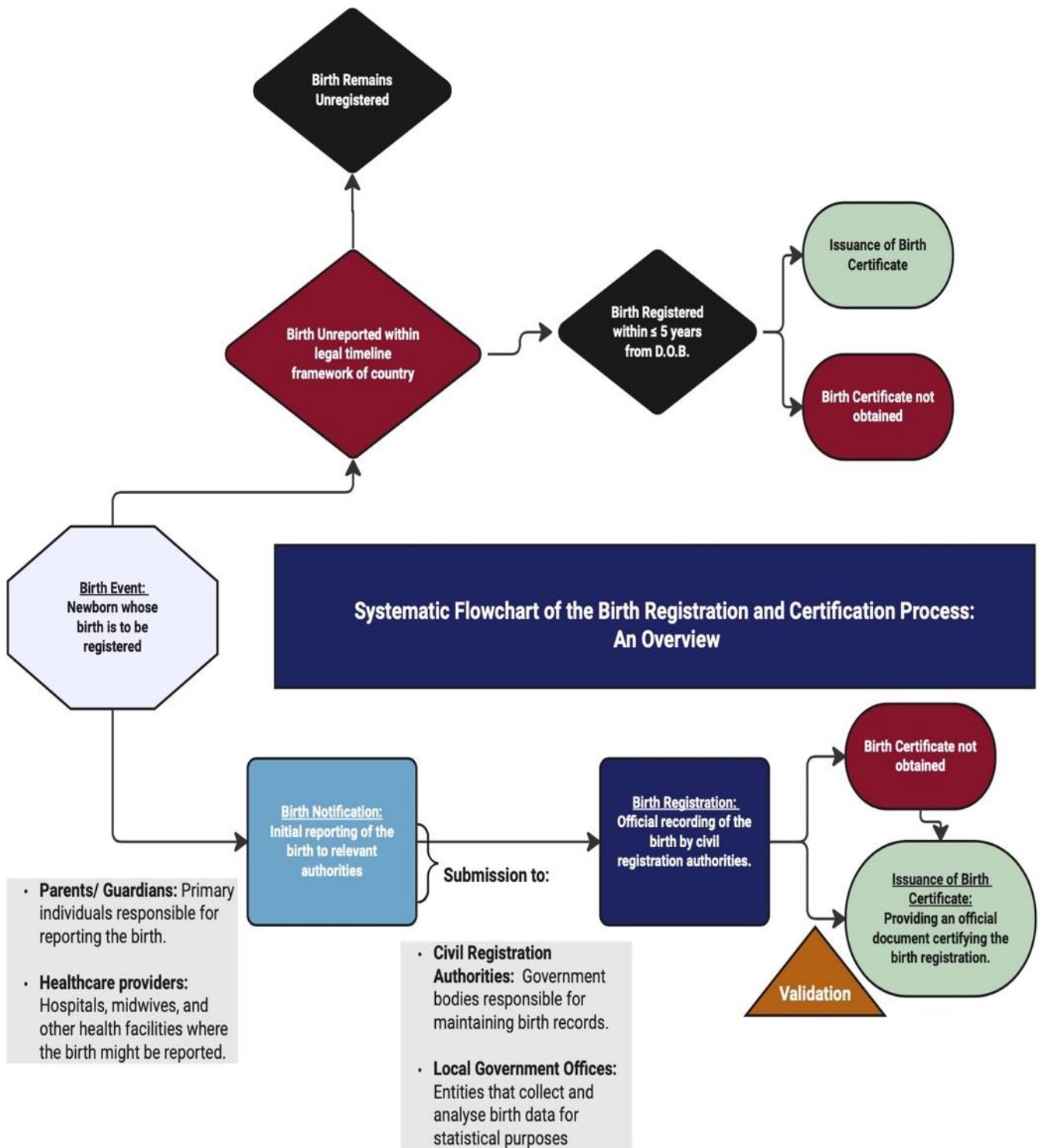
Since the year 2000, improvements in the research into birth records have positively expanded to include data from LMICSS (Makinde et al., 2016; Adair & Lopez, 2021; Chen, 2016; Van der Straaten, 2022; Sanga et al., 2020; Rao et al., 2020; Nannan et al., 2020). While these studies have contributed to a more nuanced understanding of the factors influencing BR across different regions, they have primarily concentrated on Sub-Saharan Africa (SSA) or nations predominantly in Africa (Aboagye et al., 2023; Amo-Adjei et al., 2015; Ebbers and Smits, 2022; Comandini, 2016; Griffin, 2021). An overview of the relevant scholarship is provided in Appendix A. It includes a brief summary of the evolution of birth registration, tracing its development from informal practices to modern applications. Additionally, it also discusses the contemporary interconnection between policy, institutions, and demographic influence. Lastly, it presents a list of UNICEF regions and countries that conducted two MICS surveys between 2006 and 2022, specifically: Eastern and Southern Africa, West and Central Africa, South Asia, East Asia and the Pacific, and the Middle East and North Africa. Most of the scholarship used

UNICEF's Multiple Indicator Cluster Surveys (MICS) to capture registration practices (UN, 2022).

## **2.2 BIRTH REGISTRATION PROCESS AND CRITICAL GAPS**

Today, scholarship has informed us that the BR process generally begins with a birth event, followed by the birth notification stage, where parents, guardians, or healthcare providers report the birth to civil registration authorities or local government offices. These entities formally document births in official records, but their procedures vary extensively. Upon validation, the process culminates in the issuance of a BC. A critical decision point arises concerning the timely completion of BR: if this is achieved within the stipulated legal timeframe (subject to local variations), a BC is issued, as shown in Figure 2; otherwise, the birth remains unregistered. Within this process, several critical junctures exist which cause gaps in the system.

**Figure 2: Generalised Flow Chart and Breakdown of Birth Registration**



| Generalized Flowchart Breakdown of the Birth Registration Process                                                                                |                                                                                                                                                                                                                                                                                         |
|--------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Stage                                                                                                                                            | Description                                                                                                                                                                                                                                                                             |
| <b>Birth Event</b>                                                                                                                               | The process begins with the birth of a child, necessitating formal registration. Parents, guardians, and healthcare providers, including hospitals and midwives, play a key role in initiating notification.                                                                            |
| <b>Birth Notification</b>                                                                                                                        | Collection and submission of preliminary birth details to: <ul style="list-style-type: none"> <li>- Civil Registration Authorities: Responsible for maintaining official records.</li> <li>- Local Government Offices: Tasked with statistical and administrative oversight.</li> </ul> |
| <b>Birth Registration</b>                                                                                                                        | Following notification, civil registration authorities formally document the birth, establishing the child's legal identity and enabling birth certificate issuance.                                                                                                                    |
| <b>Issuance of a Birth Certificate</b>                                                                                                           | A registered birth leads to a birth certificate, serving as official proof of registration. However, bureaucratic inefficiencies, lack of awareness, or financial constraints may prevent parents from obtaining the certificate.                                                       |
| <b>Missed Timelines &amp; Unregistered Births</b>                                                                                                | Failure to report a birth within the legally prescribed period complicates the process, potentially leaving the child without legal identity, thereby restricting access to healthcare, education, and social services.                                                                 |
| <b>Figure 2. BR Flowchart created by Tierney McCue based on the theoretical concepts from the United Nations, Statistical Commission (2020).</b> |                                                                                                                                                                                                                                                                                         |

Feedback loops play a crucial role in the resilience of these BR systems when analysed through the lens of systems analysis guided by Donella Meadows' (2008) systems thinking framework. Here, reinforcing feedback loops occur when successful registration patterns enhance data accuracy and improve service delivery. For instance, strong registration systems create a positive cycle where accurate demographic data supports better planning for health and education services, as Ebbers and Smits (2022) noted. Digital innovations, such as mobile registration units and biometric systems, can strengthen these loops by increasing accessibility and reducing bureaucratic delays, thereby enhancing human capital efficiency (Silva, 2022).

On the other hand, when examining balancing feedback loops, systematic errors can perpetuate under-registration and underutilisation of such systems. Delays or failures in birth notification can create negative cycles of societal distrust, misinformation, and reduced registration rates. Common systematic errors include bureaucratic inefficiencies, data inaccuracies, and lack of access to registration facilities, particularly in remote areas. These errors can exacerbate disparities by restricting unregistered individuals from accessing essential services, reinforcing marginalisation cycles. Addressing these issues through policy interventions and technological innovations is crucial to ensuring equitable and efficient BR systems.

In light of these blind spots between the processes in Figure 2, attention should be drawn to scholars who point out that early interventions to improve birth registration were frequently technocratic and top-down, emphasising infrastructure and data quality over community engagement or social inclusion (Yokobori et al., 2021). Without a nuanced understanding of the barriers at household and community levels, these historical initiatives were often poorly targeted, unsustainable, or ineffective in reaching the populations most at risk of exclusion.

In a call to address birth registration gaps, scholars have turned to population surveys, and census records are used to assess these data factors and to compute them retrospectively (Madhav et al., 2017). Such studies have been crucial for gauging a wide range of global challenges addressed in the SDGS (e.g., understaffed maternity clinics) and disseminating the appropriate resources (funding, human capital, etc.). In high-income nations with robust datasets, the register data, register-based census data, or well-conducted traditional censuses provide a comprehensive view of living standards, but this remains elusive to LMICS countries that are not ready to transition to

a register-based census. In contrast, LMICS often rely on conventional censuses and surveys. The traditional “door-to-door” enumeration census remains the most widely used tool for collecting population data globally (UNSD, 2024). Approximately 100 SDG indicators are calculated from population and housing censuses (UNFPA, 2024a), but they often encounter delays, a lack of funding, or setbacks, especially during a crisis. Hence, this is why data registers need to be enhanced.

## **2.3 DATA SOURCES**

The UNICEF Multiple Indicator Cluster Surveys (MICS) and the Demographic and Health Surveys (DHS) represent the principal household survey initiatives that collect essential data on BR on a global scale. Since 1999, MICS surveys have been conducted in approximately 122 countries, resulting in the collection of 408 surveys and 261 datasets.<sup>3</sup> This makes the MICS one of the most comprehensive data sources on child well-being and BR, which are carried out over an average of 3-5 years; the method of collection is via tablet during 2-3 months of fieldwork (Khan and Hancioglu, 2019). Both use two-stage sampling designs. Their weights then address over- and undersampling within the different strata, along with variations in nonresponse.

The MICS Women's, Household, and Children's surveys are conducted simultaneously and encompass maternal health, socio-economic indicators, and child well-being. They include a comprehensive array of maternal health and socio-economic indicators, including fertility history, contraceptive use, maternal care during pregnancy and childbirth, exposure to domestic violence, education, employment status, household decision-making power, and access to media. Thus, they provide critical insights into maternal well-being, a pivotal determinant of child health outcomes.

The MICS children's surveys focus on early childhood care, immunisation status, breastfeeding practices, dietary diversity, the prevalence of common childhood illnesses (diarrhoea, acute respiratory infections), healthcare access, and anthropometric measurements for malnutrition

---

<sup>3</sup> Please refer to the MICS Data Portal: <https://mics.unicef.org/>

(stunting, wasting, underweight). As a result, these are essential for monitoring child development and assessing public health interventions.

In contrast, the Demographic and Health Surveys (DHS) programme was initiated in 1993 and is currently operational in over 90 countries. While the DHS provides a rich dataset, it is somewhat narrower regarding regional scope, with the central dispersion being in African countries. As of February 2025, due to the changes in USAID, the primary funder of the DHS, the MICS remains a more steadfast survey.

## **2.4 METHODOLOGICAL CONSIDERATIONS IN BIRTH REGISTRATION AND MATERNAL HEALTH RESEARCH**

Another direction scholars have adopted to view birth records falls in line with the studies of maternal health. For example, Souza et al. (2023) use hospital records to show the immense variability when investigating the social determinants of maternal health. This variability was captured through data derived from the central health registrars. This line of scholarship should be used to understand the social determinants of birth registration, as the indicators are not mutually exclusive and intersect frequently. While projections in maternal health outcomes are used to monitor and forecast maternal mortality rates, which guides policymakers in developing targeted health interventions, the base data needs improvement. Scholars such as Onambele et al. (2023) emphasise filling these data gaps even when projections are employed. Missing or incomplete data can hinder accurate predictions and obscure disparities in maternal health outcomes, regardless of the country's world region or wealth classification. While population projections offer an incredible wealth of data, their accuracy and estimation will drastically improve when standard operational datasets are available. Whilst completeness birth registration rates offer a rapid means of assessing registration status, they do not provide direct insights into the underlying causes of those observed disparities. Hence, research examining the determinants of registration, like the research in maternal health, can shed light on inequities in access to this right. Within this framework, the social determinants of health can serve as a foundational starting point. These overlap with the socioal determinants of health.

## **2.5 THE INTERSECTION BETWEEN THE SOCIAL DETERMINANTS OF HEALTH AND THE SOCIAL DETERMINANTS OF BR**

While research in the BR field predominantly focuses on systemic enhancements for completion, it overlooks the intricate interplay between social determinants and socioeconomic factors that influence BR practices (Revenga Becedas et al., 2022). As of 2025, a comprehensive global BR database does not exist. Although an annual dissemination of aggregated BR statistics by organisations such as the WHO exists, a lack of cohesion remains (Phillips et al., 2018). This is where scholarship has used the health systems frameworks for analysis. The introduction of the social determinants of health has expanded the research of BR in conjunction with the development of public health systems research (Cantor et al., 2018; Chen et al., 2020). The applied lens of the social determinants of health shows great promise in the study of BR. This study adheres to these applications.

A common thread among these works advocates for cost-effective approaches to evaluating BR system performance, facilitating international goal setting and monitoring development goals. All three works seem to incorporate the social determinants of Mosley and Chen's (2003) and Chen et al. (2020) proximate determinants analytical framework for studying child survival in developing countries. The foundations of their framework also illustrate how household factors could mediate registration outcomes. Within the combined framework of Ebbers and Smits (2022), Mohanty and Gebremedhin (2018), and Mikkelsen et al. (2015), the following overlapping list (Figure 3) was derived for this thesis. These key determinants were utilised in the regression analyses of Ebbers and Smits (2022) and Mohanty and Gebremedhin (2018).

**Figure 3: Social Determinants of Health and BR Intersection Chart**

| Sociodeterminants of Health and Birth Registration Intersection Chart |                                                                                                                                                                                                            |                                                                                                                                                                                             |
|-----------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Sociodeterminants of Health                                           | Indicator/Statistical Performance (SPI)                                                                                                                                                                    | Impact on Birth Registration                                                                                                                                                                |
| Economic Stability                                                    | Economic challenges (e.g., poverty, lack of resources) can limit access to birth registration services due to cost, lack of documentation, or the inability to take time off work to complete the process. | Low-income families face financial barriers to registering their children, particularly if the process requires transport, documentation, or other resources they lack.                     |
| Education Access and Quality                                          | Educational level, especially of the mother or primary caregiver, influences the awareness of the importance of birth registration and the process required to complete it.                                | More educated caregivers are more likely to be informed about the registration process and its importance, ensuring timely registration of the child.                                       |
| Healthcare Access and Quality                                         | Access to healthcare is closely linked with access to maternal and child health services, where birth registration is often initiated.                                                                     | Skilled birth attendants in healthcare settings are key to initiating the birth registration process, improving registration rates.                                                         |
| Neighborhood and Built Environment                                    | The availability of birth registration offices, healthcare centers, or community awareness campaigns can vary by neighborhood infrastructure.                                                              | In urban areas, registration services are more accessible. Rural or underserved areas may lack such services, making registration harder to complete.                                       |
| Social and Community Context                                          | Social support, cultural practices, and community engagement can either facilitate or hinder the birth registration process.                                                                               | In some cultures, birth registration may be undervalued or misunderstood, resulting in lower registration rates in those communities.                                                       |
| Access to Technology and Information                                  | Digital birth registration systems and online awareness campaigns can increase accessibility to birth registration services.                                                                               | Countries with better technological infrastructure enable easier and faster birth registration through online or mobile systems, especially in remote areas.                                |
| Discrimination and Inequality                                         | Marginalized groups may face greater challenges with birth registration due to discrimination, lack of access to identity documents, or fear of authorities.                                               | Children from marginalized groups, such as undocumented migrants or ethnic minorities, are less likely to be registered, leading to a lack of access to legal rights, including healthcare. |

|                                                                                                                                                                                          |                                                                                                                           |                                                                                                                                                                                                                                         |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cultural and Religious Beliefs                                                                                                                                                           | Cultural or religious practices may either promote or hinder birth registration.                                          | Certain cultural or religious practices might de-emphasize birth registration, resulting in lower registration rates in certain communities, particularly for gender or traditional reasons.                                            |
| Government Policy and Legal Framework                                                                                                                                                    | Government policies on civil registration directly impact access to legal rights and healthcare for children.             | Strong policies and efficient systems ensure higher birth registration rates and improve access to health and social services, while poor or burdensome policies hinder registration.                                                   |
| Gender                                                                                                                                                                                   | Gender may influence the likelihood of birth registration, especially in societies where boys are prioritized over girls. | In some cultures, female children may face lower registration rates, limiting their access to rights like healthcare and education. Gender inequality in birth registration can also impact the overall health and well-being of girls. |
| Health Expenditure                                                                                                                                                                       | Economic Stability & Healthcare Access                                                                                    | Higher health expenditures often correlate with better healthcare infrastructure, leading to more accessible birth registration services.                                                                                               |
| <p><b>Source: Created by Tierney McCue based on the scholarship of Ebbers and Smits (2022), Mohanty and Gebremedhin (2018), Mikkelsen et al. (2015), and Mosely and Chen (2018).</b></p> |                                                                                                                           |                                                                                                                                                                                                                                         |

The following sections provide an in-depth contextualisation of the correlations between the social determinants of health and the social determinants of BR in their distinguished levels.

## **2.6 SOCIOECONOMIC AND CONTEXTUAL DETERMINANTS OF BC: HOUSEHOLD AND COUNTRY-LEVEL**

### **2.6.1 HOUSEHOLD WEALTH IN BR**

When investigating the wealth of households, a factor that commonly affects both perceived health and health outcomes is observed in multiple studies examining BR outcomes. Ebbers and Smits (2022) utilise the household-level International Wealth Index from the Demographic Health Survey, while Mohanty and Gebremedhin (2018) use the Household wealth quintile of the India Human Development Survey-II (IHDS-II), 2011–12, on the household level in their analysis. In this context, the negative trend is evident in self-reported birth registration,

coinciding with a decline in household wealth. This outcome mirrors the negative correlation between a decrease in household wealth and negative health outcomes. Within the MICS surveys, the distribution of household wealth is defined by the Wealth Index Quintile.<sup>4</sup>

Mohanty and Gebremedhin (2018) found a significant correlation between household wealth and BR rates, with children from the wealthiest households being 1.49 times more likely to be registered than those from the poorest households in India. Their findings align with other cross-country studies demonstrating the positive influence of economic status on registration rates (Amo-Adjei and Annim, 2015; Anaduaka, 2022). Financial constraints, particularly late registration fees imposed after the first weeks following childbirth, may discourage lower-income households from completing the process (Anaduaka, 2022). Additionally, Ebbers and Smits (2022) illustrate that children from the highest income quintile exhibit a registration probability twice that of children in the lowest quintile. Here, they hypothesise that economic security enhances household engagement with administrative institutions and facilitates the acquisition of birth certification.

In the context of socioeconomic disparities that extend beyond the confines of household wealth, these factors act as a fundamental impediment to BR, thus mirroring their impact on public health accessibility in the country. In communities grappling with economic deprivation, it is common to observe the presence of structural and bureaucratic impediments often resulting from financial constraints, opportunity costs, and competing subsistence needs. When investigating the economic burden imposed by registration fees, transportation expenditures, and documentary requirements, it becomes evident that these factors significantly detract from participation, thereby creating barriers analogous to those observed in healthcare utilisation at the household and national level.

---

<sup>4</sup> Please see Chapter 3 for a more in-depth look into the MICS Wealth Index Quintile.

## **2.6.2 HOUSEHOLD INDICATORS OF RURAL VERSUS URBAN, AND MATERNAL EDUCATION**

The process of obtaining a BC and registering a birth in terms of economic supply and demand follows a process much like the provision of public health services. From the perspective of supply, the availability, accessibility, and efficiency of government services are of paramount importance to BR and vice versa. The lack of registration offices in rural or remote areas can significantly impede parents' capacity to register their children's births. In turn, the lack of registration directly correlates to the lack of public services and disbursement based on hidden demand. If an infant is not registered, service demand often exceeds the supply. Urban areas tend also to be wealthier; in effect, these areas receive more services/supplies versus areas that also need it (rural areas).<sup>5</sup>

Recent empirical research underscores that informational deficits and perceptual barriers often suppress the demand for birth registration more significantly than the direct economic costs. In a study conducted in Kenya, Pelowski et al. (2015) found that many parents were unaware of birth certificates' legal and developmental significance. They perceived them as useful only for specific bureaucratic needs, such as school enrollment, rather than as a foundational component of their child's legal identity. This narrow understanding, coupled with mistrust of government institutions and uncertainty about the registration process, contributed to widespread under-registration, especially in rural and underserved communities.

Similarly, in a survey of postpartum women in Northwest Ethiopia, Alemu et al. (2023) identified that while most of the surveyed population had heard of birth registration, substantial gaps existed in their understanding of its timing, process, and long-term value. Notably, even among mothers who had given birth in health facilities, knowledge of the official requirement to register births remained limited. These findings indicate that demand-side deficits rooted in limited awareness, cultural perceptions, and institutional opacity are compounded by geographic and educational disadvantages, thereby hindering registration even where administrative

---

<sup>5</sup> Figure A15. (appendix) shows the distribution of wealth quantiles for all 27 surveys separately. When looking at the distribution of the household wealth index throughout the 27 MICS surveys, it can be seen that more rural residents fall within the poorest (first quintile) distribution, while urban residents have the highest distribution in the richest (fifth quintile) in Table B4. (appendix).

mechanisms nominally exist. As a result, their findings also revealed that perceived procedural complexity and indirect costs, which included time away from subsistence labour, served as key deterrents to registration. In summation, both Peliwski et al. (2015) and Alemu et al. Al (2023) illuminate how structural and informational asymmetries can compound the effects of geographic and educational disadvantage,s which suppress demand even where the supply may technically exist.

Furthermore, the social determinant of educational attainment, particularly among mothers, emerges as a critical determinant of BR. Lower literacy rates are correlated with a diminished awareness of registration's legal and social significance and ramifications and increased difficulty in navigating bureaucratic mechanisms (Beiter, 2005). Here, Mohanty and Gebremedhin (2018) demonstrate a statistically significant positive association between maternal education and BR, wherein higher levels of educational attainment correspond to increased engagement with administrative processes and personnel. In the same trend, Ebbers and Smits (2022) further highlight that educated mothers are more likely to challenge bureaucratic inefficiencies and advocate for their children's legal identities.<sup>6</sup> It has been demonstrated that the mothers surveyed are more likely to recognise the advantages of registering births when they are educated, particularly when mothers possess higher levels of education and awareness about the importance of birth certificates (Phillips et. al, 2018).

### **2.6.3 HOUSEHOLD INDICATORS OF RURAL VERSUS URBAN IN INDICATORS OF HEALTHCARE ACCESS AND BR**

In addition to healthcare access, Ebbers and Smits (2022) demonstrated that geospatial isolation was a structural constraint on BR, particularly in peripheral and underserved regions. Distance to hospitals, registration facilities, inadequate transportation networks, and infrastructural deficiencies collectively inhibited access for rural residents. The urban-residing children exhibited disproportionately higher registration rates, which Ebbers and Smits (2022) attributed to superior administrative infrastructure and enhanced modes of information dissemination.

---

<sup>6</sup> Within the 27 MICS surveys, the distribution of the mothers' educational attainment and the reported BC can be seen in Table B5 (Appendix B).

The lack of medical facilities (i.e., clinics or hospitals) nearby in rural regions diminishes community access to essential healthcare services where points of registration can occur. Ebbers and Smits (2022) highlighted that urban residence and higher utilisation of prenatal care positively influenced BR rates. Their findings indicated that children born in urban areas or regions with a higher average number of prenatal care visits have approximately 10% greater odds of being registered within the parameters of their study.

In the studies of Dünser et al. (2006) and Smith et al. (2008), healthcare outcomes for rural patients indicate negative correlations between rural and urban care, which coincides with birth registration rates. The study showed that urban medical facilities, where registrations occur, were better funded and more accessible via means of transportation and the availability of services. These urban medical facilities were strategically placed in clusters to accommodate a larger population per square mile. In contrast, rural medical facilities were often further apart and required extensive travel to access a village where registration offices were located. Furthermore, the financial implications of BR, including official fees and the time and documentation requirements, can present a significant obstacle for economically disadvantaged families that are also far from these medical centres.

This phenomenon is similar to that observed in the healthcare system, where the financial burden of treatment, the time required to access care, and the quality of care received can deter the utilisation of other services. Nevertheless, bureaucratic inefficiencies or overly complex administrative procedures, as noted in Ebbers and Smits (2022), resulted in lower registration rates. This parallels how overburdened healthcare systems can dissuade individuals from seeking medical attention, and consequently, may not encourage them to register their newborns at these designated registrars.

The influence of healthcare infrastructure on birth notification, a precursor to formal registration, appears congruent across Ebbers & Smits (2022) and Mohanty & Gebremedhin (2018). The spatial inequities in healthcare provision disproportionately impacted rural populations, where medical institutions were scarce. Furthermore, high reliance on traditional birth attendants in

specific demographic cohorts exacerbated registration deficits. Ebbers and Smits (2022) further underscored the correlation between institutional births and timely registration, while Mohanty and Gebremedhin (2018) identified maternal healthcare decision-making autonomy as a key predictor of registration compliance.

#### **2.6.4 UNDERUTILISATION OF HEALTHCARE SERVICES AND BIRTH REGISTRATIONS**

Additionally, a comparison can be drawn between BC awareness and the underutilisation of preventive health services, whereby individuals are unaware of the benefits of vaccinations or antenatal care, as shown throughout the case studies on COVID-19 vaccine equity by Van De Pas et al. (2022) and Tadesse (2020). Here, they hypothesised that a lack of education on formal healthcare resulted in low healthcare-seeking behaviour, which is similar to registration-seeking behaviour. This is not unlike the study of Phillips et al. (2018) when investigating the global utility of registered birth statistics for informing health and social policy, where they systematically assessed the availability and quality of birth registration data and highlighted how gaps in education, particularly among mothers, contribute to under-registration.

Deficiencies in informational access also function as a critical demand-side barrier to BR, similar to the underutilisation of preventive health services. Parental awareness of the long-term implications of BR for educational enrollment, healthcare access, and legal recognition is frequently suboptimal. Digital registration frameworks and targeted outreach initiatives have been explored as instruments to ameliorate informational deficits, as shown in Silva's work (2022). Mohanty and Gebremedhin (2018) emphasised that increased informational accessibility facilitated parental navigation of registration protocols, underscoring the need for awareness campaigns to enhance registration uptake.

#### **2.7 COUNTRY-LEVEL INDICATORS OF HEALTH EXPENDITURE**

The financial outlay associated with BR mirrors the economic barriers impeding healthcare access, not only on the household level but also on the national level. Mohanty and Gebremedhin (2018) identify economic vulnerability as a salient mediating factor, wherein low-income households prioritise immediate subsistence over administrative formalities. Strategies to reduce

financial impediments, such as fee waivers and subsidised registration services (including mobile registration, transportation, etc.), are crucial to enhancing registration equity. Costs associated with official fees, transportation logistics (i.e., the cost of bus tickets, petroleum, and the mode of transportation, such as by car, bus, or other means), and foregone income could potentially deter economically disadvantaged households from completing the registration process. Where BR is deprioritised or not integrated into the community, birth notification requires additional effort and attention by the families themselves. The economic burden often falls on them, rather than the administration. As a result of the discrepancies at the household level, the registration issue then surfaces at the country level.

For example, this was apparent in Muzzi's (2010) UNICEF-commissioned study, which examined national birth registration initiatives in thirteen countries across Latin America, Africa, and Asia since 1999. These countries included Brazil, Venezuela, Côte d'Ivoire, Gambia, Ghana, Madagascar, Mozambique, South Africa, Zambia, Bangladesh, Cambodia, India and Myanmar. Muzzi identified the following key strategies which improved rates over time: (1) the increased strategic positioning of civil registrars within health facilities, such as hospitals and clinics; (2) the ongoing training of community health workers and midwives to function as outreach registrars; and (3) the integration of birth registration into broader public health initiatives, including immunisation or maternal health campaigns. Furthermore, they drew attention to the fact that successful approaches to embedding birth registration within health systems recognise the lack of infrastructure, reach, and community trust often exhibited by stand-alone civil registration efforts. They concluded that this was a key factor in the absence of universal coverage.

As a result, they reported that several countries, including Brazil, Myanmar and the Gambia, witnessed an uptick in birth registration rates after implementing the three integrative approaches. These approaches capitalise on the accessibility, coverage and trustworthiness of the health sector to alleviate financial pressures and streamline logistical processes for families. The success of such integration was also influenced by national health care expenditure: countries that invest adequately in public health infrastructure, ensuring a wide network of maternal and

child health services, digitised health records, and outreach capacity, were better positioned to sustain high-quality, continuous civil registration systems. In the context of the health sector, establishing a functional vital registration system has been demonstrated to enhance the precision of health data, facilitate the implementation of targeted interventions, and furnish a demographic foundation that is indispensable for the planning and monitoring service delivery.

### **2.7.1 COUNTRY-LEVEL INDICATORS OF WOMEN’S AUTONOMY**

Additionally, gender disparities manifest in BR through differential maternal autonomy, legal constraints, and sociocultural norms. The results varied according to the gender of the head of household in both Mohanty and Gebremedhin (2018) and Ebbers and Smits (2022). While Mohanty and Gebremedhin identified female agency, conceptualised through healthcare decision-making power, mobility autonomy, and financial control, as a crucial determinant of BR in India, Ebbers and Smits found mixed results in SSA. The ability of female-headed households to allocate resources toward their children, along with potential formal and informal support mechanisms, may help mitigate disadvantages that could otherwise affect BR rates; however, this is highly dependent on the individual country. Gebremedhin (2018) concluded that policy measures aimed at augmenting female empowerment, such as microfinance programs and maternal advocacy networks, can indirectly enhance registration rates in areas where women’s autonomy is still under development. In another study, Wendt et al. (2022) found no consistent association between the sex of the household head and BR outcomes in their pooled analysis across national surveys from 93 LMICS.

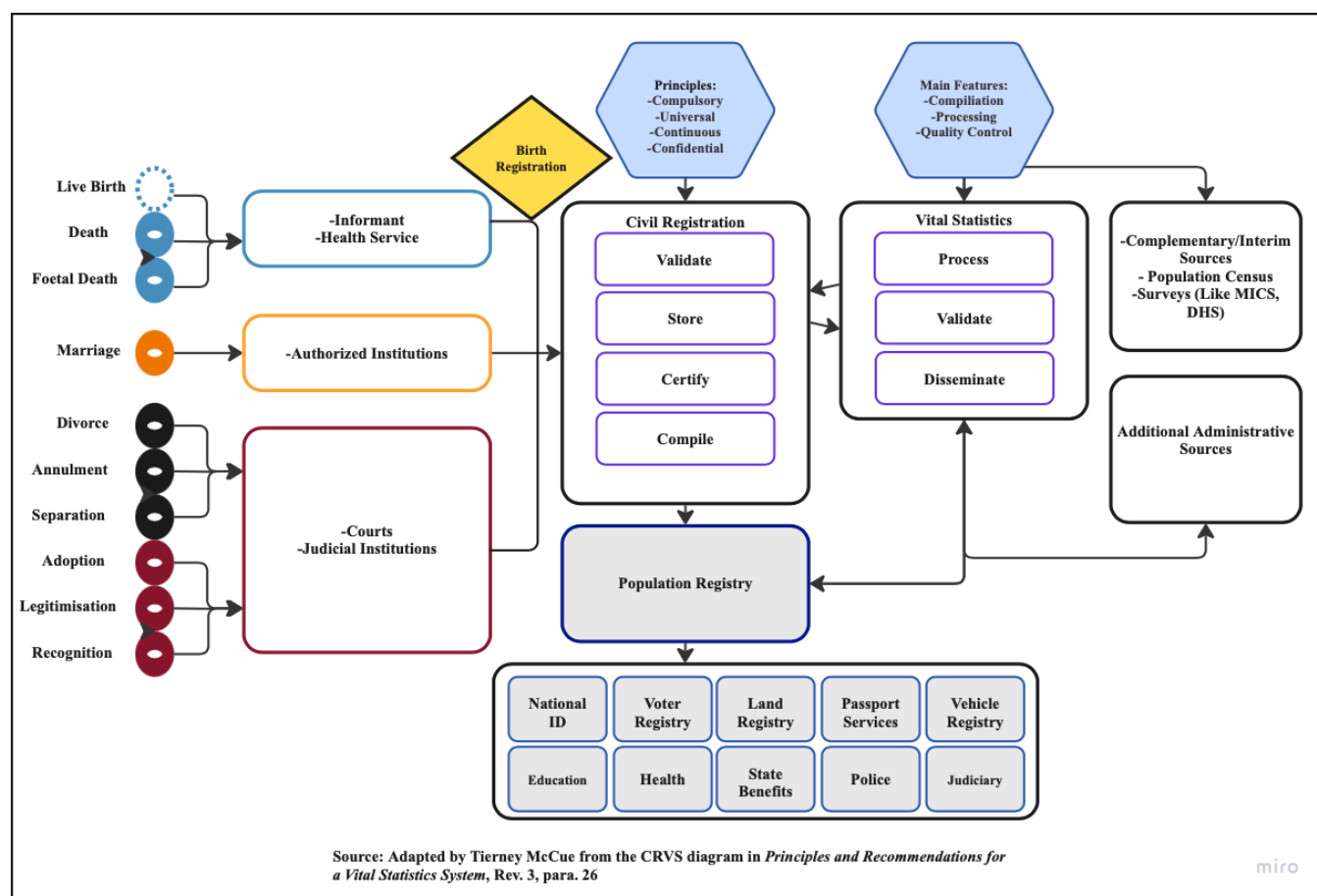
While the influence of gender dynamics on birth registration is evident across various national contexts, the structural and institutional challenges facing specific countries further illuminate how intersecting factors such as governance, infrastructure, and humanitarian conditions compound the issue. This is particularly apparent in countries like Afghanistan, the Democratic Republic of the Congo, Madagascar, the Lao People's Democratic Republic, and Sudan, where systemic barriers have significantly hindered the development and women’s autonomy.

## **2.8 CIVIL REGISTRATION AND VITAL STATISTICS (CRVS) SYSTEMS IN LOW-OR MIDDLE-INCOME COUNTRIES (LMIC)**

Birth registration is situated within the broader framework of civil registration systems, as illustrated in Figure 4 below. The United Nations defines Civil Registration (CR) as “the continuous, permanent, compulsory and universal recording of the occurrence and characteristics of vital events about the population, as provided through decree or regulation by the legal requirements in each country” (Mills et al., 2017, p.7). Modern interpretations differentiate between "civil registration systems" and "vital registration systems," with the former being the broader term (United Nations, 2022). CR primarily aims to document and analyse vital events to generate critical statistics. While vital statistics are commonly derived from CR, they can be obtained through alternative methods, such as sample surveys. Despite these distinctions, "vital registration" and "civil registration" are often used interchangeably. Historically, they reflect two predominant traditions: the English tradition, which emphasised the medical significance of recording vital events, and the French tradition, which prioritised using such records for establishing civil status and resolving legal matters (United Nations, 2022).

Following the recommendations set forth by the United Nations, countries are advised to record ten vital events: live birth, death, foetal death, adoption, marriage, annulment of marriage, divorce, judicial separation of marriage, and legitimation (Mills et al., 2019). When compiled correctly, CRVSS create the most reliable source for tracking development plans at national and sub-national levels and monitoring the SDGS (Mills et al., 2019). In contrast to population censuses, successful CRVS systems provide continuous data at the national and lower administrative levels (Mills et al., 2019). This is more effective than traditional censuses, conducted approximately every decade, and household surveys typically carried out every three to five years. These effective systems are essential in monitoring 12 of the 17 SDGS and 67 of the 232 SDG indicators (Mills et al., 2019). Over 110 LMICS still lack functional CRVS (Mills et al., 2019).

**Figure 4: Birth Registration in Civil Registration and Vital Statistics Systems**



Despite the sustained global commitments to universal birth registration (BR), stark disparities persist, especially in Least Developed Countries (LDCs)<sup>7</sup>. In turn, the operational efficiency, accessibility, and regulatory framework of civil registration systems significantly influence BR rates. Ebbers and Smits (2022) delineated the sequential distinction between birth notification, formal registration, and certification, illustrating the administrative discontinuities that preclude comprehensive registration coverage. They hypothesised that delays, procedural complexity, and governance inefficiencies collectively deter participation. While high- and middle-income

<sup>7</sup> According to the United Nations (2020), Least Developed Countries (LDCs) are those that meet three criteria: a low gross national income (GNI) per capita below \$1,045, weak human assets (as measured by factors such as education, health, and nutrition), and high economic vulnerability, while the World Bank (2021) highlights that LDCs also face significant challenges, including limited economic diversification, reliance on agriculture, and frequent exposure to natural disasters.

countries have achieved mainly near-universal birth registration, many low-income countries lag significantly behind. This disparity reflects deep-rooted systemic challenges in national data systems, which the World Bank defines as the integrated frameworks of institutions, technologies, policies, and practices that collect, process, manage, and disseminate statistical and administrative data for governance, planning, and service delivery (World Bank, 2017).

### **2.8.1 CRVS COMPLETENESS**

CRVS completeness widely varies, as shown through Mikkelsen et al.'s (2023) study of BR in 194 World Health Organisation (WHO) Member States that used data from UNICEF's database of national surveys and vital registration reports between 2015 and 2019. In this case, they obtained publicly available vital statistics compiled by national authorities. They assessed the completeness of civil registration as the percentage of children under five whose births were reported as registered. They then compared the completeness of vital statistics with the United Nations' World Population Prospects estimates of live births. One of their results concluded that around 20% of the global population resides in 43 countries with low system performance (Mikkelsen et al., 2023).

Furthermore, they concluded that CRVS systems average a score of 0.70 on a 0–1 scale worldwide, with significant discrepancies between high-income and low-income countries.<sup>8</sup> In summary, Mikkelsen et al. (2023) showed that the relatively low rates of CR observed in LMICs are attributed to these factors: (1) A legal framework that is either poorly structured or not effectively enforced, presenting challenges in implementation; (2) A lack of coordination between ministries and unclear role definitions, which create ambiguity surrounding the legal and statistical aspects of Civil Registration and Vital Statistics (CRVS), thus hindering collaboration; (3) Physical and socio-economic barriers that limit access to registration offices, despite widespread awareness of their importance; and (4) A general lack of understanding about the purpose and long-term benefits of registration, leading to limited motivation to engage in the

---

<sup>8</sup> Scores varied from under 0.50 in emerging systems to nearly 1.00 in the most advanced systems.

process.<sup>9</sup> In addition, scholars Silva (2022) and Muñoz et al. (2018) argue and propose that addressing low rates in LMICS requires successful partnerships between the health sector and CR offices to validate, compile, store, and certify microlevel birth data. When any of the components in the diagram above are dysregulated, the long-lasting effects of an unregistered population with low system performance can have significant developmental consequences. Here, health data with complementary interim data and interim sources can provide valuable insights into missing components.

The work of Yokobori et al. (2021) supports this theory by utilising the previously discussed health sector's role to approach CRVS from a population perspective, incorporating demographic methods as a solution. Muñoz et al. (2018) also propose the 'Ten CRVS Milestones Framework' to facilitate more straightforward registration procedures with streamlined administrative and legal functions.<sup>10</sup> This is where CRVS indicators from the World Bank come into play.

## **2.8.2 CRVS MEASUREMENT: WORLD DEVELOPMENT INDICATOR**

The World Bank's Civil Registration and Vital Statistics (CRVS) World Development Indicator is used to evaluate the completeness of CRVS systems, with a focus on birth and death registrations. According to the United Nations Statistics Division (UNSD) standards, a CRVS system is deemed complete if 90% of births and 75% of deaths are registered. This indicator is designed to measure the effectiveness of national civil registration systems in capturing vital statistics, and it is expressed as a ratio ranging from 0 to 1, with 0 indicating no completeness, 0.5 indicating partial completeness, and 1 indicating total completeness. Figure 5 presents the global data for 2023 (UNSD, 2023). Of the twenty-seven countries represented in this analysis, Mongolia, São Tomé Príncipe, and Vietnam are the only countries that, according to the CRVS indicator, have fully functional CRVS systems. Bangladesh has a partially functional system. The remaining twenty-three have minimal or non-functional CRVS systems. This is where the

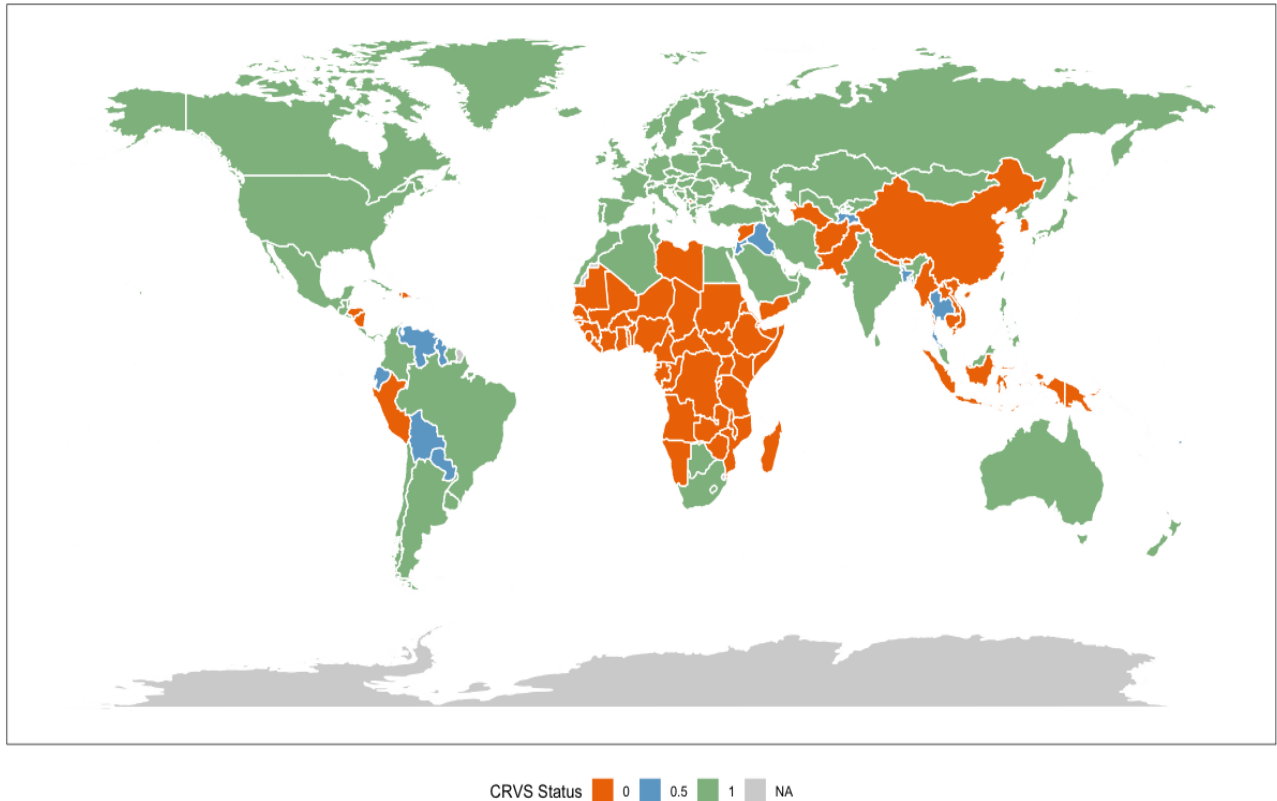
---

<sup>9</sup> Please refer to Mikkelsen, L., Iburg, K. M., Richards, N., Lopez, A. D., Setel, P. W., & Phillips, D. E. (2023). Comparative performance of national civil registration and vital statistics systems: A global assessment. *Bulletin of the World Health Organization*, 101(12), 758–767. <https://doi.org/10.2471/BLT.22.289033>

<sup>10</sup> Please refer to Yokobori, Y., Obara, H., Sugiura, Y., & Kitamura, T. (2021). Gaps in the civil registration and vital statistics systems of low- and middle-income countries and the health sector's role in improving the situation. *Global Health & Medicine*, 3(4), 243–245. <https://doi.org/10.35772/ghm.2020.01103>

Multiple Indicator Cluster (MICS) and Demographic Health Survey (DHS) complement these CRVS data gaps.

**Figure 5: World Bank Indicator: Civil Registration and Vital Statistics (CRVS) for FY2023**



*(Indicator SPL.D4.2.3.CRV5) for FY2023. World Bank Indicator counter for the Statistical Performance Indicators.  
Statistical Concept and methodology: Birth registrations 90% complete and death registration 75% complete according to UNSD.  
Accessed 21 November 2024.*

**Source: Made by Tierney McCue based on World Bank Indicator SPL.D4.3.3. CRVS Data**

## **2.9 FIVE CASE STUDIES FROM CONFLICT-AFFECTED AND DEVELOPING COUNTRIES: GOVERNMENT POLICIES AND LEGAL FRAMEWORKS**

Afghanistan (2022), the Democratic Republic of the Congo (2017), Madagascar (2018), the Lao People's Democratic Republic (2017), and Sudan (2014) all exhibit several pivotal characteristics that have impeded the development and efficacy of their birth registration systems. Each of these countries has experienced an underdeveloped or fragmented civil registration and vital statistics

(CRVS) infrastructure, which has resulted in low BR coverage and limited institutional capacity. These challenges are exacerbated by political instability, conflict or authoritarian governance, which disrupt public administration and essential services. Furthermore, these countries also face severe humanitarian and development challenges, including poverty, food insecurity and limited access to healthcare, factors that create significant barriers to registering births, particularly in rural or marginalised areas. Gender inequality further restricts women's access to civil registration services, particularly in contexts where legal or social norms limit women's mobility or decision-making authority. In most cases, international organisations such as UNICEF have played a central role in supporting and sustaining birth registration efforts due to a lack of consistent domestic investment and institutional support. Each country provides a nuanced understanding within their frameworks, which is essential when looking at overall BR trends locally, regionally, and globally.

### **2.9.1 AFGHANISTAN 2022**

Afghanistan has been marked by decades of conflict and remains one of the most fragile countries worldwide, with prolonged unrest beginning with the 1973 Afghan coup d'état. Following the Taliban's de facto rule in August 2021, Afghanistan faced a deepening humanitarian crisis (Rajmil et.al, 2022). Simultaneously, the country grappled with severe economic collapse, widespread poverty, and food insecurity, which was exacerbated by the freezing of Afghan central bank assets abroad and the suspension of most international development aid. As the Taliban imposed increasingly restrictive policies, women's rights deteriorated dramatically, which included barring girls from secondary education and limiting women's mobility and employment opportunities (Rajmil et.al, 2022).

Afghanistan's birth registration system remained severely underdeveloped and fragmented, particularly following the political transition to Taliban control. The 2022-2023 Afghanistan MICS survey, conducted between September 2022 and February 2023, revealed that the estimated birth registration rates for children within the total surveyed population were 52% for below 1 year, 51-8% for 1–2 years, 46.2 % for 2-3 years, 45.7% for 3–4 years, 43.8% for 4–5 years (UNICEF, 2023). The central civil registration authority, previously supported by

international aid and technical assistance, faced operational setbacks due to funding cuts and institutional instability. At this time, Afghan birth certificates and identity cards (tazkira) were and continue to be administered only at clinics/hospitals, with the National Statistic Information Authority (NSIA), and verified with the Embassy of the Islamic Republic of Afghanistan (Afghanistan Population Cluster, 2024). Most births must occur in the hospital to qualify for registration. However, given that upwards of  $\frac{1}{3}$  of births occur at home in Afghanistan, with at least 80% occurring in rural areas, these newborns cannot qualify for registration (UNFPA, 2024b). Births in remote or conflict-affected regions are often unregistered due to a lack of infrastructure and security concerns.

Additionally, governmental restrictions complicate efforts to improve registration (Naziri et al., 2018). Afghanistan's high rates of home births in rural areas, coupled with ongoing conflict, result in many children being born outside health facilities and bypassing the registration system. Furthermore, persistent unrest has led to a loss of trust in the government among the population (Naziri et al., 2018). Dependence on tribal or community systems for identity documentation further contributes to low registration rates (Schneider, 2005).

The Taliban's restrictive policies on women's access to health care and public services, which limited mothers' ability to engage with registration authorities, have further complicated birth registration. While some humanitarian actors, including UNICEF, continued limited engagement to support vital statistics and health system integration, the overall capacity of the birth registration infrastructure significantly weakened in 2022, threatening long-term efforts to ensure legal identity for all children in Afghanistan. This warrants further investigation into the complexities of the socio-determinants of BR following 2022.

## **2.9.2 DEMOCRATIC PEOPLE'S REPUBLIC OF THE CONGO 2017**

In the Democratic Republic of the Congo (DRC), access to skilled birth attendants remains a prevalent challenge with a shortfall of midwives by around 75% (Baba et al., 2020). According to the DHS survey of 2014, under 25% of children had their births registered with 14% owning a birth certificate; some regions had less than 10% like Nord- Kivu with 7% and Bandundu with

5% (MPSMRM et al., 2014). According to the 2017 MICS survey, the total BR remained about a quarter of the surveyed child population, with 17% having a birth certificate (UNICEF, 2023). Scholars have pointed out that birth registration and access to medical facilities, particularly in remote and conflict-affected regions, remained low. Lower rates reported in provinces such as Kasai, Tanganyika, and Itur as well as areas heavily impacted by violence and displacement. Due to the conflict, their CRVS system has suffered from chronic underinvestment, lack of trained personnel, and logistical challenges, including the absence of registration centers in many rural communities (Jarrett et al., 2020).

### **2.9.3 MADAGASCAR 2018**

In 2018, Madagascar faced significant challenges in its birth registration system, with many of the population still lacking official birth documentation. According to the 2018 MICS Madagascar report, despite ongoing efforts to improve birth registration since the national programme to restore birth registration in 2004, one in five children remains unregistered. Data also showed that mothers of three out of five unregistered children know the birth registration process. Regionally, birth registration was particularly low in rural areas, where access to registration centres was limited, and in remote communities in the highlands and coastal regions. Many rural families preferred to avoid the registration process due to the perceived complexity or expense, even though it was technically free. Additionally, socio-cultural factors, such as a lack of awareness about the importance of registration, and logistical barriers like poorly equipped civil registry offices, exacerbated the issue. This lack of birth registration meant that a significant portion of Malagasy children did not have access to essential rights, such as education, healthcare, and social protection, as official documentation is required for school enrollment, vaccination programs, and other public services.

In 2020, Madagascar's population was 26.5 million, with about 62.8% of the population residing in rural areas (United Nations, 2024). The country currently employs a decentralised CRVS framework managed by the Ministry of the Interior and Decentralisation and the Ministry of Justice. Most operations are devolved to individual municipalities (communes) and local subdivisions (fokontany). Notwithstanding a BR rate of 78%, considerable obstacles remain,

including a backlog of unregistered births (22%), incomplete issuance of BCS, and reliance on manual processes (United Nations, 2024). The traditional administrative structures in rural areas exacerbate these challenges (Harbitz, 2021).

To address these issues, the Malagasy government, with support from international organisations like UNICEF, launched several initiatives to increase birth registration, including mobile registration units and integrating birth registration with vaccination campaigns. To modernise Madagascar's CRVS system, a concerted effort has been to update the legal framework and establish a National Civil Registration and Identification Centre (Harbitz, 2021). Their government's objective has been twofold: firstly, to centralise and digitise records, and secondly, to issue unique identification numbers and streamline registration processes. However, while their reforms aimed to address gaps in registration, ensure equitable access, and integrate CRVS data into vital statistics, approximately 30% of the children captured from the 2018 MICS lacked a birth certificate. While Madagascar's commitment to improving governance and developmental outcomes has been notable, a gap remains (Harbitz, 2021).

#### **2.9.4 LAO PEOPLE'S DEMOCRATIC REPUBLIC 2017**

In Lao PDR, BR is commonly understood as registration in the family book, rather than possessing a birth certificate, which may lead to underreporting of legal identity status. The Ministry of Home Affairs has managed the civil registration system since 2011. In the MICS 2017 survey, this question was taken into account, and the book was referred to as opposed to ownership of a certificate. Birth registration coverage in Lao PDR remains critically low, with only 26.1% of children under the age of five possessing a 'birth certificate'. This limited access to legal identity is shaped by stark regional, socioeconomic, and educational disparities. Urban children are more likely to be registered (39.1%) compared to those in rural areas, especially in villages without road access, where rates drop to just 15.4%. Regional variation is also significant, with provinces like Luangnamtha reporting the highest registration rates at 58.5%, while provinces such as Attapeu and Khammua report some of the lowest, at 10.4% and 14.6% respectively. Maternal education strongly correlates with birth registration; only 13.5% of children whose mothers have no education are registered, compared to 49.1% among those

whose mothers have higher education. Ethnic and linguistic barriers further compound the problem. Birth registration rates are highest among Lao-Tai households (30.3%) and notably lower among Mon-Khmer and Hmong-Mien communities, many of whom do not speak Lao, the official language used in registration documents and processes. Economic inequality also plays a key role; only 12.7% of children from the poorest households are registered, in contrast to 45.6% from the richest quintile. At the same time, awareness is relatively high, with about 73% of mothers or caretakers knowing how to register.

A substantial wealth gap exists, with many rural households still living in poverty. According to the World Bank Group's 2023 report, about 10% of the total rural population lived below the poverty line, which accounted for about 55% of the country's overall 18.3% rate of poverty (World Bank Group, 2023). These communities often lack the resources to provide the necessary resources to complete the BR (Do et al., 2018). Additionally, the complexity of administrative procedures in Laos discourages participation. There is also a lack of awareness regarding the importance of BR, especially among parents in rural and marginalised communities (Spoorenberg, 2014).

Laos is home to 49 ethnic groups, many of which do not speak Lao, the lingua franca. While awareness is relatively high, with about 73% of mothers or caretakers knowing how to register births, structural barriers such as distance, administrative complexity, language exclusion, and cost continue to hinder widespread registration. Registration forms, instructions, and information campaigns are typically available only in Lao, discouraging non-native speakers of Hmong, Thai, Mandarin, etc., from registering their children. Geographical factors also play a significant role. In Laos, seasonal weather patterns such as monsoon flooding can limit access to registration services during critical periods (Nomura et al., 2018).

Health facilities play a crucial role in registering births; however, many births occur outside hospitals in countries like Laos (Nomura et al., 2018). Country-specific challenges further complicate the situation. In Laos, a substantial proportion of births take place at home, often attended by traditional birth attendants rather than medical professionals. This practice is deeply

rooted culturally and logistically, particularly in rural and mountainous regions with limited health infrastructure. Traditional birth attendants are vital in geographically or economically isolated communities, but seldom possess the training or resources necessary to report births to civil registration systems (Lane & Garrod, 2016). Ethnic minorities face additional challenges, as many maintain traditions and worldviews that prioritise community recognition over formal government documentation (Lane & Garrod, 2016). Consequently, registering births with the state is perceived as less valuable. For instance, some groups believe that naming ceremonies or communal acknowledgements suffice to confirm a child's identity, reducing the motivation for formal registration (Withers et al., 2018).

### **2.9.5 SUDAN 2014**

Birth registration rates in Sudan have greatly fluctuated over the past twenty years. Despite the ongoing conflict in Sudan, the 2014 Sudan Multiple Indicator Cluster Survey (MICS) report revealed that approximately 59% of children in Sudan were registered in 2010. The same report also estimated that it rose to around 67.3 per cent as of 2014 (Central Bureau of Statistics & UNICEF Sudan, 2016).

In Sudan, according to the International Rescue Committee, “more than 11.4 million people are now considered displaced within the country and over 3 million people—mostly women and children—have fled Sudan to neighbouring countries” (IRC, 2025). In Sudan, prolonged internal civil wars have destroyed many administrative institutions or interrupted access to them, resulting in large portions of the population remaining unregistered (Khalifa, 1983). Additionally, in Sudan, the lack of resources and the country's vast size exacerbate inequalities in access to registration services (Aboagye et al., 2023).

The current state of BC ownership is difficult to gauge. Conflicts further compromise infrastructure and administrative capacities. The civil registration system in Sudan remains underdeveloped, with insufficient facilities; civil status registers are reportedly only sporadically updated (Altijani et al., 2023). Additionally, high maternal mortality rates in Sudan are a significant issue (Ebberts & Smits, 2022). Many parts of the country rely on traditional birth

attendants, and only a small proportion of the population interacts with the formal healthcare system, which is crucial for linking births to civil registers (Tongun et al., 2019). The study of Sudan offers a compelling lens through which to examine the complex interplay between conflict, displacement, institutional fragility, and access to civil registration systems.

## **2.10 RISKS AND IMPLICATIONS**

Children who do not possess birth certificates are more likely to be marginalised and excluded from healthcare services, social welfare programmes, and other such provisions. This is particularly the case for those who are considered to be vulnerable. The denial of access to educational institutions and social welfare programmes may also result in a lack of recourse to the legal system (UNICEF, 2013). For internally displaced and refugee children, BR is even more critical due to the constraints of their precarious situations, which include extreme vulnerability, hardship, and uncertainty. These children often face heightened risks.

Statelessness, in particular, leaves children without legal ties to any country, impeding their access to essential resources and protections and making them more vulnerable to further exploitation. While this thesis does not include refugee camp data, it is another important branch in the BR field. Notwithstanding, it is critical to capture BR for the two vital functions (1) establishing legal identity, and (2) generating vital demographic data (UNICEF, 2013).

## **2.11 RESEARCH GAPS AND OBJECTIVES**

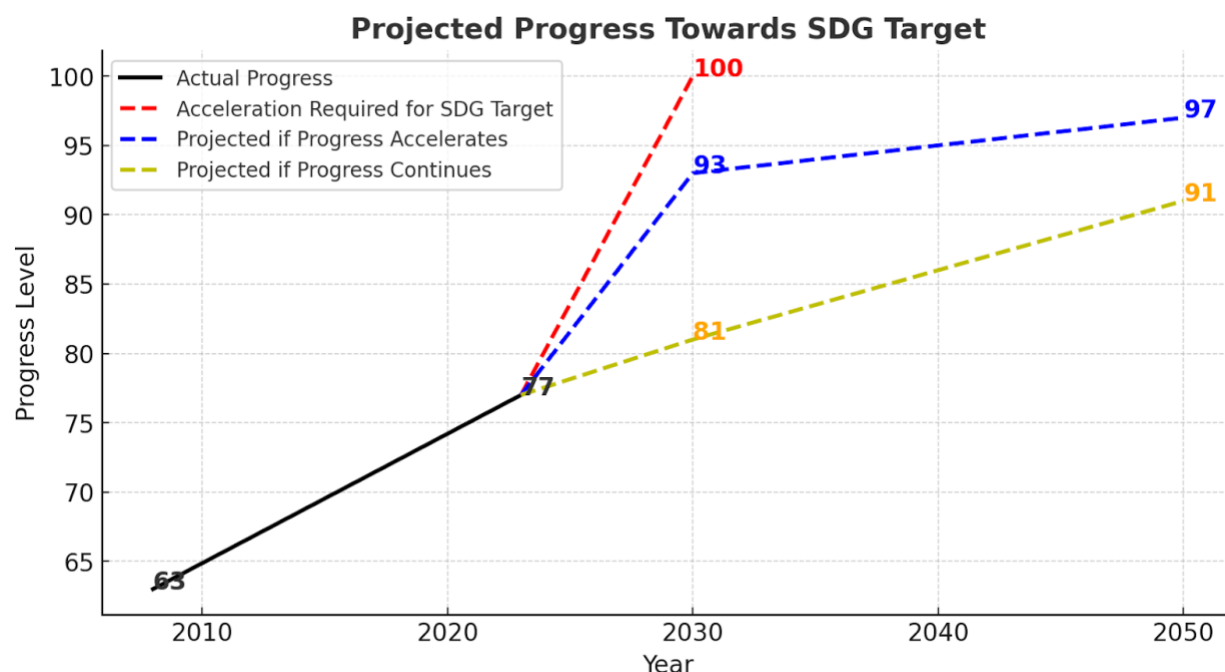
Notwithstanding the considerable advances made over the past three decades, the lack of accurate and universal BR impedes the effective management of population demographics.

Despite the commendable efforts of international bodies such as UNFPA, UNHCR Expert Group on Refugee, Internally Displaced Populations and Statelessness Statistics (EGRISS), the Centre of Excellence for Civil Registration and Vital Statistics Systems (Coe-CRVS), and the World Health Organisation (WHO) in improving vital statistics like BR, a significant gap persists that leaves at-risk and vulnerable populations without legal identity.

UNICEF's 2005 report and 2024 update to *The Rights Start to Life: A Statistical Analysis of BR* created a strong foundation that defined BR differentials through socio-economic, demographic,

proximate, and knowledge variables through multivariate analysis, utilising household survey data from the MICS and the DHS. Yet, up until 2025, composite trends of global BR rates remain relatively below 77 per cent. Hence, an important contribution to existing research is understanding previous social determinant effects. As shown in Figure 6, current projections highlight the different pathways to universal birth registration, which will take the next twenty years to reach 91 per centt with current trends. While optimistic, this rate could be accelerated with the right interventions by targeting the social determinant barriers within the CRVS system.

**Figure 6: UNICEF Projected Progress Towards SDG Target: Birth Registration Rates (Children 0-5)**



Source: Graph by Tierney McCue based on the data of UNICEF (2024). *The right start in life: Global levels and trends in birth registration – 2024 update*. United Nations Children's Fund.

A large sentiment by the UNICEF update in 2024 reiterated that a substantial proportion of the population residing in rural areas cannot access registration services across the various UNICEF-classified regions. Prevailing financial constraints, such as the inability to afford the registration fee or the cost of travel to registration sites, also present a considerable obstacle. In some countries, the registration systems are not fully operational, further complicating the process

(UNICEF, 2024). Additionally, a lack of awareness about the importance of BR among parents contributes to low registration rates. In certain regions, cultural or legal restrictions prevent mothers from registering their children independently, as they are often required to have the father present to complete the registration.

## **2.12 HYPOTHESES**

This section outlines the hypothesis underlying the study of birth certificate (BC) ownership among children (aged 0-5 years) in several LMICS. These hypotheses are based on the literature on civil registration and vital statistics (CRVS) systems (in Chapter 2), rural-urban disparities, and household-level determinants of birth registration.

The first hypothesis focuses on how household social determinants affects the probability of BC ownership within Afghanistan, DRC, Lao PDR, Madagascar, and Sudan, taking into account household-level determinants and cluster factors in five selected MICS surveys:

- **H1 (Household hypothesis): Controlling for household and cluster-level determinants, children (aged 0–5) with higher levels of maternal education, increases in household economic stability, urban residence, and household access to healthcare and information will be positively associated with increased likelihood of birth certification ownership, while household experiences of discrimination and poor environmental or housing conditions will be negatively associated with certification ownership.**

The second hypothesis examines the role of country level determinants, as shaped by Ebbers and Smits (2022) in shaping cross-national disparities in birth certification ownership and sub-national disparities in 27 LDCs:

- **H2 (Country-Level Hypothesis): Country-level structural factors, namely public health expenditure, governance quality, and urban–rural population distribution, are significant independent and interactive predictors of birth certificate ownership among children under five across 27 low- and middle-income countries between 2013 and 2023, as assessed within a multilevel logistic regression framework informed by Ebbers and Smits (2022) and Mohanty and Gebremedhin (2018).**

## **CHAPTER 3: DATA STRUCTURE AND METHODOLOGICAL FRAMEWORK**

This analysis employs the IPUMS-MICS database to harmonise data from the UNICEF Multiple Indicator Cluster Surveys (MICS) to facilitate cross-country comparisons. Specifically, data were collected from the UNICEF MICS Women's surveys (which target women aged 15–49) and the corresponding Children's surveys (which cover children under five). A total of 27 women's and 27 children's surveys were downloaded from the IPUMS-MICS database, and the distribution is seen in Table B1, Appendix B. The study uses a structured sample merger process and data cleaning using the IPUMS database.

### **3.1 MICS SELECTION**

This research chose the MICS surveys over the DHS surveys for two reasons. The first and central point is that the MICS has a broader regional representation; it has a more diverse sampling across geographical boundaries, whereas the DHS tends to focus more on sub-Saharan Africa and parts of South Asia. The MICS is particularly advantageous for examining East Asia and the Pacific BR trends. The second reason is that since 2013, MICS has released more surveys than DHS. It is relevant to the study to have a more contemporary and comprehensive dataset that reflects more recent trends in BR. The higher frequency of MICS surveys ensures that the analysis captures more up-to-date variations within registration practices, policy implementations, and socioeconomic influences on BR.

### **3.2 MICS WOMEN AND CHILDREN'S SURVEY: SURVEY DESIGN, WEIGHTS**

MICS surveys use a multistage sampling design that relies on already existing sample frames; these frames come from the latest population and housing census or an appropriate master sample frame (Khan and Hancioglu, 2019). Additionally, these sample frames have well-determined units of area with the geographical codes as a measure of size (households or population) and additional information for stratification (Khan and Hancioglu, 2019). The sample frames of each survey are in Table B2, Appendix B.

Within the principal stage of the sample design, the census enumeration areas (EAS) are selected using probability proportional to size; other distributions are also accepted on the grounds of similarities to EAS (Khan and Hancioglu, 2019). During the second stage, “households in the selected EAs are listed to ensure that the size measures are fully updated (except in cases where an updated list is available from a master sampling frame, another survey or a recent census within the last 12 months)” (Khan and Hancioglu, 2019, p. 282). Then, “from the updated list, a systematic random sample of households is selected to form the survey clusters” (Khan and Hancioglu, 2019, p. 282). These clusters are about 20-25 households, which are moderated to reduce the effect of the design. In the last stage, individuals (e.g., a random child aged 5-17) are selected randomly, decreasing the interview burden and sample size (e.g., a random child aged 5-17). Such random selection reduces interview burden and sample size, which can be an issue for low-prevalence indicators (Khan and Hancioglu, 2019).

The sample weight of children in the households (WEIGHTCH) reports “the inverse of the probability of inclusion. To address unequal probability of selection and unequal response rates and ensure the survey population is representative of the full population” (IPUMS, n.d). It is taken into account according to the MICS survey design. These weights are unrelated to the countries’ populations.

The ‘IMICSCLUSTER’ variable is the primary sampling unit within these surveys. It is “within groups of 20-25 households drawn from a census (or similar) enumeration area using random systematic sampling” (IPUMS, n.d).

### **3.3 MICS SURVEYS MERGED**

The data preparation and analysis were conducted using StataNow/BE 18.5. Software and Rstudio. The merging process is visually documented in the appendix, as shown in Figure A12 (Appendix A) for transparency in the data integration methodology. The first step involved merging the conglomerated women’s datasets, which were downloaded as one through the IPUMS data portal, with the children's datasets, which followed the same process. Following the merger, the data was cleaned, whereby only matched records were retained.

The original women's dataset contained 569,212 observations, and the children's dataset contained 533,749 observations. To facilitate the merge, the mother's line number variable in the children's data was renamed to match the corresponding variable in the women's data. The two datasets were merged using key identifiers: sample, year, cluster, household number and mother's line number according to MICS guidelines. A many-to-one ("m:1") merge structure was used, and only matched records, as indicated by STATA's merge code, were retained for analysis.

Furthermore, the data were filtered to include only completed surveys, defined by the conditions "resultwm = "Completed"" for the women's survey and "resultch = "Completed"" for the children's survey. During data cleaning, 25,463 cases were removed from the women's survey based on the 'resultswm' variable. In comparison, 8,257 cases were removed from the children's survey based on the 'resultsch' variable through listwise deletion. This procedure ensured that only households with complete responses from women and children were included in the final dataset. Due to the standardised structures of the women's and children's surveys, those without a complete result are unweighted. Hence, the dropped observations had no weights attached to them. The completed entries retained in the final dataset also contained household survey weights and children's responses, which were necessary for any subsequent weighted analysis.

After this merger, the dataset included N=325,344 observations that matched the two surveys. This approach integrates maternal and child-level data, enabling more robust analyses of household and individual-level determinants of child health. This was the preliminary step in cleaning the data.

### **3.4 BR QUESTIONS ACROSS MICS QUESTIONNAIRES**

The outcome variable in both analyses is the variable 'birthcert', which is defined in BR1. When examining the survey questionnaires of the MICS surveys, the BR (BR) section consists of: (BR1) Does (name) have a birth certificate? (BR2) Has (name)'s birth certificate been registered with the Registrar General's Office?; and (BR3) Do you know how to register (name)'s birth, as shown in Figure 7. These questions remain standardised across all twenty-seven samples, with

language adaptation within administrative zones. The BR2 question varies in terminology depending on the parameters of their registering bodies due to the countries' differing registration authorities.

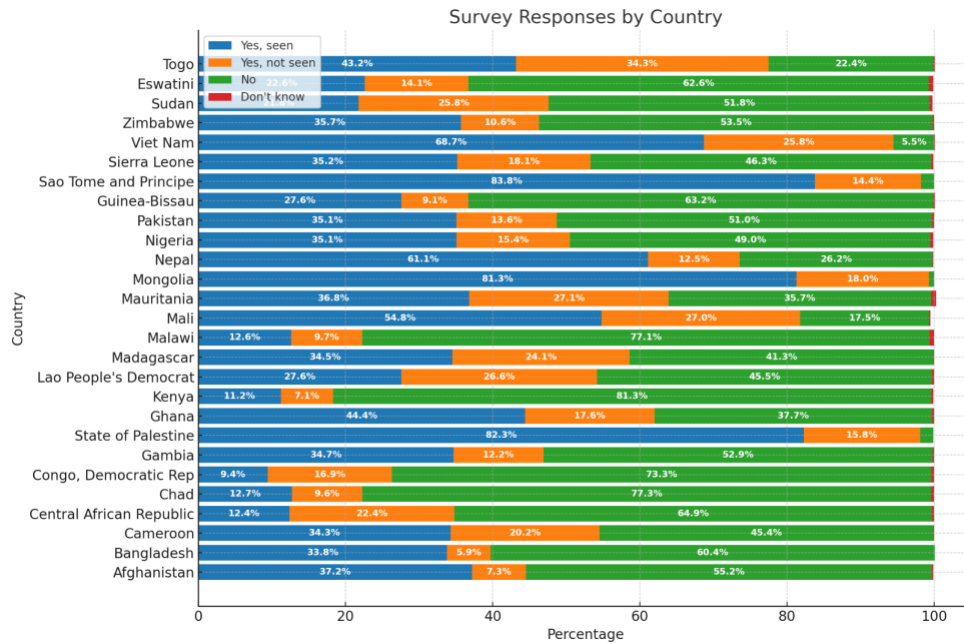
**Figure 7: MICS Questionnaire BR Extract**

| <b>BIRTH REGISTRATION</b>                                                                                      |                    | <b>BR</b>      |
|----------------------------------------------------------------------------------------------------------------|--------------------|----------------|
| <b>BR1.</b> Does ( <i>name</i> ) have a birth certificate?<br><br><i>If yes, ask:</i><br>May I see it?         | YES, SEEN.....     | 1              |
|                                                                                                                | YES, NOT SEEN..... | 2              |
|                                                                                                                | NO.....            | 3              |
|                                                                                                                | DK.....            | 8              |
|                                                                                                                |                    | 1⇒End<br>2⇒End |
| <b>BR2.</b> Has ( <i>name</i> )'s birth been registered with the City corporation/municipality/ Union council? | YES.....           | 1              |
|                                                                                                                | NO.....            | 2              |
|                                                                                                                | DK.....            | 8              |
| <b>BR3.</b> Do you know how to register ( <i>name</i> )'s birth?                                               | YES.....           | 1              |
|                                                                                                                | NO.....            | 2              |

**Source: United Nations Children's Fund (UNICEF). 2023. MICS questionnaire BR extract: Afghanistan 2022-2023 survey.**

The general trend observed across the countries in the dataset, as seen in Figure 8 below, indicates varying levels of BC possession, with significant differences between countries. In many countries, the percentage of children with BCS (Yes, seen) is notably lower than those without one (No), indicating a widespread gap in BR coverage. Some countries like Palestine (82.3%), Mongolia (81.3%), and Sao Tome and Principe (83.8%) show a very high percentage of children possessing a BC. In contrast, others, such as Kenya (11.2%) and Chad (12.7%), have much lower percentages of children with a BC. This frequency figure displays the response counts before the outcome variable is coded (as described in section 3.5).

**Figure 8. BR1 Survey Responses**



**Source: Tierney McCue**

Additionally, a significant portion of the data shows a large percentage of children reported as "No" (i.e., without a BC, especially in countries like Chad (77.3%) and the Central African Republic (64.9%), where the majority of children are reported as lacking a BC. Countries like Mali (54.8%) and Nepal (61.1%) have a more balanced distribution of BC possession, with a substantial portion of children reporting "Yes, seen" and a minor percentage reporting "No."

### 3.5 BIRTH CERTIFICATE BINARY OUTCOME LOGIC

As shown in Appendix A, Figure, the BC data were coded as a binary (binomial) variable of "Yes" and "No" for several logical reasons. First, the binary categorisation simplified the analysis by focusing solely on whether a child has a reported BC, which is the primary objective of understanding the self-reported BC to capture BR trends. By collapsing the data into these two categories, the study will be better situated to effectively assess the gap in BR completeness across countries.

Second, categories like “Yes, seen”/ “Yes, not seen” and “No” directly address the core question of self-reported BC possession. It is important to note the categories "Do not know" (0.30% of the total dataset) and “No” since it cannot be marked as “Yes”, and it is a negligible proportion of the data; it does not provide meaningful analytical differentiation. By consolidating these categories, the analysis maintains clarity and reduces fragmentation in the dataset, ensuring more robust statistical interpretation. Due to their minor frequency, the "Missing" (with 91 responses in total) have been excluded through listwise deletion from the final data. Following this process, the dataset consisted of  $N = 325,253$  entries, according to the binary outcome of BR1, before further cleaning, as detailed in Chapter 4.

This coding enables a more explicit comparison of BR rates across different countries and regions, thereby supporting the identification of trends, disparities, and potential factors influencing registration completeness while taking this into account. Consequently, "Yes" and "No" provide a more transparent, actionable framework for understanding and addressing the global disparities in BR. This outcome variable is employed in section (1) case studies and (2) global analysis. Prior to the analysis, a multitude of Pearson correlations were run before determining the final variables. Figure A11, Appendix A, displays the preliminary correlations before the reduction of variables.

### **3.6 SECTION ONE: MICS Household Variables Used in the MELOGIT Analysis Across the Five Case Studies: Afghanistan (2022–2023), Democratic Republic of the Congo (2017), Madagascar (2017), Lao People's Democratic Republic (2017), and Sudan (2014)**

The independent variables used in Section 1 (Case Study Analysis) are grouped into three deterministic factors:

1. **Child-Level/Mother-Level Factors within Household**– Age, sex, birth circumstances, mother’s education level.
2. **Household-Level Factors** – Socioeconomic status, family structure, residence type
3. **Community-Level Factors** – Cluster effects and survey design.

The independent variables used at the household level are all sourced from the UNICEF Multiple Indicator Cluster Survey (MICS). The coding of each variable can be seen in Figure A14 (Appendix A). The distribution of these variables within each survey can be seen in the appendix under the sections for the countries. The variables were chosen after a multitude of Pearson correlation trials and reduced based on the results.

### 3.6.1 HOUSEHOLD FACTORS

**Figure 9. Selected Household Variables for the Case Studies**

| Variable                                 | Source: MICS, Description                                                                                                                                                                       | Type        |
|------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| MICS CHILD WEIGHT                        | The sample weight of the child, reflecting the inverse of the probability of inclusion, ensuring the survey population is representative of the full population (IPUMS, n.d.).                  | Weight      |
| MICS CLUSTER                             | The primary sampling unit, consisting of groups of 20-25 households drawn from a census or similar enumeration area using random systematic sampling (IPUMS, n.d.).                             | Cluster     |
| MICS HOUSEHOLD                           | The number of the household within the sampling cluster, sequentially numbered from 1 to N within each cluster (IPUMS, n.d.).                                                                   | Household   |
| CHILD'S AGE                              | Categorizes children in the household by their age in completed years (0-4), ranging from less than 1 year (0) to the end of their 4th year (4) (IPUMS, n.d.).                                  | Categorical |
| SEX OF THE CHILD                         | Classifies children based on their biological sex, with Male (1) and Female (2), helping to understand gender distribution within the household (IPUMS, n.d.).                                  | Categorical |
| HOUSEHOLD WEALTH OF THE CHILD AND MOTHER | The Wealth Index Quantile (windex5), indicating the economic status of the household, divided into five quintiles, based on durable assets, housing, and services (IPUMS, n.d.).                | Categorical |
| DELIVERY ASSISTANCE AT BIRTH             | A merged variable combining individual variables (doctor, nurse/midwife, traditional birth attendant, etc.) by prioritizing the most professional form of assistance (IPUMS, n.d.).             | Categorical |
| URBAN/RURAL RESIDENCY                    | Identifies the household's location: rural area (2), urban area (1), or refugee camp (5), providing context for understanding environmental factors affecting household dynamics (IPUMS, n.d.). | Categorical |
| EDUCATIONAL LEVEL (MOTHER)               | Indicates the highest level of education attained by the mother or caretaker, ranging from less than primary education (10) to tertiary/university education (42) (IPUMS, n.d.).                | Categorical |
| CURRENT MARRIAGE STATUS (MOTHER)         | Reflects the marital status of the mother or caretaker, with categories such as married (11), living with a partner (12), or not in a union (20), showing family structure (IPUMS, n.d.).       | Categorical |
| SEX HEAD OF HOUSEHOLD                    | Reports the sex of the household head (IPUMS, n.d.).                                                                                                                                            | Categorical |
| NUMBER OF CHILDREN IN HOUSEHOLD          | Reports the total number of children in the household eligible for inclusion in the child survey (IPUMS, n.d.).                                                                                 | Categorical |
| MOBILE PHONE OWNERSHIP                   | Indicates whether any member of the household owns a mobile phone (IPUMS, n.d.).                                                                                                                | Categorical |

**Source: Tierney McCue**

### 3.6.2 SURVEY DESIGN AND REPRESENTATIVENESS

To ensure the statistical integrity of the analysis, several variables are included to account for the survey design's inherent limitations. The MICS household weight is essential for adjusting for sampling probabilities. The MICS cluster and MICS household control the hierarchical structure of the data. The children are nested within households and clusters. Therefore, these variables account for within-cluster similarities, crucial in an ME-Logit where responses from the same household and cluster may be correlated.

### **3.6.3 DEMOGRAPHIC CHARACTERISTICS OF THE CHILD**

The **CHILD’S AGE** is critical since birth registration likelihood can vary based on age; older children might have a lower probability of being registered due to delays or systemic barriers.

The **SEX OF THE CHILD** helps identify potential gender disparities in birth registration, which may exist due to cultural or policy-related biases favouring boys over girls in some societies.

### **3.6.4 HOUSEHOLD SOCIOECONOMIC STATUS AND ENVIRONMENT**

As a key informant of hypothesis H1, the **URBAN/RURAL RESIDENCY** factor is essential, as rural households may face infrastructural and administrative barriers that hinder BR compared to urban areas. The **MOBILE PHONE OWNERSHIP** variable is due to the key proxy position for household connectivity and access to information, which could influence awareness and ease of birth registration. Based on previous studies, household economic conditions have consistently proven to be a key determinant of BR, with wealthier households generally having better access to registration services.

The family's economic standing can be understood through the use of the **HOUSEHOLD WEALTH variable, which pertains to both the mother/guardian and the child**. The Wealth Index Quantile (windex5) divides the household into five wealth quintiles, from Poorest, the first quantile (1), to Richest, the fifth quantile (5). It is based on durable asset ownership, housing characteristics, and basic services. For each survey, a principal components analysis is performed by UNICEF for a set of indicator variables to determine a derived wealth level for the household. The method was originally developed by Filmer and Pritchett (2001) and subsequently expanded upon by Rutstein et al. (2014), as described by IPUMS (n.d.). This variable has already been calculated and completed for each survey. It is available across all MICS surveys as windex5.

### **3.6.5 BIRTH CIRCUMSTANCES AND HEALTHCARE ACCESS**

**DELIVERY ASSISTANCE AT BIRTH** is included because birth registration is often tied to healthcare access; children born in hospitals or with skilled birth attendants are more likely to be registered at birth. This categorical variable was created after a multicollinearity check of relevant variables that individually classified the assistance at birth. These variables (e.g., doctor, nurse/midwife, traditional birth attendant, etc.) were merged into a single categorical variable by

prioritising the most professional form of assistance. If a doctor assisted, the merged variable was coded as "doctor" (1); if a nurse/midwife assisted, it was coded as "nurse/midwife" (2), and so on, with lower priority categories (e.g., traditional birth attendant, relative/friend) assigned subsequent values. The result also included cases where no assistance was provided (coded as 6) or the information was not applicable (coded as 9 for NIU). Following the merging process, the multicollinearity was checked between the original variables to reveal correlations between the different types of assistance. These correlations were addressed by eliminating the redundant variables through this merger.

### **3.6.6. EDUCATIONAL LEVEL (MOTHER)**

This categorical variable indicates the highest level of education attended by the mother/Caretaker (edlevelmom). It ranges from less than primary education (10) to tertiary/university education (42), as well as specific classifications such as vocational/technical education (50) or Koranic schooling (61) (IPUMS, n.d.).

### **3.6.7 FAMILY AND HOUSEHOLD STRUCTURE**

The family environment within the households plays a part in birth registration decisions. The **CURRENT MARRIAGE STATUS (MOTHER)** captures whether the child's mother is in a stable union, which may influence birth registration accessibility. At the same time, the **SEX HEAD OF HOUSEHOLD** provides insights into household dynamics. Here, female-headed households may face different administrative challenges, which can vary across the cultural norms of individual countries. The **NUMBER OF CHILDREN IN a household** accounts for resource allocation within the household, where larger households may have lower birth registration rates due to financial constraints or administrative burdens. Families with multiple children may have more experience registering their children, or paradoxically, those with more children may have little knowledge about the process or a lesser desire to engage in it.

The Urban Status (**URBAN/RURAL RESIDENCY**) variable identifies the household's location, indicating whether it is situated in a rural area (2), urban area (1), or a refugee camp (5) (IPUMS n.d.). This classification offers valuable insight into the environmental factors that

influence household dynamics. This is particularly relevant to the hypothesis that urban children are more likely to be registered.

### **3.7 SECTION TWO: World Bank Country-Level Variables Used in the MELOGIT Analysis of the 27 Low- and Middle-Income Countries (LMICs)**

The independent variables used in Section 2 (Global Analysis) are grouped into three deterministic factors:

1. **Child-Level/Mother Factors** – Age, sex, birth circumstances, mother’s education level.
2. **Household-Level Factors** – Socioeconomic status, family structure, residence type, and education.
3. **Country-Level Factors** – Country effects and survey design.

While the primary child-, mother-, and household-level variables in Section 1 are sourced from the UNICEF Multiple Indicator Cluster Survey (MICS), this section introduces country-level variables drawn from the World Bank Data Portal (n.d.). These country-level indicators have been merged with individual-level MICS data, attributing national characteristics to each child included in the analysis. The sources of these indicators, as compiled by the World Bank, are detailed below. Variable codings are provided in Figure A15 (Appendix A).

**Figure 10: Selected Three-Level Variables for the Global Analysis**

| Variable                                                   | Source/Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Type        |
|------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| MICS CHILD'S AGE                                           | Categorizes children in the household by their age in completed years (0-4), ranging from less than 1 year (0) to the end of their 4th year (4) (IPUMS, n.d.).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Categorical |
| MICS SEX OF THE CHILD                                      | Classifies children based on their biological sex, with Male (1) and Female (2), helping to understand gender distribution within the household (IPUMS, n.d.).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Categorical |
| MICS HOUSEHOLD WEALTH OF THE CHILD AND MOTHER              | The Wealth Index Quantile (windex5), indicating the economic status of the household, divided into five quintiles, based on durable assets, housing, and services (IPUMS, n.d.).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Categorical |
| MICS DELIVERY ASSISTANCE AT BIRTH                          | A merged variable combining individual variables (doctor, nurse/midwife, traditional birth attendant, etc.) by prioritizing the most professional form of assistance (IPUMS, n.d.).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Categorical |
| MICS URBAN/RURAL RESIDENCY                                 | Identifies the household's location: rural area (2), urban area (1), or refugee camp (5), providing context for understanding environmental factors affecting household dynamics (IPUMS, n.d.).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Categorical |
| MICS EDUCATIONAL LEVEL (MOTHER)                            | Indicates the highest level of education attained by the mother or caretaker, ranging from less than primary education (10) to tertiary/university education (42) (IPUMS, n.d.).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Categorical |
| Civil Registration and Vital Statistics (CRVS) Completion; | Source/Code: SPI.D4.2.3.CRVS, United Nations SDG Database. It "measures completeness and reliability of a country's civil registration system, including birth and death registration coverage. (0= No CRVS, 1=Partial, 2=Full CRVS). Birth registrations 90% complete and death registration 75% complete according to UNSD. Unweighted average of indicators in this dimension. Scores range from 0-1, with a score of 1 representing the best possible score." (World Bank, n.d)                                                                                                                                                                                                                                                                                                                                                                                                       | Categorical |
| Statistical Performance Indicators (SPI) Overall Score     | Source: The World Bank. It represents the average score for the indicators associated with Sustainable Development Goals (SDGs) 1 through 6. The score is primarily derived from the UN SDG database, which includes data submitted by countries that have committed to the SDGs. However, the score may also reflect a country's willingness to report data, particularly in cases where developed countries have not submitted their full available data. For OECD countries, the average score is supplemented with comparable data from the OECD's "Measuring Distance to the SDG Targets 2019" report. Statistical Capacity Score (Overall Average) (scale 0 - 100)(IQ.SCI.OVRL) The World Bank. A weighted average of statistical performance indicators that assess the overall statistical capacity of a country. Score ranges from 0 to 100. This was coded into five quintiles. | Categorical |
| CPIA Gender Equality Rating                                | Source: World Bank Group, CPIA Database. Assesses gender equality in a country by evaluating its policies and institutions that ensure equal access for men and women in education, health, and the economy.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Categorical |
| Dimension 3.1: Social Statistics                           | Source/Code: SPI.DIM3.1.INDEX, United Nations SDG Database. Assesses social statistics on indicators like health, education, and welfare, focusing on social well-being.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Continuous  |
| Current Health Expenditure per Capita (US\$)               | Source: World Health Organization (WHO) Global Health Expenditure Database (SH.XPD.CHEX.PC.CD). Measures current health expenditure per capita in US dollars, reflecting healthcare investments.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Continuous  |

**Source: Tierney McCue**

### 3.7.1 Civil Registration and Vital Statistics (CRVS) Completion (SPI.D4.2.3. CRVS)

This World Bank indicator evaluates the completeness and reliability of a country's civil registration system by assessing the coverage of birth and death registrations. It employs a categorical scoring system, where 0 indicates no CRVS system, 1 represents partial coverage, and 2 signifies full CRVS coverage. This is defined as 90% completeness for birth registrations and 75% for death registrations, in accordance with UN standards. The final score is an unweighted average of indicators in this dimension, normalised on a scale from 0 to 1, where 1 represents the highest level of performance.

### 3.7.2 Statistical Performance Indicators (SPI) Overall Score

This score, also pulled from the World Bank Data portal, reflects a country's performance in producing and reporting statistics related to the first six Sustainable Development Goals (SDGs). It provides a general measure of a country's statistical system maturity (0-100) through five pillars: Data use, data services, data sources, and data infrastructure. For this analysis, it has been coded categorically into four quantiles: 1st Quartile (Q1): 1 to 25, 2nd Quartile (Q2): 26 to 50,

3rd Quartile (Q3): 51 to 75, 4th Quartile (Q4): 76 to 100. This score is used as a measure of how well a country can collect, analyse, and disseminate high-quality statistical data.

World Bank Country Policy and Institutional Assessment (CPIA), Gender Equality Rating

The World Bank's CPIA categorical indicator measures how effectively a country's policies and institutions promote gender equality. It assesses the legal and institutional frameworks that enable equal access for men and women in education, health services, and economic participation. It provides a snapshot of gender-sensitive governance through a rating of 1-6, with 6 being the highest possible score. This is coded into three categories: Low (1-2), Medium (3-4), and High (5-6) in the analysis.

### **3.7.3 Quality and Availability of Core Social Statistics Indicator (World Bank SPI**

#### **Dimension 3.1 Index – SPI.DIM3.1.INDEX)**

This categorical indicator is sourced from the World Bank's Statistical Performance Indicators (SPI), and it measures the production, availability, and quality of a country's core social statistics, including those related to health, education, employment, and income distribution. The index is constructed by assessing the presence of a defined set of core social indicators in each national reporting system. Then, each indicator's availability is evaluated and standardised to ensure cross-country comparability through this normalisation. It is an aggregated score. The resulting index is calculated using a weighted average method and yields a final score ranging from 0 to 1 for country comparison. This score reflects how consistently and comprehensively a country produces key social data. The indicator forms part of the SPI framework's "Data Products" pillar, with higher scores indicating stronger, more inclusive national social statistics systems.

### **3.7.4 Current Health Expenditure per Capita (US\$) (SH.XPD.CHEX.PC.CD)**

The World Health Organisation's data on current health expenditure per capita (in US dollars) is divided into quantiles to obtain a distribution of countries or regions based on their health expenditure per capita. The expenditures were categorised into the following groups: <US\$29.7, US\$29.7-43.49, US\$43.4-54.8, US\$54.8-83.8, and >US\$83.8. This quantile breakdown facilitates a comparative understanding of the healthcare spending landscape and highlights the differences between high, medium, and low spending groups. It also enables the identification of trends in healthcare financing and the concentration of resources across different income groups or economic classifications, facilitating a nuanced analysis of global healthcare financing patterns.

## **3.8 LIMITATIONS OF SELF-REPORTED BR COMPLETENESS IN THE MICS**

Due to the nature of the MICS surveys, the foundational household -level indicators that provide the household information are captured with minimal 'missings.' When the data is initially captured, the surveys that are not fully completed are weightless within the final dataset, ensuring a high quality within the framework. The final descriptive statistics are presented in the appendix. Chapter 4 provides details on cleaning the data.

While MICS data offers several advantages, it is essential to acknowledge the limitations of self-reported data on successful BR. Research by Adair and Lopez (2021) found that self-reported BR completeness for children under five years was, on average, six percentage points higher than CRVS estimates based on UN birth data and eight percentage points higher compared to GBD estimates across 57 countries. In countries where CRVS completeness was below 95%, self-reported registration was higher in 26 out of 28 cases, with an average overestimation of 13 percentage points and a median overestimation of 9–10 percentage points. In some cases, such as in three countries where self-reported completeness exceeded CRVS completeness by at least 30 percentage points, the discrepancy was even more pronounced. This pattern suggests that self-reported data may systematically overstate actual BR levels, particularly in contexts with weaker civil registration systems.

Additionally, it is worth noting that within the MICS surveys, bias may be introduced for children whose mother/guardian did not complete the survey in full or was not present. This may result in an exclusion of certain children from the dataset, thus leading to an underrepresentation of individuals from more vulnerable or transient populations, which may already be excluded from the accounted birth registration. This, in turn, could potentially distort the overall assessment of birth registration coverage and equity. Therefore, there should be a careful interpretation of MICS-based estimates.

However, in the absence of robust civil registration and vital statistics (CRVS) systems in numerous LMICS, the MICS surveys remain crucial for collecting data to calculate probabilities on BC ownership. It provides extensive, nationally representative samples, allowing robust statistical modelling of individual and household characteristics associated with BR<sup>11</sup>. The survey questions are standardised across countries, ensuring comparability across different contexts and facilitating cross-national analysis. Moreover, self-reported data captures household perceptions of BR, crucial for understanding behavioural and institutional barriers to registration. Given its broad geographic coverage and the frequency of data collection, MICS enables a more comprehensive and contemporary analysis of BR trends, making it a suitable dataset for studying the likelihood of reporting registration at national and regional levels.

While this study does not cross-compare MICS data with CRVS records, acknowledging the differences between self-reported and administrative data remains essential. Understanding the potential overestimation in survey responses reinforces the need for careful interpretation of results and helps situate findings within the broader landscape of BR research. By recognising these nuances, a more informed analysis of the factors influencing BR contributes to ongoing efforts to strengthen civil registration systems globally via their self-reported responses.

---

<sup>11</sup> Please see A. Hancioglu & F. Arnold, "Measuring coverage in MNCH: Tracking progress in health for women and children using DHS and MICS household surveys," *PLoS Medicine*, 10(5), e1001391, <https://doi.org/10.1371/journal.pmed.1001391>.

### **3.9 THEORETICAL JUSTIFICATION: MOHANTY AND GEBREMEDHIN (2018) AND EBBERS AND SMITS (2022)**

This study synthesises the theoretical frameworks of Mohanty and Gebremedhin (2018) and Ebbers and Smits (2022) on BR as a process influenced by microeconomic determinants (e.g., parental education, family characteristics) and macroeconomic factors (e.g., institutional infrastructure, political stability). These frameworks underscore the interplay between individual behaviour and system structure, providing a framework for designing methodologies and interpreting results. The integration of the ME-Logit regression modelling, as articulated by Mohanty and Gebremedhin (2018) and Ebbers and Smits (2022), provides a baseline framework for examining variations in BR at multiple levels. This methodological approach is well suited to answering the thesis's stated research questions on how different socio-demographic factors shape BR outcomes in subregional and global contexts.

Mohanty and Gebremedhin (2018) and Ebbers and Smits (2022) employ a three-level ME-Logit analysis in their respective studies. This approach is used for two primary purposes: first, to address households within subnational regions and countries, and second, to use two empty models to estimate the random effects at the national and local levels. Consequently, these models estimate the intraclass correlation to ascertain variations within and across different levels. Ebbers and Smit (2022) employed ME-Logit analysis using self-reported birth registration (BR) data for 358,842 children across 40 sub-Saharan African countries. They explored the influence of household, sub-national, regional, and country-level factors on BR rates. Their key determinants included poverty, education, women's autonomy, and religious affiliation. Additionally, they explored the relationship between contextual factors, including prenatal care access, urbanisation, BR legislation, decentralisation of the registration system, and fertility rates, in their model. Their multilevel analysis captured the complex relationships between individual, household, and regional factors that influence BR rates in sub-Saharan Africa. Similarly, Mohanty and Gebremedhin (2018) utilised an ME-Logit to investigate the impact of maternal socio-economic status on BR in India, incorporating district and community-level influences and individual child characteristics. Their findings underscore the substantial influence of maternal autonomy, including the capacity to move freely and exercise control over

resources, on the probability of BR. Other salient determinants encompass institutional births, antenatal care, caste, religion, wealth, and parental education.

### **3.10 ME-LOGIT APPLICATION**

The following section provides a rationale for using the works of Mohanty and Gebremedhin (2018) and Ebbers and Smits (2022) to address the two research questions. By drawing on the principles outlined in their analyses, this study has adopted and applied the ME-Logit model for three principal reasons:

1. The hierarchical structure of the data (child → household → cluster).
2. There is a need to account for variation at multiple levels.
3. This model aims to improve accuracy over standard logistic regression for complex survey design.

**1. To what extent do household-level social determinants of health, derived from Chen's (2020) framework, including economic stability, maternal education, healthcare access, housing and environment, social context, information access, and discrimination, independently predict the likelihood of birth certification ownership among children under five in five conflict-affected, low- and lower-middle-income countries with limited statistical capacity, using MICS data from Afghanistan (2022–2023), the Democratic Republic of the Congo (2017), Lao PDR (2017), Madagascar (2018), and Sudan (2013–2014)?**

To address the first research question, it is necessary to utilise country-level multilevel logistic regression models to analyse how household determinants impacts BR disparities across the five countries. The variables in this analysis diverge from those utilised in their respective studies. This model can identify how these determinants contribute to BR inequalities within countries (e.g. rural-urban divides) and across countries by including random effects at the regional and national levels. These disparities are crucial for understanding similar household occurring patterns which deter birth registration, as vulnerable populations often face unique barriers, such as limited access to healthcare and government services, which may hinder BR. The multilevel

approach enables the examination of these variations within individual countries to provide new analysis.

Furthermore, using ME-Logit regression models enables a country-specific analysis of the impact of maternal education in both urban and rural contexts, considering national variations in educational attainment and other contextual factors. This methodological approach facilitates comparisons between countries, identifying countries experiencing the most significant disparities in BR rates based on maternal education and the implications for national policy. The relationship between maternal education and BR offers insights into broader social and policy issues, including the potential for enhancing BR systems, particularly in low-income countries, through increasing maternal education.

In conjunction with the country-level binary logistic regression models, the model can further investigate how rural residency influences BR disparities at the country level, accounting for the national population distribution. Using normalised weights for each country, the model provides accurate country-specific estimates, revealing how rural residency contributes to disparities in BR rates and how these trends vary across different national contexts. This approach aligns with global patterns of inequality in civil registration by identifying country-level differences in the rural-urban divide.

**2. Within a multilevel logistic regression framework informed by Ebbers and Smits (2022) and Mohanty and Gebremedhin (2018), to what extent do country-level structural factors such as public health expenditure, governance quality and urban–rural population distribution independently and interactively influence the likelihood of birth certificate ownership among children under five across 27 low- and middle-income countries between 2013 and 2023?**

To address the second research question, the multilevel logistic regression model also enables an examination of country level factors affect birth certification while still investigating household level determinants such as maternal education as an independent variable. The multilevel approach offers insight into how maternal education interacts with household-level variables

(e.g., wealth, access to healthcare) and contextual variables (e.g., national policies, health infrastructure) to influence BR rates. Furthermore, a comparison of these results across countries provides valuable insights into how statistical capacity and country determinants like gender equality indicators impact registration outcomes within the context of national systems. This can highlight areas where improvements to the registration process may be required.

### **3.11 CONCLUSION**

The employment of ME-Logit regression models provides a robust framework for analysing BR disparities, with the multilevel model accounting for the data's hierarchical structure, thereby enabling the study of both within-country and between-country variations. In contrast, the country-level logistic regression models allow for a deeper understanding of nationally specific trends. The integration of these two methodologies enables the comprehensive investigation of the influence of rural residency, maternal education, and child age on BR outcomes. This framework ensures the generation of reliable and actionable results that can inform policy and interventions to reduce disparities in birth registration (BR) on household and country-level scales.

## CHAPTER 4: STATISTICAL MODELS AND METHODOLOGY

### 4.1 RESEARCH DESIGN AND SCOPE: SECTION ONE (5 UNICEF REGIONAL CASE STUDIES)

This study is divided into two sections of analysis that were conducted independently following the codification of the BIRTHCERT binary. In the first section, this study employs the following **multilevel mixed-effects logistic regression models** (ME-Logit) on a case study selected from each of the UNICEF regions:

|                                            |                                       |
|--------------------------------------------|---------------------------------------|
| <b>UNICEF South Asia</b>                   | Afghanistan 2022-2023                 |
| <b>UNICEF West and Central Africa</b>      | Democratic Republic of the Congo 2017 |
| <b>UNICEF Eastern and Southern Africa</b>  | Madagascar 2018                       |
| <b>UNICEF East Asia and Pacific</b>        | Lao People's Democratic Republic 2017 |
| <b>UNICEF Middle East and North Africa</b> | Sudan 2014                            |

This is done to analyse factors associated with the possession of self-reported birth certificates. Before the models were run, the data were cleaned according to the procedures laid out in Chapter 3. Following the preliminary VIF calculation to establish the relationship between variables, the subsequent order is as follows:

1. **Null Model**
2. **Child and Maternal Characteristics Model within the Household**
3. **Household Structure and Access Model**
4. **Household Structure and Access Model with Interaction Terms**

Due to the hierarchical nature of the data, where individuals (children) are nested within households, which are in turn nested within clusters, this approach effectively accounts for both within-group and between-group variations.

## 4.2 ANALYTICAL FRAMEWORK (5 UNICEF CASE STUDIES)

### 1. The Null Model

This baseline model includes only the intercept and random effects at the household and cluster levels, without any of the predictor variables. This will be used to assess the **intra-class correlation (ICC)** to assess the proportion of total variance attributable to differences between clusters and households. The ICC results will determine the relevancy of the multilevel modelling.

$$\text{logit}(\text{birthcert}) = \beta_0 + u_{\text{imicscluster}} + v_{\text{hhno}} + \epsilon.$$

- $\beta_0$  is the *overall intercept* (average log-odds of having a birth certificate).
- $u_{\text{imicscluster}} \sim N(0, \sigma_{\text{imicscluster}}^2)$  represents the *random intercept* for each cluster (e.g., community/district).
- $v_{\text{hhno}} \sim N(0, \sigma_{\text{hhno}}^2)$  represents the *random intercept* for each household.
- $\epsilon \sim N(0, \sigma^2)$  is the individual-level residual error.

The Null model will serve as a comparison for the following two models with predictors, allowing for the improvement in the model's fit to be measured when the explanatory variables are added. The formula for the ICC will show how much of the total variance is due to the clustering:

$$\text{ICC} = \frac{\sigma_{\text{imicscluster}}^2 + \sigma_{\text{hhno}}^2}{\sigma_{\text{imicscluster}}^2 + \sigma_{\text{hhno}}^2 + \sigma^2}.$$

## 2. Child and Maternal Characteristics Model within the Household

This model then introduces **individual- and household-level predictor variables** related to the child (e.g., age, sex), mother (e.g., education level, marital status), and head of household. It accounts for household- and cluster-level random effects while assessing how individual and maternal factors influence birth certificate possession.

The second model includes the following predictor variables:

$$\log\left(\frac{P(Y_{ijk} = 1)}{1 - P(Y_{ijk} = 1)}\right) = \beta_0 + \beta_1 \text{Age}_{ijk} + \beta_2 \text{Sex}_{ijk} + \beta_3 \text{Wealth}_{ijk} \\ + \beta_4 \text{DeliveryPlace}_{ijk} + \beta_5 \text{Urban}_{ijk} + \beta_6 \text{MotherEd}_{ijk} \\ + \beta_7 \text{Marriage}_{ijk} + \beta_8 \text{SexHead}_{ijk} + u_k + v_{jk} + \epsilon_{ijk}.$$

**Where:**

- $Y_{ijk}$  is the binary outcome variable (birth certificate possession).
- $i$  represents the child level,  $j$  represents the household level, and  $k$  represents the cluster level.
- $\beta_0$  is the intercept.
- $\beta_1, \beta_2, \dots, \beta_8$  are the fixed-effect coefficients for predictors:
  - $\text{Age}_{ijk}$ : Child's age (categorical: `i.agech`)
  - $\text{Sex}_{ijk}$ : Child's sex (categorical: `i.sexch`)
  - $\text{Wealth}_{ijk}$ : Wealth index (categorical: `i.windex5`)
  - $\text{DeliveryPlace}_{ijk}$ : Place of delivery (categorical: `i.delplace`)
  - $\text{Urban}_{ijk}$ : Urban–rural factor (categorical: `i.urban_factor`)
  - $\text{MotherEd}_{ijk}$ : Mother's education level (categorical: `i.edlevelmom`)
  - $\text{Marriage}_{ijk}$ : Mother's current marital status (categorical: `i.marrcurr`)
  - $\text{SexHead}_{ijk}$ : Sex of household head (categorical: `i.sexhhead`)

**Random Effects:**

- $u_k \sim N(0, \sigma_u^2)$ : Cluster-level variation (`imicscluster`).
- $v_{jk} \sim N(0, \sigma_v^2)$ : Household-level variation (`hhno`).
- $\epsilon_{ijk}$ : Residual error term.

**Weighting:**

- The model applies probability weights `pweight = weightch`, meaning individual-level observations are weighted accordingly.

### 3. Household Structure and Access Model

Building on the second model, this specification incorporates **structural household characteristics**, including the number of children in the household, the age of the household head, and mobile phone ownership. It enables a more comprehensive assessment of how both demographic and infrastructural factors correlate with birth registration disparities.

$$\log\left(\frac{P(Y_{ijk} = 1)}{1 - P(Y_{ijk} = 1)}\right) = \beta_0 + \sum_m \beta_m X_{ijk}^m + u_k + v_{jk} + \epsilon_{ijk}.$$

**Where:**

- $Y_{ijk}$ : Binary outcome (child has a birth certificate).
- $i$ : Individual/child level,  $j$ : Household level,  $k$ : Cluster level.
- $\beta_0$ : Intercept.
- $X_{ijk}$ : Fixed-effect predictors:
  - `i.agech`: Child's age (categorical)
  - `i.sexch`: Child's sex (categorical)
  - `i.windex5`: Wealth index (categorical)
  - `i.delplace`: Place of delivery (categorical)
  - `i.urban_factor`: Urban–rural status (categorical)
  - `i.edlevelmom`: Mother's education level (categorical)
  - `i.marcurr`: Mother's marital status (categorical)
  - `i.sexhhead`: Household head's sex (categorical)
  - `i.sub_num`: Number of regions in country (categorical)
  - `i.numch`: Number of children in the household (categorical)
  - `i.agehead`: Age of the household head (categorical)
  - `i.mobphone_gh`: Mobile phone ownership in the household (categorical)

**Random Effects:**

- $u_k \sim N(0, \sigma_u^2)$ : Cluster-level variation (`imicscluster`).
- $v_{jk} \sim N(0, \sigma_v^2)$ : Household-level variation (`hhno`).
- $\epsilon_{ijk}$ : Residual error term.

**Weighting:**

- The model applies probability weights `pweight = weightch`, meaning individual-level observations are weighted accordingly.

## 4. Household Structure and Access Model with Interaction Terms

Expanding on the third model, this specification incorporates **interaction effects**, such as the interactions between the quantile of wealth and education level of the mother, the marriage status of the mother and the sex of the head of household.

$$\log\left(\frac{P(Y_{ijk} = 1)}{1 - P(Y_{ijk} = 1)}\right) = \beta_0 + \sum_m \beta_m X_{ijk}^m + u_k + v_{jk} + \epsilon_{ijk}.$$

Where:

- $Y_{ijk}$ : Binary outcome (child has a birth certificate).
- $i$ : Individual/child level,  $j$ : Household level,  $k$ : Cluster level.
- $\beta_0$ : Intercept.
- $X_{ijk}$ : Fixed-effect predictors:
  - `i.agech`: Child's age (categorical)
  - `i.sexch`: Child's sex (categorical)
  - `ib3.windex5`: Wealth index (categorical, baseline = 3)
  - `i.delivery_assistance`: Assistance of delivery (categorical)
  - `i.urban_factor`: Urban-rural status (categorical)
  - `i.edlevelmom`: Mother's education level (categorical)
  - `i.marrcurr`: Mother's marital status (categorical)
  - `i.sexhhead`: Household head's sex (categorical)
  - `i.numch`: Number of children in the household (categorical)
  - `i.mobphone_gh`: Mobile phone ownership in the household (categorical)

Interaction Terms:

- `i.windex5 × i.edlevelmom`: Wealth index and mother's education level.
- `i.marrcurr × i.sexhhead`: Marital status and household head's sex.

Random Effects:

- $u_k \sim N(0, \sigma_u^2)$ : Cluster-level variation (`imicscluster`).
- $v_{jk} \sim N(0, \sigma_v^2)$ : Household-level variation (`hhno`).
- $\epsilon_{ijk}$ : Residual error term.

Where:

- $\gamma_1$  is the coefficient for the interaction between wealth index and mother's education level, (`WealthIndex5ijk × EducationLevelMotherijk`).
- $\gamma_2$  is the coefficient for the interaction between marital status and sex of household head, (`MaritalStatusijk × SexHeadijk`).
- $v_{jk}$  is the random effect at the household level, capturing unobserved heterogeneity across households within clusters.
- $\epsilon_{ijk}$  is the error term at the individual level, capturing unobserved heterogeneity at the individual level.

#### **4.2.2 VARIANCE-COVARIANCE AND ROBUSTNESS**

The models apply the robust standard errors (vce(robust)) to address potential heteroskedasticity. Additionally, the probability weights (pweight) are incorporated to adjust for survey design effects, ensuring that estimates remain generalisable to the target populations.

#### **4.2.3 CONCLUSION**

This research design integrates hierarchical data structures with individual and household characteristics, as well as robust variance estimation techniques, to provide an approach to understanding BC possession disparities. The four-model framework enables a progressive evaluation of explanatory factors, ensuring that both individual and structural determinants are systematically accounted for. The interaction terms are used to capture how the effect of one predictor variable on BC depends on the level of another predictor, revealing any conditional relationships that would be missed in an additive model.

### **4.3 SECTION ONE: KEY ANALYTICAL STEPS, DATA CLEANING PROCEDURES AND HANDLING MISSING DATA (5 UNICEF COUNTRY CASE STUDIES)**

The data cleaning procedures undertaken for five UNICEF MICS datasets used in this study: Afghanistan (2022–2023), Democratic Republic of Congo (2017), Madagascar (2018), Lao People’s Democratic Republic (2017), and Sudan (2014). Each dataset underwent a tailored cleaning process to ensure consistency, remove outliers, address missing or miscoded data, and align variables for comparative and multilevel analysis. While the surveys share core methodological features which include stratified sampling, and household-level weights, country-specific adjustments were necessary due to differences in variable structure, data quality, and survey execution. The subsections below detail the cleaning steps applied to each dataset, including cases removed, variable recoding, and weight application strategies. The final steps of the data cleaning can be seen in Table A1, Appendix A. This procedure was done following the steps outlined in the initial merger process as shown in Figure A12, Appendix A, 27 MICS Sample Merger Process (Women and Child Surveys) and Figure A13 BIRTHCERT Outcome Variable Codification. The steps can be seen in Appendix A, Table A1.

#### **4.3.1 MICS AFGHANISTAN 2022-2023**

Following the initial data cleaning with the completed merger and the binary coding of BIRTHCERT, further cleaning involved the following steps: (1) First, the observations with two missing observations for the variable ‘Currently married or in a union’ were removed. (2) Next, 35 observations were discarded because the ‘Number of Children’ exceeded 11, which were identified as outliers. (3) Lastly, for the variable ‘Mobile Phone ownership’, 20 observations were also removed due to their categorisation as missing or invalid. Within this MICS round, one child was randomly selected from each household for the Children’s survey.

#### **4.3.2 MICS DEMOCRATIC REPUBLIC OF CONGO 2017**

Like Afghanistan, the DRC data cleaning process involved several transformations to handle the categorical variables and the missing data. (1) For the ‘Wealth Index Quantile’, the fourth and fifth quantiles were merged into a single category to reduce granularity and improve model stability. (2) Additionally, any missing or 'Other' categories within (windex5) were combined into a new category, and the (3) 154 observations classified as 'Other' were reassigned as missing. Regarding the weighting schedule, the household weights were applied as one child was selected per household.

#### **4.3.3 MICS MADAGASCAR 2018**

The Madagascar MICS 2018 employs a multi-stage stratified cluster sampling approach, designed to ensure national representativeness. As a result, this methodology has allowed for the quintessential collection of data from multiple children within households to capture the estimates at the national and regional levels, as well as for urban and rural areas. The cleaning process focused on addressing missing data and categorisation issues, such as removing the (1) missing values in the ‘Married Currently’ field, which resulted in the deletion of 2 observations. (2) The variable ‘Wealth Index’ was combined into fewer categories to improve the interpretability and stability of the analysis. (3) In the final step, the ‘Number of Children’ was recategorised into a ‘4+’ group to consolidate the categories with low frequencies. To address the

nested data, weights were applied according to the independent levels of the child, followed by the children's determinants, and then the household weights for the household determinants.

#### **4.3.4 MICS LAO PEOPLE'S DEMOCRATIC REPUBLIC 2017**

The MICS Lao Social Indicator Survey II 2017 (LSIS II) integrated the methodologies of the MICS and Demographic and Health Survey (DHS). The sampling frame consisted of all villages within the country and was subsequently organised by the provinces' size estimates. In line with the MICS Madagascar, a stratified sampling approach was employed. The child weights were used for the child-level determinants, while the household weights were applied to the household structure variables.

The data-cleaning process was simple. (1) It primarily involved combining the fourth and fifth quantiles of the "Wealth Index." This transformation was done to avoid issues arising from the low frequencies. There were no specific issues with missing data for the Lao PDR, but the general cleaning steps involved ensuring that all variables were coded consistently.

#### **4.3.5 MICS SUDAN 2014**

The Sudan MICS 2014 covered all eighteen states at the national level between August and December 2014. The sampling frame was based on the Sudan Population Census 2008 and also used a multi-stage and stratified cluster sampling approach. The weights used in the regression followed the same methodology as Laos.

(1) The first cleaning step involved consolidating the 4th and 5th wealth quintiles, resulting in 1,764 changes, as both are represented in the 4+ quantile wealth category. (2) Additionally, the 'Number of Children' was adjusted, resulting in 36 changes and the combination of 5 or more children. (3) Fifteen missing observations for the mother's level of education were removed. Furthermore, 12 observations for mobile phone ownership were deleted.

#### 4.4 MULTICOLLINEARITY CHECK, VARIATION INFLATION FACTOR

After cleaning, a multicollinearity check was performed on all five samples using the Mean Variance Inflation Factor (VIF). First, a regression model was run with the ‘Birth Certificate’ binary as the dependent variable and the independent variables of ‘Age of Child’, ‘Sex of Child’, ‘Wealth Index Quantile’, ‘Delivery Assistance’, ‘Urban or Rural Classification’, ‘Educational Attainment of the Mother’, ‘Marriage Status of their Mother/Caretaker’, ‘Number of Children in the household’, and ‘Mobile Phone Ownership’. The results are presented as follows: Afghanistan (Appendix D, Table D2), Democratic People's Republic of the Congo (Appendix F, Table F2), Madagascar (Appendix G, Table G2), Lao PDR (Appendix H, Table H2), and Sudan (Appendix I, Table I2). The mean VIF’s of each country is shown in Figure 11.

**Figure 11: 5 UNICEF Country Case Studies Mean VIF**

| MICS Survey                           | Mean Variance Inflation Factor |
|---------------------------------------|--------------------------------|
| Afghanistan 2022-2023                 | 1.75                           |
| Democratic Republic of the Congo 2017 | 3.40                           |
| Madagascar 2018                       | 2.36                           |
| Lao People’s Democratic Republic 2017 | 1.61                           |
| Sudan 2014                            | 2.02                           |
| Source: Tierney McCue                 |                                |

Afterwards, the null models for each survey were created using the mixed-effects logistic regression (melogit), which incorporated the pweight variable to account for the survey design. Then, the Intraclass Correlation Coefficient (ICC) was calculated to assess the proportion of variance in the outcome that is attributable to clustering at both the cluster and household levels

which can be seen for Afghanistan (Appendix D, Table D4), Democratic People's Republic of the Congo (Appendix F, Table F4), Madagascar (Appendix G, Table G4), Lao PDR (Appendix H, Table H4), and Sudan (Appendix I, Table I4).

#### **4.5 INTRACCLASS CORRELATION COEFFICIENT (ICC) AS JUSTIFICATION FOR MULTILEVEL LOGISTIC REGRESSION MODELS**

The VIF of the model variables for the MICS Afghanistan 2022-2023 was 1.75, well below the  $>10$  threshold for multicollinearity. The analysis incorporated a large sample of 32,350 observations and clustered adjustments for 972 clusters at the cluster level, as well as 16,749 households (Appendix D, Table D3). The baseline null model yielded an intraclass correlation coefficient (ICC) of 0.41 at the cluster level and 0.76 at the household level, indicating significant variance in outcomes between the two groups (Appendix D, Table D5). As a result, the subsequent ME-Logit analyses were done by introducing individual/mother determinants and household structure and access determinants. Although the null model's primary strength lies in its ability to measure the variance components, the significance of the clustering effects at both the household and community levels underscores the need for further investigation by including explanatory variables in the subsequent models.

Like the analysis with Afghanistan, the analysis of the MICS Democratic People's Republic of the Congo (DPRC) 2017 MICS dataset also followed a four-model approach to examine the BC outcomes, starting with a baseline model and progressively introducing the individual, household, and structural factors with  $N=20,195$  observations across 709 clusters, and 11,966 households (Appendix F, Table F3). The VIF was 3.40. The results of Model 1, the null model, indicated that 45.3% of the variation is explained by differences between clusters ( $ICC = 0.4529$ ). In comparison, a substantial 86.7% of the variation occurs at the household level ( $ICC = 0.8675$ ) (Appendix F, Table F5). The high household-level variance ( $Var(cons) = 10.2167$ ) also suggested that significant unobserved heterogeneity exists. As a result, it showed the need for additional explanatory variables to address the heterogeneity. The absence of such key socioeconomic and demographic predictors, as used in Ebbers and Smits (2022) and Mohanty and Gebremedhin (2018), introduces the potential for omitted variable bias.

For MICS Madagascar 2018 the models had  $N = 12,025$  observations across 774 clusters and 8,546 households (Appendix G, Table G3). After adjusting for the VIF of 2.36, the null model for the MICS Madagascar survey resulted in an ICC, with 47.7% of the variation in BC explained at the community level. In contrast, 75.3% of the household variation is accounted for within clusters (Appendix G, Table G5). As a result, this suggests that there are also strong clustering effects, showing that BC counts are not randomly distributed but rather highly dependent on their prospective community characteristics. The log pseudolikelihood of -5541.4459 confirms a reasonable model fit, which also serves as a baseline for comparison within the more complex models.

The MICS Lao People's Democratic Republic 2017 had  $N = 10,843$  observations clustered within 1,157 imicsclusters and 8,149 households (Appendix H, Table H3). Following the calculation of the  $VIF = 1.61$ , the Null model estimated an ICC with 44.7% of the variation explained by differences between clusters ( $ICC = 0.4471$ ), while a substantial 80.6% of the variation occurred at the household level ( $ICC = 0.8059$ ) (Appendix H, Table H5). In line with all other case studies, the high household-level variance ( $Var(cons) = 6.08$ ) suggested significant unobserved heterogeneity, which continued to indicate that crucial household-level factors remain unaccounted for.

The MICS Sudan 2014  $N = 13,672$  observations clustered within 720 imicsclusters and 8,535 households (Appendix I, Table I3). The VIF for Sudan was 2.02, and the ICC showed that 45.1% of the variation was explained by differences between clusters ( $ICC = 0.4506$ ) (Appendix I, Table I5), while a significant 80.0% of the variation occurred at the household level ( $ICC = 0.8001$ ). The high household-level variance ( $Var(cons) = 5.7521$ ) suggested substantial unobserved heterogeneity. Therefore, this model justified a multilevel modelling approach.

Each ICC warranted the need for further modeling, while taking into account the household and cluster levels. Hence, as a result Model 2: Child and Maternal Characteristics Model within the Household, Model 3: Household Structure and Access Model, and Model 4: Household Structure and Access Model Interaction Terms are warranted to explain the unobserved heterogeneity.

#### **4.6 RESEARCH DESIGN AND SCOPE: SECTION TWO (UNICEF GLOBAL-27 MICS SURVEYS)**

In the second section of the analysis, the study looks at 27 MICS surveys from the five UNICEF regions. This is also done through the use of the ME-Logit regression framework. Within this analysis, the data have been merged and cleaned. Per the methodology outlined by Ebbers and Smits (2022), the household weights were initially de-normalised and subsequently re-normalised following the national population sizes to ensure the creation of a representative sample across the 27 countries. Then, they took into account the size of the total sample population of the combined surveys.

## 1. The Null Model

This baseline model includes only the intercept and the random effects at the country, cluster, and household levels. The **intra-class correlation (ICC)** will then assess the proportion of total variance attributable to differences between countries, clusters, and households and will determine the relevance of the multilevel modelling.

$$\log\left(\frac{P(Y_{ijk} = 1)}{1 - P(Y_{ijk} = 1)}\right) = \beta_0 + u_k + v_{jk} + w_{ijk} + \epsilon_{ijk}.$$

Where:

- $Y_{ijk}$  is the binary outcome variable (birth certificate possession).
- $i$  represents the child level,  $j$  represents the household level, and  $k$  represents the cluster level.
- $\beta_0$  is the intercept, representing the average log-odds of birth certificate possession across the sample.
- **Random Effects:**
  - $u_k \sim N(0, \sigma_u^2)$  is the country-level random intercept (variation across countries).
  - $v_{jk} \sim N(0, \sigma_v^2)$  is the cluster-level random intercept (variation across clusters: `imicscluster_nested`).
  - $w_{ijk} \sim N(0, \sigma_w^2)$  is the household-level random intercept (variation across households: `hhno`).
  - $\epsilon_{ijk}$  is the residual error term at the child level.
- **Weighting:**
  - In line with the MICS survey design, household weights were first de-normalized and then re-normalized based on the national population sizes of children under five, following the approach outlined by Ebbers and Smits (2022). These adjusted weights were then applied at the household level as probability weights (`[pw=weighthh]`), and cluster-robust standard errors were specified using `vce(cluster imicsclusternested)` to account for the complex sampling structure across countries.

The ICC formula for the total variance due to the country, clustering, and household:

$$ICC_{\text{total}} = \frac{\sigma_{\text{country}}^2 + \sigma_{\text{cluster}}^2 + \sigma_{\text{household}}^2}{\sigma_{\text{country}}^2 + \sigma_{\text{cluster}}^2 + \sigma_{\text{household}}^2 + \frac{\pi^2}{3}}$$

## 2. Determinants of Birth Certificate Ownership: Multilevel Logistic Regression Model (Household, Cluster, Country)

This model utilises the following variables. It accounts for household, cluster-level, and country random effects:

$$\log\left(\frac{P(Y_{ijk} = 1)}{1 - P(Y_{ijk} = 1)}\right) = \beta_0 + \beta_1 \text{Age}_{ijk} + \beta_2 \text{Sex}_{ijk} + \beta_3 \text{Wealth}_{ijk} \\ + \beta_4 \text{DeliveryAssistance}_{ijk} + \beta_5 \text{Urban}_{ijk} + \beta_6 \text{MotherEd}_{ijk} \\ + \beta_7 \text{CRVS}_{ijk} + \beta_8 \text{SPIIndex}_{ijk} + \beta_9 \text{CPIA}_{ijk} \\ + \beta_{10} \text{SPIDim3.1}_{ijk} + \beta_{11} \text{HealthExpenditure}_{ijk} \\ + u_k + v_{jk} + w_{ijk} + \epsilon_{ijk}.$$

**Where:**

- $Y_{ijk}$  is the binary outcome variable (birth certificate possession).
- $i$  represents the child level,  $j$  represents the household level, and  $k$  represents the cluster level.
- $\beta_0$  is the intercept.
- $\beta_1, \beta_2, \dots, \beta_{11}$  are the fixed-effect coefficients for predictors:
  - $\text{Age}_{ijk}$ : Child's age (categorical: `i.agech`)
  - $\text{Sex}_{ijk}$ : Child's sex (categorical: `i.sexch`)
  - $\text{Wealth}_{ijk}$ : Wealth index (categorical: `i.windex5`)
  - $\text{DeliveryAssistance}_{ijk}$ : Birth delivery assistance (categorical: `i.delivery.assistance`)
  - $\text{Urban}_{ijk}$ : Urban–rural factor (categorical: `i.urban.factor`)
  - $\text{MotherEd}_{ijk}$ : Mother's education level (categorical: `i.edlevelmom`)
  - $\text{CRVS}_{ijk}$ : Civil registration and vital statistics score (categorical: `i.crvs.cat`)
  - $\text{SPI}_{ijk}$ : Statistical Performance Indicator (scaled, categorical: `i.SPI.Quartile`)
  - $\text{CPIA}_{ijk}$ : CPIA gender equality rating (categorical: `i.CPIA.cat`)
  - $\text{SPI Dim 3.1}_{ijk}$ : SPI 3.1 Dimension (categorical: `spidim3index`)
  - $\text{HealthExpenditure}_{ijk}$ : Health expenditure per capita category (categorical: `i.healthexpcapita.cat`)
- **Random Effects:**
  - $u_k \sim N(0, \sigma_u^2)$  is the cluster-level random intercept (variation across clusters: `imicscluster`).
  - $v_{jk} \sim N(0, \sigma_v^2)$  is the household-level random intercept (variation across households: `hhno`).
  - $w_{ijk} \sim N(0, \sigma_w^2)$  is the country-level random intercept (variation across countries).
  - $\epsilon_{ijk}$  is the residual error term.
- **Weighting:**
  - In line with the MICS survey design, household weights were first de-normalized and then re-normalized based on the national population sizes of children under five, following the approach outlined by Ebberts and Smits (2022). These adjusted weights were then applied at the household level as probability weights (`[pw=weighthh]`), and cluster-robust standard errors were specified using `vce(cluster imicsclusternested)` to account for the complex sampling structure across countries.

## **4.7 SECTION TWO: KEY ANALYTICAL STEPS, DATA CLEANING PROCEDURES (UNICEF GLOBAL ANALYSIS)**

The final descriptive statistics for the following variables in the dataset are presented in Appendix B: Table B1 (Sample Frequencies and Percentages), Table B2 (MICS Sampling Design), Table B3 (Childbirth Certificate Ownership by Country), Table B4 (Urban Status by Wealth Index Quintile, with percentages), and Table B5 (Cross-Table Distribution of Mothers' Educational Attainment and Birth Certificate Outcomes).

Regarding the 'Urban/Rural' division, the observations from refugee camps were excluded from this variable, 1,157 cases. To reduce sparsity, the 'Mother/Caretaker's Level of Education' was recorded and reclassified into the following final categories: Low Education (less than primary and primary), Middle Education (lower secondary), and High Education (secondary and above). Due to the small sample size of the educational subcategories, specifically Koranic or Madrasa, and Vocational/Technical, 3,418 observations were excluded. The Primary and Lower secondary categories were then merged into one.

Due to the distribution of the Statistical Performance Indicators (SPI) Overall Score, it was re-categorised into first quartile, second quartile, third quartile, and fourth quartile. Therefore, the SPI is shown in distinct ordinal categories. The CPIA Gender Equality Rating was also re-categorised into the following three categories: (Group 1) Low (1-2); (Group 2) Medium (3-4); and (Group 3) High (5-6). Furthermore, the Dimension 3.1: Social Statistics was divided into four levels: (Group 1) Low ( $\leq 0.61$ ); (Group 2) Low-Medium ( $0.61 - \leq 0.70$ ), (Group 3) Medium-High ( $0.70 - \leq 0.73$ ), and (Group 4) High ( $> 0.73$ ).

Lastly, the Health Expenditure (per Capita) was categorised into five levels: (Group 1) Health expenditure ranging ( $<29.7$ ); (Group 2) Health expenditure ranging from (29.7-43.49); (Group 3) Health expenditure ranging from (43.5 to 54.8); (Group 4) Health expenditure ranging from (54.8-83.8); (Group 5) Health expenditure ( $>83.8$ ).

#### **4.7.1 MULTICOLLINEARITY CHECK, VARIATION INFLATION FACTOR, INTRACLASS CORRELATION COEFFICIENT (ICC)**

In the global analysis, the multicollinearity check was done using the VIF after the cleaning process concluded. Then, the VIF test was conducted to check for any potential multicollinearity among these explanatory variables. Following the VIF, the Null Model and the ME-Logit regression model were run, which incorporated (pweight=weight\_hh) to account for the survey design after re-normalisation according to the methods of Ebberts and Smits (2022). Then, the Intraclass Correlation Coefficient (ICC) was calculated to evaluate the proportion of variance in the outcome that is attributable to clustering at the country, cluster, and household levels.

## **CHAPTER 5: RESULTS AND SUMMARY OF KEY FINDINGS**

### **5.1 OVERVIEW OF FINDINGS**

This section summarises the key results from the five ME-Logit case studies within the UNICEF regions, as well as the ME-Logit analysis using the 27 MICS surveys conducted between 2013 and 2022. These findings highlight significant correlations between distinct sociodemographic factors at the individual, household, cluster, and national levels. The summary statistics for each country's surveys can be found in the appendix. Additionally, the frequency distributions and cross-tabulations, as well as the relevant tables and figures, are shown.

### **5.2 THE 5 UNICEF CASE STUDIES MULTILEVEL REGRESSION RESULTS**

#### **MICS Afghanistan 2022-2023 Results**

Of all the four models, according to AIC and reduced ICC values, Model 3: Household Structure and Access Model (Appendix D, Table D7) offers the best overall model fit. Although Model 4: Household Structure and Access Model with Interaction Terms (Appendix D, Table D8) includes additional interaction terms and has the highest Wald Chi<sup>2</sup>, its slightly higher AIC and BIC suggest marginal gains in terms of explanatory power at the cost of increased complexity.

To begin with, the introductory Model 2: Child and Maternal Characteristics Model within the Household (Appendix D, Table D6), the child's age was a significant predictor when adding the determinants of BC possession within the household. The child's sex is not a strong determinant (OR = 1.092,  $p = 0.083$ ), but the wealth of the household shows that children from the wealthiest households are 1.7 times more likely to have a birth certificate than those from the third quantile ( $p < 0.000$ ). In terms of delivery assistance at birth, children born with the help of traditional birth attendants (OR = 0.362,  $p < 0.001$ ) or relatives (OR = 0.386,  $p < 0.001$ ) have significantly lower odds of BC possession than those delivered by the reference value of the doctors. For rural residents, the likelihood of registration (OR = 0.531,  $p = 0.003$ ) was lower compared to their urban counterparts. At the same time, maternal education was a strong predictor; higher education levels increased the odds of birth certificate ownership (OR = 1.945,  $p < 0.001$ )

compared to less than primary education. Additionally, children from female-headed households had 1.52 times higher odds of possessing a BC ( $p = 0.014$ ) than children from male-headed households. In terms of male and female heads of household, it is worth noting that female-headed households were negligible compared to male-headed households in distribution.

Model 3: Household Structure and Access Model (Appendix D, Table D7) extended this analysis by incorporating additional components of household structure and access, including mobile phone ownership and the number of children, as factors. In this model, age continued to be a significant predictor, with older children exhibiting decreasing odds of registration in comparison to infants (<1 years old), while the household wealth continued to be a critical determinant; the children from the wealthiest households were nearly 2.8 times more likely to have a BC than those from the third quantile ( $OR = 2.796$ ,  $p < 0.001$ ). Rural residency remained a disadvantage ( $OR = 0.581$ ,  $p = 0.012$ ) compared to urban, and maternal education proved to be a strong predictor, with secondary or higher education being the most influential ( $OR = 1.918$ ,  $p < 0.001$ ). The larger households, with an increased number of children, showed lower registration odds. Mobile phone ownership was associated with higher odds ( $OR = 1.434$ ,  $p = 0.001$ ). To refine the model, interaction effects, such as maternal education  $\times$  wealth, are examined in Model 4 to assess whether education mitigates wealth disparities in registration. However, educational disparities highlighted ongoing challenges, particularly the intersection of wealth and maternal education levels.

### **MICS Democratic People's Republic of the Congo 2017 Results**

Like Afghanistan, Model 3: Household Structure and Access Model (Appendix F, Table F7) was the best fit, as it had the lowest AIC (14401.96), a high Wald  $\chi^2$  (668.20), and an improved log-likelihood compared to earlier models. Model 4 introduces complexity but only offers a minimal AIC improvement and a higher BIC.

The first analysis, Model 2: Child and Maternal Characteristics Model within the Household (Appendix F, Table F6) incorporated child and maternal characteristics, which were the same across all cases, thereby improving the model's explanatory power from the ICC. The results showed that males had 28.6% higher odds of the outcome compared to females in the cohort ( $OR$

= 1.2858,  $p = 0.010$ ). The disparities in wealth were starkly displayed, where the children from the fourth and fifth wealthiest quantile households had 3.55 times higher odds than those from the third quantile ( $OR = 3.5538$ ,  $p < 0.001$ ). Additionally, the assistance at birth also played a role. As shown, the children born without medical assistance faced dramatically lower odds of a favourable BC outcome ( $OR = 0.0167$ ,  $p < 0.001$ ). Maternal education also showed an increase in BC with secondary education or higher ( $OR = 2.5588$ ,  $p < 0.001$ ) compared to less than primary education. In contrast, primary and lower secondary education showed no significant impact. Children living in rural areas were 77.5% less likely to be registered at birth than those in urban areas, a statistically significant difference ( $p < 0.000$ ). They could be correlated with a lack of accessibility to registration services, awareness, and administrative barriers.

Model 3: Household Structure and Access Model (Appendix F, Table F7) expanded this analysis by incorporating household structure and access variables through the number of children residing in the household and mobile phone ownership. The wealth trends from Model 2 persisted, and rural households faced lower odds ( $OR = 0.2427$ ,  $p < 0.001$ ) than urban households, further highlighting urban-rural geographic disparities in this country. Mobile phone ownership was a positive factor, with households owning a mobile phone exhibiting 74.5% higher odds ( $OR = 1.7447$ ,  $p < 0.000$ ). The introduction of these predictors reduced the household-level variance, indicating that some of the unobserved heterogeneity was accounted for.

### **MICS Madagascar 2018 Results**

For Model 2: Child and Maternal Characteristics Model within the Household (Appendix G, Table G6), the explanatory power was assessed by the Wald  $\chi^2$  statistic, which yielded a value of 370.59 and a p-value of less than 0.001. Results showed that a child's age is a significant predictor of birth registration, with older children being more likely to be registered than infants ( $<1$ ); specifically, four-year-olds have 5.36 times higher odds of registration ( $p < 0.001$ ) compared to infants ( $<1$ ), which could indicate that there were potential delays in birth registration. The socioeconomic status of the household also played a crucial role, as the children from fourth fifth quintile households had approximately 2.46 times higher odds of being registered ( $p < 0.001$ ) than those in the third income quintile, which reinforced previous that financial resources enhanced access to registration services in the foundational scholarship of

Ebbers & Smits (2022). Maternal education emerged as a strong determinant, where mothers who have completed secondary education or higher are approximately 4.69 times more likely ( $p < 0.001$ ) to register their children than those with less than primary education, suggesting a possible positive correlation between education and increased awareness of the benefits of vaccination.

Additionally, delivery assistance showed a minor effect on BC. Births attended by traditional birth attendants ( $OR = 0.43$ ,  $p = 0.004$ ) had lower registration odds than births attended by a doctor or health worker, although the significance value was mixed. It was also demonstrated that geographical disparities played a role, with children born in rural areas being significantly less likely to be registered ( $OR = 0.36$ ,  $p < 0.001$ ) compared to those in urban areas. This reinforced existing theories that correlate limited access to registration offices with negative BC outcomes. Moreover, the results indicated that the sex of the child in this case was not a significant predictor ( $p = 0.967$ ), which raises questions about the role of gender for Madagascar in BC.

In Model 3: Household Structure and Access Model, (Appendix G, Table G7), age remained a strong predictor, as four-year-olds exhibited 5.88 times higher odds of registration ( $p < 0.001$ ) than infants, while wealth effects persisted, with children from the poorest households having the lowest registration odds ( $OR = 0.26$ ,  $p < 0.001$ ). There were persistent socioeconomic disparities in BC outcomes. The influence of delivery assistance and rural-urban residence remained consistent. It confirmed that traditional birth settings and rural environments present barriers, with rural residents being 36% less likely to register births. However, mobile phone ownership was associated with 42% higher odds of registering births ( $OR = 1.42$ ,  $p = 0.002$ ). The results suggest that digital connectivity enhances access to registration services. The model's fit further improved (Wald  $\chi^2 = 379.40$ ,  $p < 0.001$ ), indicating more substantial explanatory power, though some of the limitations of the previous models persisted. Model 3 is the best fit of all models because it has the lowest AIC (10,120.82), BIC (10,320.47), and Wald  $\chi^2$  (379.40), all with 28 degrees of freedom. Although some households in the Madagascar survey are recorded as having zero children present, the child-related data about children who live elsewhere were still collected from adult respondents. Marital status played a role; children of partnered mothers

living with partners had lower odds ( $OR = 0.50, p < 0.001$ ) than those who were married and not living with their partners. Model 4: Household Structure and Access Model, (Appendix G, Table G8) showed minimal changes with interaction terms present.

### **MICS Lao People's Democratic Republic 2017 Results**

In Model 2: Child and Maternal Characteristics Model within the Household (Appendix H, Table H6), the household-level covariates revealed that older children were significantly more likely to be registered, with two-year-olds having 78% higher odds of registration ( $OR = 1.78, p = 0.000$ ) than infants under one. The children from the poorest households had significantly lower odds, and those from the wealthiest households were 3.53 times more likely to be registered ( $OR = 3.53, p < 0.001$ ) than the third quantile. As shown in the data, maternal education played a crucial role: secondary or higher education increased the odds of registration ( $OR = 9.10, p < 0.001$ ) compared to those with an education level below primary. Birth assistance also mattered, with births attended by a traditional birth attendant ( $OR = 0.0495, p < 0.001$ ) or those receiving no assistance at all ( $OR = 0.1644, p < 0.001$ ) significantly decreasing the likelihood of registration compared to doctor-assisted births. Rural residence was significantly associated with reduced BC ownership, with rural children being 71.4% less likely to be registered ( $OR = 0.2859, p < 0.001$ ). The sex of the child ( $OR = 1.0685, p = 0.508$ ) and household head ( $OR = 1.0670, p = 0.730$ ) were not significant predictors. Potential multicollinearity between maternal education and the wealth index is explored further in Model 4 to address bias.

In terms of similarities, Model 3: Household Structure and Access Model, (Appendix H, Table H7) aligns with Model 2 in its findings on wealth, education, and rural disparities. However, it reveals that children from households with seven or more children are 76% less likely to be registered ( $OR = 0.2439, p < 0.001$ ). Mobile phone ownership did not significantly affect registration ( $OR = 1.0146, p = 0.932$ ), while the high household-level variance ( $Var(cons) = 5.65$ ) indicated the presence of unobserved household dynamics. The model did not fully explain why larger households registered fewer children, which warrants further investigation.

In Model 4: Household Structure and Access Model with Interaction Terms, (Appendix H, Table H8), two-year-olds had higher registration odds ( $OR = 1.76, p < 0.000$ ) than those below one

year old. However, gender did not appear as a significant factor (OR = 1.064,  $p = 0.483$ ). Household wealth was a strong determinant, as children from the poorest households had significantly lower odds (OR = 0.247,  $p < 0.000$ ) compared to those from the third quantile. Children in the wealthiest groups showed no significant difference. Additionally, the delivery assistance also mattered; children born with the help of traditional birth attendants (OR = 0.049,  $p < 0.000$ ) or relatives (OR = 0.106,  $p < 0.000$ ) were significantly less likely to have a BC compared to those delivered by medical professionals, such as doctors. Furthermore, being a rural resident significantly reduced the likelihood of registration (OR = 0.289,  $p < 0.001$ ).

For the educational component, maternal education was another changing factor. In comparison, mothers with secondary or higher education had a higher likelihood of having a self-reported BC than mothers with less than primary education (OR = 5.0,  $p < 0.001$ ). The marital status of the mother also influenced registration, as the children of mothers living with a partner or in a union had significantly lower odds (OR = 0.174,  $p < 0.001$ ) compared to those with married mothers living outside of their partnership or union. In contrast, those of unmarried mothers showed no significant difference (OR = 1.007,  $p = 0.984$ ). The gender of the household head did not affect BC significantly (OR = 1.051,  $p = 0.803$ ). The interaction effects suggested that maternal education amplifies the impact of wealth, although none of these interactions were statistically significant. Similarly, children of partnered female-headed households had higher odds of BC (OR = 3.799,  $p = 0.161$ ), but this effect was not conclusive. The results overall showed that BC ownership was significantly associated with the child's age, the mother's level of maternal education, wealth, rural residence, delivery assistance, marital status, and family size. The interactions also suggest potential compounding effects that warrant further investigation. Model 4 was the best fit because it had the lowest AIC (24,965.62), BIC (25,204.84), and the highest Wald  $\chi^2$  (167.89), with 39 degrees of freedom.

### **MICS Sudan 2014 Regression Results**

The Model 3: Household Structure and Access Model's (Appendix I, Table I7) is the best fit for the Sudan 2014 data because it has the lowest AIC (12,046.43) and BIC (12,242.03) values

compared to the others. It also maintains a strong Wald  $\chi^2$  (343.97) with fewer degrees of freedom than Model 4.

Model 2: Child and Maternal Characteristics Model within the Household (Appendix I, Table I6) found that older children have significantly higher odds of being registered; three-year-olds have 16.25 times the odds of newborns ( $OR = 16.25, p < 0.001$ ). Household wealth showed to be a strong predictor as children from the poorest households were significantly less likely to be registered ( $OR = 0.12, p < 0.001$ ) and those from the wealthiest households were 9.05 times more likely to be registered ( $OR = 9.05, p < 0.001$ ) with the third quantile as reference. In line with previous countries, maternal education played a significant role; primary education increased the odds of registration by 2.58 times ( $OR = 2.58, p < 0.001$ ), and secondary or higher education further enhanced the likelihood ( $OR = 8.91, p < 0.001$ ) compared to below primary education. Likewise, the delivery assistance affected registration rates. Children born with a traditional birth attendant ( $OR = 0.25, p < 0.001$ ) or without assistance ( $OR = 0.54, p = 0.369$ , not significant) faced lower odds of BC compared to a doctor-assisted birth. Rural children were 79.2% less likely to be registered ( $OR = 0.2084, p < 0.001$ ), while male children had slightly higher odds of registration ( $OR = 1.36, p = 0.002$ ), though the effect size is small. The female-headed households showed lower registration rates, though not significantly ( $p = 0.322$ ).

The Model 3: Household Structure and Access Model's (Appendix I, Table I7) results align with those of Model 2 in terms of age, wealth, education, and rural residence. The delivery assistance effects continued to persist and reinforced the role of healthcare access in registration, while model fit slightly improved, with a lower log-pseudolikelihood of -5118.43 compared to Model 2, which had a log-pseudolikelihood of -6014.70. However, the ownership of a mobile phone did not significantly impact BC ( $OR = 1.0146, p = 0.932$ ), nor did the number of children. At the same time, the high household-level variance ( $Var(cons) = 5.65$ ) suggested that unobserved household and community factors continued to influence BC.

In Model 4: Household Structure and Access Model with Interaction Terms, (Appendix I, Table I8), the child's age strongly influenced registration, with older children having substantially higher odds (e.g., age 1:  $OR = 3.14, p < 0.001$ ; age 2:  $OR = 8.71, p < 0.001$ ; age 3:  $OR = 16.57$ ,

$p < 0.001$ ). Males also had slightly higher odds than females ( $OR = 1.37, p = 0.001$ ), and wealth remained a significant factor, with the poorest households having significantly lower odds ( $OR = 0.14, p < 0.001$ ). Households in the fourth quintile of wealth had significantly higher odds ( $OR = 8.98, p < 0.001$ ) than those in the third quintile. Birth assistance mattered with children born with traditional birth attendants ( $OR = 0.26, p < 0.001$ ) or other non-medical assistance ( $OR = 0.46, p = 0.039$ ) who were less likely to have BCs than those with doctor-assisted births. Rural residence lowered the odds ( $OR = 0.21, p < 0.001$ ) compared to urban and, for maternal education, primary education increased the odds ( $OR = 2.14, p = 0.002$ ), and secondary/higher education had an effect which showed significance ( $OR = 7.11, p < 0.001$ ). Children of unmarried mothers had lower odds of being born to a mother who was unmarried ( $OR = 0.43, p = 0.032$ ), although this difference was not statistically significant. Additionally, the gender of the household head was not a significant factor ( $OR = 0.85, p = 0.427$ ). The number of children was insignificant, while mobile phone ownership was positively associated with BC ( $OR = 1.99, p < 0.001$ ). The interaction effects, although statistically significant, were not significant in the poorest households with secondary/higher education ( $OR = 0.60, p = 0.403$ ) or second-quintile households with secondary/higher education ( $OR = 1.61, p = 0.322$ ). The interaction between marital status and household head gender was also non-significant ( $OR = 1.23, p = 0.731$ ). The random effects also indicated that variation existed at the imicscluster (variance = 2.33) and household levels (variance = 8.57).

### **5.3 SUMMARY OF ANALYSIS ONE: KEY RESULTS**

**H1 (Household hypothesis): Controlling for household and cluster-level determinants, children (aged 0–5) with higher levels of maternal education, increases in household economic stability, urban residence, and household access to healthcare and information will be positively associated with increased likelihood of birth certification ownership, while household experiences of discrimination and poor environmental or housing conditions will be negatively associated with certification ownership.**

Based on the ME-Logit analyses of Models 1-4, the findings support the primary hypothesis (H1). After controlling for household-level determinants, the Chen (2020) socio determinants did

show to be statistically significant. In terms of urban-rural residency, children aged 0–5 living in rural areas are significantly less likely to own a birth certificate than their urban counterparts. It should be noted that the negative correlation between rural residency and BC ownership is consistently observed across all of the examined MICS surveys within the five UNICEF regions (Afghanistan 2022-2023, Democratic Republic of the Congo 2017, Lao PDR 2017, Madagascar 2018, and Sudan 2014).

In all five countries, the role of the mother's educational attainment level and the child's BC outcome (0-5) were positively correlated, with some nuances. Among mothers surveyed in Afghanistan, 15,581 had less than primary education, while only 813 mothers had attained secondary education or higher. This stark educational disparity implies that while higher education substantially increases the likelihood of legal identity acquisition for children, the population-level impact remains limited due to the relatively small proportion of these women with higher educational attainment.

In Madagascar, both primary and secondary education, as well as higher education, increased the outcome of reported BC ownership. Similarly, in Lao PDR, the association proved to be especially strong, with mothers at the secondary education or higher level being nearly nine times more likely to have their child's birth certified compared to those with less than primary education (OR = 8.91).

By contrast, the Democratic Republic of the Congo (DRC) remains an outlier, with maternal education exerting negligible effects at lower levels. It became significant only at the secondary education or higher level; this could ultimately point to more systemic barriers that blunt the effect of educational attainment on legal identity behaviours within these lower levels.

The effect of maternal education in Sudan is also statistically significant and substantively meaningful, though the magnitude falls between that observed in Madagascar and Afghanistan. Specifically, mothers with secondary education or higher exhibit a markedly increased likelihood of registering their child's birth, with the odds ratio indicating a seven-fold increase (OR =7.1) This suggests that in Sudan, as in other contexts, maternal education enhances awareness,

prioritisation, and navigation of civil registration systems, even amid the country's broader challenges with governance and service delivery.

#### **5.4 LIMITATIONS AND OVERALL MODEL IMPROVEMENTS (5 UNICEF CASE STUDIES)**

One of the key limitations of this study is the increased potential for model overfitting due to the complexity of the dataset and the number of parameters involved in the analysis. Although efforts were made to optimise the models, concerns remain regarding the generalizability of the results, especially when applying them to real-world scenarios involving self-reported birth certificate ownership from the mother or guardian.

Another limitation lies in the dataset itself. Biases that could be present in the data may have influenced the model's predictions, leading to suboptimal or skewed results. Although measures were done to clean the data, imbalanced classes or underrepresented subgroups within the dataset could alter the results. In terms of future analysis, a potential route to improve the models' optimisation could be to use integrated explainable AI to explore the interactions between the independent factors and the binary outcome variable. Also, exploring alternative architectures, such as machine learning, alongside advanced optimisation and domain-specific feature selection, could help improve accuracy and interpretability.

#### **5.5 SECTION TWO: GLOBAL MULTILEVEL REGRESSION RESULTS**

Within this mixed-effects logistic regression model,  $N = 320,769$  observations were incorporated, which included a hierarchical data structure with random intercepts at three levels: (1) household, (2) cluster, and (3) country levels. The Null model justified the need for an ME-Logit due to the substantial variance in the outcome across countries, clusters and households. The intraclass correlation coefficients also indicated that 31.7% of the variance is attributed to the country level, 30.4% to the cluster level, and 37.9% to the household level. This clustering provides additional support for the validity of a three-level hierarchical model. The significant intercept indicated that the mean odds of the outcome are considerably different from zero across the population. The large variances that occurred at each level, particularly at the household level

(var = 7.06), suggested that considerable within-group correlations existed, which justified the use of a mixed-effects framework, like Ebbers & Smits' (2022) analysis.

The fixed effects do show several statistically significant associations. For example, the child's age is positively associated with the outcome of self-reported BC ownership; each age category showed increasing coefficients, and the confidence intervals did not include zero, which indicates precision in these estimates. The male children had slightly higher odds than females (coef = 0.049, 95% CI: [0.030, 0.068]). In terms of household wealth, there was a gradient: the children in the poorest households had significantly lower odds (coef = -0.62, 95% CI: [-0.833, -0.407]) while those in the richest households showed higher odds (coef = 0.57, 95% CI: [0.313, 0.824]). For maternal education, the secondary level or higher was also associated with higher odds of the outcome (coef = 0.39, 95% CI: [0.146, 0.627]). However, primary education did not reach conventional levels of statistical significance, which warrants further investigation.

## **5.6 SUMMARY OF SECTION TWO: KEY RESULTS**

**H2 (Country-Level Hypothesis): Country-level structural factors, namely public health expenditure, governance quality, and urban–rural population distribution, are significant independent and interactive predictors of birth certificate ownership among children under five across 27 low- and middle-income countries between 2013 and 2023, as assessed within a multilevel logistic regression framework informed by Ebbers and Smits (2022) and Mohanty and Gebremedhin (2018).**

The ME-Logit results do support the hypothesis that children residing in households within the highest wealth quintiles are significantly more likely to possess a BC than those in lower quintiles globally. Although, another juxtaposition of the data reveals that children from the richest and fourth quintiles exhibit considerably higher odds of registration compared to those from the middle (third) quintile. This could be due to the contextual significance of the wealth difference between the two, or more likely, due to the sparsity of people in the fourth quintile. Conversely, children from the poorest and second quintiles demonstrate a significantly lower likelihood of registration.

However, the data presents several limitations: the average of only 1.6 children per household may weaken household-level variance estimates, and some macro-level coefficients (e.g., CRVS, SPI indices) appear implausibly large, which suggests that there is still potential multicollinearity or instability due to sparse or uneven group sizes. It is also possible that important cultural or bureaucratic factors that influence registration beyond wealth are omitted. While the fundamental relationship remains valid, these limitations necessitate a cautious interpretation and underscore the need for additional robustness checks in future models at the global level.

While the findings also do provide support that children born outside formal health systems, particularly those delivered by traditional birth attendants, relatives, or without any skilled assistance, are considerably less likely to possess a BC, several methodological concerns still mitigate the strength of this conclusion. Firstly, by treating delivery assistance as a categorical exposure without accounting for possible clustering by facility or region, it shows that there may be obscure and underlying systemic differences in the contextual healthcare infrastructure or administrative linkages to CRVS. Additionally, the model failed to work due to the omission of interaction terms with contextual variables, such as rurality, maternal education, and wealth. It has the potential to obscure heterogeneity in the impact of institutional delivery on registration.

Furthermore, the utilisation of self-reported data for delivery assistance may give rise to recall or social desirability bias, particularly in contexts where traditional births are stigmatised or underreported. The broad confidence intervals and non-significance of specific categories (e.g., "No one assisted" and "Nurse/Midwife") does raise concerns for the integrity of the data, specifically there could be the potential for small subgroup sizes or inconsistent classification methods even after the cleaning of the data, which could compromise the precision of the estimates. In conclusion, the model does not account for potential pathway variables, such as postnatal care contact or facility follow-up, which could mediate the relationship between delivery context and registration. This limitation of the model restricts causal interpretation.

## **5.7 LIMITATIONS AND OVERALL MODEL IMPROVEMENTS (GLOBAL)**

Several other contextual and structural variables also showed strong associations, although their interpretation should also be approached with caution. Countries with no CRVS systems were

associated with substantially lower odds (coef = -3.59, 95% CI: [-4.990, -2.190]), but this large effect size, while statistically significant, may be influenced by unobserved national-level factors. The analysis in Stata did not allow the model to run when either countries or UNICEF regions were used as independent variables. Some predictors, such as categories within the SPI Dimension 3 Index, also showed large coefficients but wide confidence intervals, as in the "Low-Medium" group (coef = -3.71, 95% CI: [-7.636, 0.209]), which suggests uncertainty in the estimate. Similarly, the health expenditure categories generally showed negative associations with the outcome; however, the range and directionality of the coefficients warrant closer investigation into possible reverse causality or confounding. The variables, such as CPIA scores and certain delivery assistance categories, were not statistically significant and had confidence intervals that included zero, indicating limited evidence of association in this model. Overall, while the multilevel model is appropriate and includes theoretically relevant variables, some estimates, particularly those with wide confidence intervals or unexpectedly large magnitudes, do warrant further validation through further sensitivity analysis or alternative model specifications outside of this analysis.

## CHAPTER 6: CONCLUSION

### 6.1 SUMMARY OF KEY FINDINGS

The main findings of this thesis conclude as follows, the socio determinants of health by Mosely and Chen (2003) can be used to fundamentally understand the barriers that hinder successful birth certificate ownership at the household level as shown to be statistically significant by the models of this analysis. These socio-determinants include: the child's age, household wealth, maternal education, birth assistance, rural-urban residency, and mobile phone ownership. Overall, across all five countries an increase in household wealth, higher levels of maternal educational attainment, having trained health assistants in birth, and urban residency along with phone ownership showed elevated levels of self-reported birth certificate ownership for children under five within the MICS surveys used. Lack of registration at the household level could lead to discrepancies within the wider Central Vital Registration Statistics. As birth certificates serve two critical functions (1) establishing legal identity, and (2) generating vital demographic data (UNICEF, 2013), it is important to rectify and target these barriers through local intervention at the cluster level.

On the country level, informed by Ebbers and Smits et.al (2022), and Mohanty and Gebremedhin (2018), the second section of analysis across 27 LMICS countries between 2013-2023 highlighted the relevancy of the socio-determinants at the household level, cluster level, and the country level. This statistically significant model showed that the age of the child, sex of the child, delivery assistance at birth, urban/rural residency, educational attainment level of the mother, CRVS score, gender, availability of statistical data, and health expenditure do matter when looking at the outcome of birth certificate ownership. As a result, such interventions, as mentioned by Mikkelsen et. al (2023) at the country level would be to improve upon the physical and socio-economic barriers that limit access to registration offices, despite widespread awareness of their importance as well as to enhance understanding about the purpose and long-term benefits of registration.

## **6.2 CONCLUDING REMARKS**

In comparison, the analysis of individual countries and the global analysis, the country levels appear to yield far more robust and interpretable results compared to the global pooled model. Yet, in both cases of modelling the coefficients at the household or child level generally show similar outcomes in terms of positive or negative correlations of birth certificate outcomes, thereby reinforcing their importance in the scholarship of birth registration.

## **6.3 TOWARD UNIVERSAL BIRTH REGISTRATION: CONFRONTING STRUCTURAL BARRIERS THROUGH DATA**

At the heart of demography is data. Not only is it critical to invest in robust population data systems, but it is also important to understand existing gaps through past censuses, household surveys, and administrative records. With this data, trends in fertility, mortality, migration, and education can be identified and analysed. In particular, civil registration and vital statistics (CRVS) systems with birth registration at their core are foundational for producing continuous, individual-level data. Birth registration establishes the foundation for a legal identity, facilitates documentation to access essential health and social services, and ensures the inclusion of individuals in national and global statistics. Without it and other complete vital statistics, entire segments of the population may remain unaccounted for in development planning. Although advancements in GIS mapping and alternative methods for counting vulnerable populations offer a way forward, a retrospective analysis allows for a more nuanced understanding of the existing data.

In response, the utilisation of household surveys, such as the DHS and MICS, can provide numerous insights into the problematic deficiencies created by data deserts. In the context of birth registration data, it is evident that critical gaps remain for both children under five and beyond, as shown by the data compiled by UNICEF. To reiterate, as of December 2024, over 150 million children under the age of five worldwide remain unregistered.

While the foundational research into the social determinants of birth registration, such as the work of Ebbers and Smits (2022) and Mohanty and Gebremedhin (2018), underscores the urgency of strengthening birth registration mechanisms, significant gaps remain in understanding the intersectional and context-specific barriers that hinder universal registration.

Hence, this study builds on foundational research to address critical knowledge gaps by investigating both household- and system-level factors influencing birth certificate ownership within the confines of the UNICEF regions from a global overview to more nuanced country specific analysis using the MICS Afghanistan 2022-2023, Democratic Republic of the Congo 2017, Lao People's Democratic Republic 2017, Madagascar 2018, and Sudan 2013-2014 surveys. By grounding the study in the frameworks of Ebbers and Smits (2022) and Mohanty and Gebremedhin (2018), it engages directly with the scholarship. It emphasises the structural and social determinants of birth certificate ownership within these countries. Previous analyses have not systematically examined birth registration outcomes for the aforementioned surveys; therefore, this study undertakes a critical assessment of these outcomes. In response to calls for more intersectional and context-sensitive approaches, these two objectives were used to provide a comprehensive analysis of how rural residence and national CRVS systems affect BC coverage. Ultimately, this study aimed to identify and address structural inequalities to strengthen registration systems and promote equitable access to legal identity.

#### **6.4 LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH**

While this thesis offers insights into the structural and social determinants of BC ownership, it is essential to acknowledge several key limitations. Firstly, the utilisation of cross-sectional data from the MICS limits the capacity to derive causal inferences. Furthermore, the uncertain continuity of complementary datasets, such as the MICS, limits longitudinal analysis across contexts. It is recommended that future research prioritise the development of strategies that enhance causal inference. Such strategies should include the integration of survey data with retrospective policy evaluations or administrative records.

Furthermore, some of the challenges that arose pertain to data completeness, potential recall bias in household survey responses, and unmeasured cultural or political factors influencing BC

coverage, which warrant further exploration. This study lacks indicators related to religion, ethnicity, national legislature involvement in BR processes, and variables regarding the father's or additional caregivers' levels of education. Also, further insights into the quality of care during the prenatal and postnatal periods, as well as the quality of the registration systems within cluster-level areas, are very relevant to the outcome. The incorporation of more granular sub-national analyses could elucidate geographic disparities, while the integration of qualitative data would provide deeper insights into contextual barriers to registration. Due to the constraints of STATA itself, the global analysis took several days to run the full model, creating an issue with running the model. Further development of the model and the use of UNICEF regions as determinants could provide better insights into regional trends and offer more reliable and robust contextualisation.

Ultimately, subsequent research endeavours should consider demographic metabolism frameworks, such as those proposed by Lutz (2014), to monitor generational shifts in education and identity documentation across the life course of the guardians, if the data are available. Additionally, the MICS survey provides indicators for the states or provinces of the countries in which the clusters are based. Through the use of individual countries' surveys, additional analysis can display the BC outcomes within those defined regions of the countries.

## **6.5 CONTRIBUTIONS TO SCHOLARSHIP**

This study aimed to contribute to the broader discourse on CRVS systems by highlighting the multifaceted barriers to universal birth registration. The empirical findings emphasise the necessity for multi-faceted policy strategies that address both household- and system-level determinants of BC ownership. In particular, strengthening institutional CRVS frameworks, expanding access in rural and underserved areas, and mitigating socioeconomic disparities are critical to improving BR rates on a global scale.

The implementation of targeted policy interventions, including the enhancement of maternal education, the promotion of maternal empowerment, the reduction of financial impediments, and the introduction of digital registration platforms, could provide a potential strategy to promote

equitable access to legal identity. These interventions, when considered in conjunction with initiatives aimed at enhancing public awareness and reducing logistical barriers, have the potential to significantly improve BR outcomes. Reliable birth registration is foundational for legal identity and social protection, as well as for inclusive governance and the realisation of human rights.

## BIBLIOGRAPHY

1. Abay, S. T., & Gebre-egziabher, A. G. (2020). Status and associated factors of birth registration in selected districts of Tigray region, Ethiopia. *BMC International Health and Human Rights*, 20, 20. <https://doi.org/10.1186/s12914-020-00235-x>
2. Aboagye, R. G., Okyere, J., Seidu, A. A., Ahinkorah, B. O., Budu, E., & Yaya, S. (2023). Determinants of birth registration in sub-Saharan Africa: Evidence from demographic and health surveys. *Frontiers in Public Health*, 11, 1193816.
3. AbouZahr, C., de Savigny, D., Mikkelsen, L., Setel, P. W., Lozano, R., Nichols, E., Notzon, F., & Lopez, A. D. (2015). Civil registration and vital statistics: Progress in the data revolution for counting and accountability. *Lancet (London, England)*, 386(10001), 1373–1385. [https://doi.org/10.1016/S0140-6736\(15\)60173-8](https://doi.org/10.1016/S0140-6736(15)60173-8)
4. Adair, T., & Lopez, A. D. (2021). Generating age-specific mortality statistics from incomplete death registration data: Two applications of the empirical completeness method. *Population Health Metrics*, 19(1), 29.
5. Adi, A. E., Abdu, T., Khan, A. N., Rashid, M. H., Ebri, U. E., Cockcroft, A., ... & Andersson, N. (2015). Understanding whose births get registered: A cross-sectional study in Bauchi and Cross River states, Nigeria. *BMC Research Notes*, 8(1). <https://doi.org/10.1186/s13104-015-1026-y>
6. Afghanistan Protection Cluster. (2024, May). *Legal identity and civil documentation in Afghanistan*. UNHCR/Oxygen Empire Media.
7. Alemu, H. N., Wubneh, S. B., Yute, A. H., Tekletsadik, K. F., Ofgea, B. M., & Kassie, B. A. (2023). Birth notification and registration: A survey on knowledge and attitude among postpartum women in Northwest Ethiopia. *Risk Management and Healthcare Policy*, 16, 2097–2107. <https://doi.org/10.2147/RMHP.S427926>
8. Altijani, N., Khogali, M., Hinton, L., Opondo, C., Eljack, E., Knight, M., & Nair, M. (2023). Trends in birth attendants in Sudan using three consecutive household surveys (from 2006 to 2014). *Frontiers in Global Women's Health*, 4, 1012676.
9. Amo-Adjei, J., & Annim, S. K. (2015). Socioeconomic determinants of birth registration in Ghana. *BMC International Health and Human Rights*, 15, 14. <https://doi.org/10.1186/s12914-015-0053-z>
10. Anaduaka, U. S. (2022). Multilevel analysis of individual- and community-level determinants of birth certification of children under-5 years in Nigeria: Evidence from a household survey. *BMC Public Health*, 22, 2340. <https://doi.org/10.1186/s12889-022-14786-2>
11. Asian Development Bank. (2022). *Poverty in Viet Nam*. Asian Development Bank. <https://www.adb.org/where-we-work/viet-nam/poverty>
12. Baba, A., Martineau, T., Theobald, S., Ssali, S., & Vong, S. (2020). Using data to support evidence-informed decisions about skilled birth attendants in fragile contexts: A situational analysis from Democratic Republic of the Congo. *Human Resources for Health*, 18(1), 82. <https://doi.org/10.1186/s12960-020-00511-w>
13. Beiter, K. D. (2005). *The protection of the right to education by international law: Including a systematic analysis of Article 13 of the International Covenant on Economic, Social and Cultural Rights* (Vol. 82). Brill.
14. Bhatia, A., Kim, R., & Subramanian, S. V. (2021). Birth registration in India: Are wealth inequities decreasing? *SSM - Population Health*, 13, 100728. <https://doi.org/10.1016/j.ssmph.2021.100728>
15. Bhatia, A., Krieger, N., Beckfield, J., Barros, A. J. D., & Victoria, C. (2019). Are inequities decreasing? Birth registration for children under five in low-income and middle-income countries, 1999–2016. *BMJ Global Health*, 4(e001926). <https://doi.org/10.1136/bmjgh-2019-001926>

16. Bolgrien, A., Boyle, E. H., Sobek, M., & King, M. (2024). *IPUMS MICS data harmonisation code* (Version 1.2) [Stata syntax]. IPUMS. <https://doi.org/10.18128/D082.V1.2>
17. Births and Deaths Registry, Ghana. (n.d.). Birth registration. <https://bdr.gov.gh>
18. Brown, E. (1938). Value of the vital statistics data on birth and death certificates in county health work. *American Journal of Public Health*, 28, 1398–1402.
19. Brumberg, H. L., Dozor, D., & Golombek, S. G. (2012). History of the birth certificate: From inception to the future of electronic data. *Journal of Perinatology*, 32(6), 407–411.
20. Brzoska, M., & Fröhlich, C. (2016). Climate change, migration and violent conflict: Vulnerabilities, pathways and adaptation strategies. *Migration and Development*, 5(2), 190–210.
21. Burbank, J., & Cooper, F. (2011). *Empires in world history: Power and the politics of difference*. Princeton University Press.
22. Candia, D. A. (2019). Determinants of birth registration of children under 5 years in Uganda. *International Journal of Advanced Medical and Health Research*, 6(1), 12–17. [https://doi.org/10.4103/IJAMR.IJAMR\\_55\\_18](https://doi.org/10.4103/IJAMR.IJAMR_55_18)
23. Cantor, M. N., & Thorpe, L. (2018). Integrating data on social determinants of health into electronic health records. *Health Affairs*, 37(4), 585–590.
24. Castle, S., Ortiz, E., & Setel, P. (2020). Demand-side factors related to the registration of births, marriages, and deaths: A literature review. *CRVS Working Paper Series, Issue 2*.
25. Central Bureau of Statistics (CBS) & UNICEF Sudan. (2016). *Sudan Multiple Indicator Cluster Survey 2014: Final Report*. Khartoum, Sudan: CBS and UNICEF Sudan
26. Central Statistical Office, Government of the Kingdom of Eswatini. (2023). *Annual vital statistics report: January 2022 – December 2022*. Government of the Kingdom of Eswatini.
27. Chen, W. (2016, October 3). *Evaluation of the completeness of birth registration in China using analytical methods and multiple sources of data* [Paper presentation]. United Nations Expert Group Meeting on Methodology and Lessons Learned to Evaluate the Completeness and Quality of Vital Statistics Data from Civil Registration, New York, NY, United States.
28. Clarke-Deelder, E., Afriyie, D. O., Nseluke, M., Masiye, F., & Fink, G. (2022). Health care seeking in modern urban LMIC settings: Evidence from Lusaka, Zambia. *BMC Public Health*, 22(1), 1205.
29. CM Advocates. (2023). *Gazette Vol. 241 (Revocation) Special Issue (November 14, 2023)*. [https://cmadvocates.com/storage/blog/Gazette%20Vol%20241%2014-11-23%20Special%20\(Revocation\)\\_231114\\_203743%20\(1\).pdf](https://cmadvocates.com/storage/blog/Gazette%20Vol%20241%2014-11-23%20Special%20(Revocation)_231114_203743%20(1).pdf)
30. Cobos Muñoz, D., Abouzahr, C., & de Savigny, D. (2018). The ‘Ten CRVS Milestones’ framework for understanding Civil Registration and Vital Statistics systems. *BMJ Global Health*, 3(e000673). <https://gh.bmj.com/content/3/2/e000673>
31. Cohn, B. S. (1996). *Colonialism and its forms of knowledge: The British in India*. Princeton University Press. <https://doi.org/10.2307/j.ctv1h9dgs1>
32. Comandini, O., Cabras, S., & Marini, E. (2016). Birth registration and child undernutrition in sub-Saharan Africa. *Public Health Nutrition*, 19(10), 1757–1767.
33. Conklin, A. L. (1998). Colonialism and human rights: A contradiction in terms? The case of France and West Africa, 1895–1914. *The American Historical Review*, 103(2), 419–442. <https://doi.org/10.2307/2649774>
34. Corbacho, A., Brito, S., & Osorio Rivas, R. (2012). Birth registration and the impact on educational attainment (No. IDB-WP-345). IDB Working Paper Series.
35. Dake, F., & Fuseini, K. (2018). Registered or unregistered? Levels and differentials in registration and certification of births in Ghana. *BMC International Health and Human Rights*, 18, 10. <https://doi.org/10.1186/s12914-018-0163-5>

36. Do, N., Tran, H. T. G., Phonvisay, A., & Oh, J. (2018). Trends of socioeconomic inequality in using maternal health care services in Lao People's Democratic Republic from year 2000 to 2012. *BMC Public Health*, 18, 1–8.
37. Donzelot, J. (1980). *A policia das famílias* (Vol. 9). Graal.
38. Dünser, M. W., Baelani, I., & Ganbold, L. (2006). A review and analysis of intensive care medicine in the least developed countries. *Critical Care Medicine*, 34(4), 1234–1242.
39. Durand, J. D. (1974). *Historical estimates of world population: An evaluation*. University of Pennsylvania.
40. Ebberts, A. L., & Smits, J. (2022). Household and context-level determinants of birth registration in Sub-Saharan Africa. *PloS One*, 17(4), e0265882. <https://doi.org/10.1371/journal.pone.0265882>
41. Ensor, T., & Cooper, S. (2004). Overcoming barriers to health service access: Influencing the demand side. *Health Policy and Planning*, 19(2), 69–79.
42. Euro-Peristat Research Network. (2021). Population birth data and pandemic readiness in Europe. *BJOG: An International Journal of Obstetrics and Gynaecology*, 129(2), 179–184. Advance online publication. <https://doi.org/10.1111/1471-0528.16946>
43. Fagernäs, S., & Odame, J. (2013). Birth registration and access to health care: An assessment of Ghana's campaign success. *Bulletin of the World Health Organization*, 91(6), 459–464. <https://doi.org/10.2471/BLT.12.111351>
44. Filmer, D., & Pritchett, L. H. (2001). Estimating wealth effects without expenditure data--or tears: An application to educational enrollments in states of India. *Demography*, 38(1), 115–132. <https://doi.org/10.1353/dem.2001.0003>
45. Gadabu, O. J., Ben-Smith, A., Douglas, G. P., Chirwa-Nasasara, K., Manjomo, R. C., Harries, A. D., ... & Chinsinga, F. B. (2018). Scaling up electronic village registers for measuring vital statistics in rural villages in Malawi. *Public Health Action*, 8(2), 79–84.
46. Garenne, M., Collinson, M. A., Kabudula, C. W., Gómez-Olivé, F. X., Kahn, K., & Tollman, S. (2016). Improving completeness of birth and death registration in rural Africa. *The Lancet Global Health*, 4(9), e604–e605.
47. Glass, D. V. (1951). A note on the under-registration of births in Britain in the nineteenth century. *Population Studies*, 5(1), 70–88. <https://doi.org/10.1080/00324728.1951.10416675>
48. Gourbin, G., & Masuy-Stroobant, G. (1995). Registration of vital data: Are live births and stillbirths comparable all over Europe? *Bulletin of the World Health Organization*, 73(4), 449.
49. Graham, W., Brass, W., & Snow, R. W. (1989). Estimating maternal mortality: The sisterhood method. *Studies in Family Planning*, 20(3), 125–135.
50. Griffin, T. E. (2021). Birth registration and educational access in Sub-Saharan Africa: The case for an explanatory spatial research design. *The University of Vermont and State Agricultural College*.
51. Guzel, A. E., Arslan, U., & Acaravci, A. (2021). The impact of economic, social, and political globalization and democracy on life expectancy in low-income countries: Are sustainable development goals contradictory? *Environment, Development and Sustainability*, 23(9), 13508–13525. <https://doi.org/10.1007/s10668-020-00876-4>
52. Hammoudeh, D., Coast, E., Lewis, D., Van Der Meulen, Y., Leone, T., & Giacaman, R. (2017). Age of despair or age of hope? Palestinian women's perspectives on midlife health. *Social Science & Medicine*, 184, 108–115.
53. Hancioglu, A., & Arnold, F. (2013). Measuring coverage in MNCH: Tracking progress in health for women and children using DHS and MICS household surveys. *PLoS Medicine*, 10(5), e1001391. <https://doi.org/10.1371/journal.pmed.1001391>
54. Hanke, S. H. (2024, March 8). Zimbabwe inflates again. *Cato Institute*. <https://www.cato.org/commentary/zimbabwe-inflates-again>
55. Harbitz, M. (2021). Snapshot of civil registration and vital statistics systems of Madagascar.

56. Hassan, S., Vikanes, A., Laine, K., et al. (2017). Building a research registry for birth complications and outcomes in six Palestinian governmental hospitals. *BMC Pregnancy and Childbirth*, 17, 112. <https://doi.org/10.1186/s12884-017-1296-6>
57. Health Metrics Network, & World Health Organization. (2008). *Framework and standards for country health information systems* (2nd ed.). World Health Organization. [https://iris.who.int/bitstream/handle/10665/43872/9789241595940\\_eng.pdf?sequence=1](https://iris.who.int/bitstream/handle/10665/43872/9789241595940_eng.pdf?sequence=1)
58. Hoffmann, R., Abel, G., Malpede, M., Muttarak, R., & Percoco, M. (2023). Climate change, aridity, and internal migration: Evidence from census microdata for 72 countries (Working Paper No. WP-23-008). *International Institute for Applied Systems Analysis*. <https://pure.iiasa.ac.at/id/eprint/18922/1/WP-23-008.pdf>
59. Hunter, L. M., Luna, J. K., & Norton, R. M. (2015). Environmental dimensions of migration. *Annual Review of Sociology*, 41, 377–397. <https://doi.org/10.1146/annurev-soc-073014-112223>
60. Idris, I. (2021). Increasing birth registration for children of marginalized groups in Pakistan.
61. IPUMS. (n.d.). WSCORE: Wealth index score. *The Demographic and Health Surveys Program*.
62. Jarrett, P., Zdravetz, F. J., O'Keefe, J., Nshombo, M., Karume, A., & Roberts, L. (2020). Evaluation of a population mobility, mortality, and birth surveillance system in South Kivu, Democratic Republic of the Congo. *Disasters*, 44(2), 390–407.
63. Jewkes, R., & Wood, K. (1998). Competing discourses of vital registration and personhood: Perspectives from rural South Africa. *Social Science & Medicine*, 46(8), 1043–1056. [https://doi.org/10.1016/S0277-9536\(97\)10036-3](https://doi.org/10.1016/S0277-9536(97)10036-3)
64. Kasasa, S., et al. (2021). Birth, stillbirth, and death registration data completeness, quality, and utility in population-based surveys: EN-INDEPTH study. *Population Health Metrics*, 19, 14. <https://pophealthmetrics.biomedcentral.com/articles/10.1186/s12963-020-00231-2>
65. Khalifa, M. A. (1983). Age pattern of fertility in the Sudan. *Journal of Biosocial Science*, 15(3), 317–324.
66. Khan, S., & Hancioglu, A. (2019). Multiple indicator cluster surveys: Delivering robust data on children and women across the globe. *Studies in Family Planning*, 50(3), 279–293. <https://mics.unicef.org/sites/mics/files/2024-05/Studies%20in%20Family%20Planning%20-%202019%20-%20Khan%20-%20Multiple%20Indicator%20Cluster%20Surveys%20-%20Delivering%20Robust%20Data%20on%20Children%20and%20Women.pdf>
67. Khatib, R., McKee, M., & Yusuf, S. (2024). Counting the dead in Gaza: Difficult but essential. *Lancet (London, England)*, 404(10449), 237–238. [https://doi.org/10.1016/S0140-6736\(24\)01169-3](https://doi.org/10.1016/S0140-6736(24)01169-3)
68. Kumar, K., & Saikia, N. (2021). Determinants of birth registration in India: Evidence from NFHS 2015–16. *PLoS One*, 16(9), e0257014. <https://doi.org/10.1371/journal.pone.0257014>
69. Lane, K., & Garrod, J. (2016). The return of the traditional birth attendant. *Journal of Global Health*, 6(2).
70. Lewando-Hundt, G., Abed, Y., Skeik, M., Beckerleg, S., & El Alem, A. (1999). Addressing birth in Gaza: Using qualitative methods to improve vital registration. *Social Science & Medicine*, 48(6), 833–843.
71. Lutz, W. (2021). *Advanced introduction to demography*. Edward Elgar Publishing.
72. Lutz, W., & KC, S. (2011). Global human capital: Integrating education and population. *Science*, 333(6042), 587–592. <https://doi.org/10.1126/science.1206964>
73. Madhav, N., Oppenheim, B., Gallivan, M., et al... (2017). Pandemics: Risks, impacts, and mitigation. In D. T. Jamison, H. Gelband, S. Horton, et al. (Eds.), *Disease control priorities: Improving health and reducing poverty* (3rd ed., Chapter 17). The International Bank for Reconstruction and Development / The World Bank. [https://doi.org/10.1596/978-1-4648-0527-1\\_ch17](https://doi.org/10.1596/978-1-4648-0527-1_ch17)
74. Makinde, O. A., Olapeju, B., Ogbuaji, O., & Babalola, S. (2016). Trends in the completeness of birth registration in Nigeria: 2002–2010. *Demographic Research*, 35, 315–338. <http://www.jstor.org/stable/26332080>

75. Mamdani, M. (1996). *Citizen and Subject: Contemporary Africa and the Legacy of Late Colonialism*. Princeton University Press. <https://doi.org/10.2307/j.ctvc77c7w>
76. Mayhew, M., Hansen, P. M., Peters, D. H., Edward, A., Singh, L. P., Dwivedi, V., ... & Burnham, G. (2008). Determinants of skilled birth attendant utilization in Afghanistan: A cross-sectional study. *American Journal of Public Health*, 98(10), 1849-1856.
77. Meadows, D. H. (2008). *Thinking in systems: A primer*. Chelsea Green Publishing.
78. Mikkelsen, L., Hooper, J., Adair, T., Badr, A., & Lopez, A. D. (2023). Comparative performance of national civil registration and vital statistics systems: A global assessment. *Bulletin of the World Health Organization*, 101(12), 758–767. <https://doi.org/10.2471/BLT.22.289033>
79. Mikkelsen, L., Phillips, D. E., AbouZahr, C., Setel, P. W., De Savigny, D., Lozano, R., & Lopez, A. D. (2015). A global assessment of civil registration and vital statistics systems: Monitoring data quality and progress. *The Lancet*, 386(10001), 1395-1406.
80. Ministère du Plan et Suivi de la Mise en oeuvre de la Révolution de la Modernité (MPSMRM), Ministère de la Santé Publique (MSP), & ICF International. (2014). *Democratic Republic of Congo Demographic and Health Survey 2013–14: Key findings* (DHS Preliminary Report No. SR218). ICF International. <https://dhsprogram.com/pubs/pdf/sr218/sr218.e.pdf>
81. Mitala, H. (2021). Snapshot of Civil Registration and Vital Statistic System of Malawi. International Development Research Centre, 19.
82. Mohanty, I., & Gebremedhin, T. A. (2018). Maternal autonomy and birth registration in India: Who gets counted? *PLOS ONE*, 13(3), e0194095. <https://doi.org/10.1371/journal.pone.0194095>
83. Moriyama, I. M. (1990). *Measurement of birth and death registration completeness*. Bethesda, MD: International Institute for Vital Registration and Statistics.
84. Mosley, W. H., & Chen, L. C. (2003). An analytical framework for the study of child survival in developing countries. *Bulletin of the World Health Organization*, 81, 140-145.
85. Murray, C. J. L., et al... (2010). What can we conclude from death registration? Improved methods for evaluating completeness. *PLoS Medicine*, 7(4), e1000262.
86. Musizvingoza, R., et al. (2023). Trends and determinants of birth registration completeness in Zimbabwe, 2005–2015. *Comparative Population Studies*, 48. <https://doi.org/10.12765/CPoS-2023-01>
87. Muzzi, M. E. (2020). *UNICEF good practices in integrating birth registration into health systems (2000–2009): Case studies: Bangladesh, Brazil, the Gambia and Delhi, India*. UNICEF.
88. Nagabhatla, N., et al. (2021). Water, conflicts, and migration and the role of regional diplomacy: Lake Chad, Congo Basin, and the Mbororo pastoralist. *Environmental Science & Policy*, 122, 35–48. <https://doi.org/10.1016/j.envsci.2021.04.014>
89. Nannan, N., Dorrington, R., & Bradshaw, D. (2019). Estimating completeness of birth registration in South Africa, 1996–2011. *Bulletin of the World Health Organization*, 97(7), 468.
90. National Revenue Authority (NRA). (n.d.). Individuals and partnerships: Fees. <https://www.nra.gov.sl/about-us/overview>
91. Naziri, M., Higgins-Steele, A., Anwari, Z., Yousufi, K., Fossand, K., Amin, S. S., ... & Varkey, S. (2018). Scaling up newborn care in Afghanistan: Opportunities and challenges for the health sector. *Health Policy and Planning*, 33(2), 271-282.
92. Ncube, N., Chimbwanda, T., & Willie, N. (2019). Citizenship alterities: The case of child birth registrations in the Tongogara Refugee Camp of Zimbabwe. *African Journal of Social Work*, 9, 64–72.
93. Nichols, E. K., Giles, D., Kang'oma, S., Mwalwanda, L., Onaka, A., & Notzon, F. (2015). Rapid assessment of Malawi's civil registration and vital statistics system. *Public Health Action*, 5(3), 162-164.
94. Nomura, M., Xangsayarath, P., Takahashi, K., Kamiya, Y., Siengsounthone, L., Ogino, H., & Kobayashi, J. (2018). Socioeconomic determinants of accessibility to birth registration in Lao PDR. *BMC Public Health*, 18, 1-9.

95. Onagoruwa, A., & Wodon, Q. (2021). Correlates of birth registrations in East and Southern Africa and implications for civil registration and vital statistics systems. *Public Health*, 195, 70-75.
96. Pelowski, M., Wamai, R. G., Wangombe, J., Nyakundi, H., Oduwo, G. O., Ngugi, B. K., & Ogembo, J. G. (2015). Why don't you register your child? A study of attitudes and factors affecting birth registration in Kenya, and policy suggestions. *The Journal of Development Studies*, 51(7), 881–904. <https://doi.org/10.1080/00220388.2015.1010156>
97. Pelowski, M., Oduwo, G. O., Wamai, R. G., Ngugi, B., Osoti, A., Ndege, S., & Njuguna, S. (2015). Why don't you register your child? A study of attitudes and factors affecting birth registration in Kenya, and policy suggestions. *Journal of Development Studies*, 51(7), 881–904. <https://doi.org/10.1080/00220388.2015.1010156>
98. Petrozziello, A. J. (2019). Bringing the border to baby: Birth registration as bordering practice for migrant women's children. *Gender & Development*, 27(1), 31–47. <https://doi.org/10.1080/13552074.2019.1570724>
99. Phillips, D. E., Adair, T., & Lopez, A. D. (2018). How useful are registered birth statistics for health and social policy? A global systematic assessment of the availability and quality of birth registration data. *Population Health Metrics*, 16, 1-13.
100. Pont, A. V., Hafid, H., Ramadhan, K., Al-Mutairi, W. M., Irab, S. P., & Efendi, F. (2023). Factors associated with birth registrations in Indonesia. *Electron Journal of General Medicine*, 20(2), em462. <https://doi.org/10.29333/ejgm/12900>
101. Rahman, M. H., Cox, A. B., & Mills, S. L. (2019). A missed opportunity: Birth registration coverage lags behind Bacillus Calmette–Guérin (BCG) immunization coverage and maternal health services utilization in low- and lower-middle-income countries. *Journal of Health, Population and Nutrition*, 38(1), 1–12. <https://jhpnp.biomedcentral.com/articles/10.1186/s41043-019-0183-3>
102. Rajmil, D., Morales, L., Aira, T., & Cardona Valles, M. (2022). Afghanistan: A Multidimensional Crisis. *Peace Review*, 34(1), 41–50. <https://doi.org/10.1080/10402659.2022.2023428>
103. Rao, C., & Gupta, M. (2020). The civil registration system is a potentially viable data source for reliable subnational mortality measurement in India. *BMJ Global Health*, 5(8), e002586.
104. Revenga Becedas, R., Sant Fruchtmann, C., Dincu, I., De Savigny, D., & Cobos Muñoz, D. (2022). Addressing the evidence gap in the economic and social benefits of civil registration and vital statistics systems: A systematic review. *Public Health Reviews*, 43, 1604560.
105. Rosental, P. A., & Mandelbaum, J. (2003). The novelty of an old genre: Louis Henry and the founding of historical demography. *Population*, 58(1), 97-130.
106. Rutstein, S. O., & Staveteig, S. (2014). Making the demographic and health surveys wealth index comparable (Vol. 9). Rockville, MD: ICF International.
107. Sacks, E., Khumalo, P., Tsabedze, B., Montgomery, W., Mthethwa, N., Nhlabatsi, B., ... & Chouraya, C. (2020). "The right time is just after birth": Acceptability of point-of-care birth testing in Eswatini: Qualitative results from infant caregivers, health care workers, and policymakers. *BMC Pediatrics*, 20, 1-10.
108. Salisbury, P., Hall, L., Kulkus, S., et al... (2016). Family planning knowledge, attitudes and practices in refugee and migrant pregnant and post-partum women on the Thailand-Myanmar border – A mixed methods study. *Reproductive Health*, 13, 94. <https://doi.org/10.1186/s12978-016-0212-2>
109. Sanga, C., Kabadi, G., Karugendo, E., de Savigny, D., Cobos Muñoz, D., & Adair, T. (2020). Decentralisation of birth registration to local government in Tanzania: The association with birth registration and certification completeness. *Global Health Action*, 13(1), 1831795.
110. Sankoh, O., et al. (2020). Births and deaths must be registered in Africa. *The Lancet Global Health*, 8(1), e33–e34. [https://doi.org/10.1016/S2214-109X\(19\)30442-5](https://doi.org/10.1016/S2214-109X(19)30442-5)
111. Schneider, I. (2005). Registration, court system, and procedure in Afghan family law. *YB Islamic & Middle EL*, 12, 209.

112. Scott, J. C. (1998). *Seeing like a state: How certain schemes to improve the human condition have failed*. Yale University Press.
113. Sekar, C. C., & Deming, W. E. (1949). On a method of estimating birth and death rates and the extent of registration. *Journal of the American Statistical Association*, 44(245), 101–115.  
<https://doi.org/10.1080/01621459.1949.10483294>
114. Setel, P. W., Macfarlane, S. B., Szreter, S., Mikkelsen, L., Jha, P., Stout, S., & AbouZahr, C. (2007). A scandal of invisibility: Making everyone count by counting everyone. *The Lancet*, 370(9598), 1569–1577.  
[https://doi.org/10.1016/S0140-6736\(07\)61307-5](https://doi.org/10.1016/S0140-6736(07)61307-5)
115. Sharma, S. K., Ghimire, D. R., Adhikari, D., & Thapa, S. (2023). Birth registration in Nepal: An assessment of progress based on two national surveys. *PLOS Global Public Health*, 3(1), e0000759.
116. Shonchay, A., & Wahhaj, Z. (2023). Birth registration, child rights, and local governance in Bangladesh.
117. Silva, R. (2022). Population perspectives and demographic methods to strengthen CRVS systems: Introduction. *Genus*, 78(8). <https://doi.org/10.1186/s41118-022-00156-8>
118. Silva, R., Breckenridge, K., Gruskin, S., & Klaaren, J. (2023). Rights and ethics in biometric population registration: Mapping the limits of digital recognition and the drivers of exclusion. *SSRN*.  
<https://doi.org/10.2139/ssrn.4647719>
119. Simon, S. (1988). The importance of social intervention in Britain's mortality decline c. 1850–1914: A re-interpretation of the role of public health. *Social History of Medicine*.
120. Singogo, E., Kanike, E., Van Lettow, M., Cataldo, F., Zachariah, R., Bissell, K., & Harries, A. D. (2013). Village registers for vital registration in rural Malawi. *Tropical Medicine & International Health*, 18(8), 1021–1024.
100. Smith, K. B., Humphreys, J. S., & Wilson, M. G. A. (2008). Addressing the health disadvantage of rural populations: How does epidemiological evidence inform rural health policies and research? *Australian Journal of Rural Health*, 16(2), 56–66.
101. Sommet, N., & Morselli, D. (2017). Keep calm and learn multilevel logistic modeling: A simplified three-step procedure using Stata, R, Mplus, and SPSS. *International Review of Social Psychology*, 30(1), 203–218. <https://doi.org/10.5334/irsp.90>
102. Souza, J. P., et al. (2023). A global analysis of the determinants of maternal health and transitions in maternal mortality. *The Lancet Global Health*, 12(2), e306–e316. [https://doi.org/10.1016/S2214-109X\(23\)00468-0](https://doi.org/10.1016/S2214-109X(23)00468-0)
103. Sow, P., Adaawen, S. A., & Scheffran, J. (2014). Migration, social demands and environmental change amongst the Frafra of Northern Ghana and the Biali in Northern Benin. *Sustainability*, 6(1), 375–398.  
<https://doi.org/10.3390/su6010375>
104. Spoorenberg, T. (2014). Reconciling discrepancies between registration-based and survey-based estimates of fertility in Mongolia. *Population Studies*, 68(3), 375–382.  
<https://doi.org/10.1080/00324728.2014.935461>
105. Szreter, S. (2007). The right of registration: Development, identity registration, and social security—a historical perspective. *World Development*, 35(1), 67–86. <https://doi.org/10.1016/j.worlddev.2006.09.004>
106. Tadesse, E. (2020). Antenatal care service utilisation of pregnant women attending antenatal care in public hospitals during the COVID-19 pandemic. *International Journal of Women's Health*, 12, 1181–1188.  
<https://doi.org/10.2147/IJWH.S287534>
107. Tan, Y., Kwan, M.-P., & Chai, Y. (2022). How the Chinese hukou system shapes ethnic dissimilarity in daily activities: A study of Xining, China. *Cities*, 122, 103520. <https://doi.org/10.1016/j.cities.2021.103520>
108. Teperi, J. (1993). Multi-method approach to assessing data quality in the Finnish Medical Birth Registry. *Journal of Epidemiology & Community Health*, 47(3), 242–247.
109. Tongun, J. B., Mukunya, D., Tylleskar, T., Sebit, M. B., Tumwine, J. K., & Ndeezi, G. (2019). Determinants of health facility utilisation at birth in South Sudan. *International Journal of Environmental Research and Public Health*, 16(13), 2445. <https://doi.org/10.3390/ijerph16132445>
110. United Nations, Department of Economic and Social Affairs. (2021). Handbook on the least developed country category: Inclusion, graduation and special support measures.  
<https://www.un.org/development/desa/dpad/publication/lcd-handbook/>

111. UNFPA. (2024a). Population data: ICPD30 brief [PDF]. United Nations Population Fund.  
[https://www.unfpa.org/sites/default/files/resource-pdf/3.%20Population\\_data\\_ICPD30\\_BRIEF\\_050624\\_WEB.pdfEN\\_.pdf](https://www.unfpa.org/sites/default/files/resource-pdf/3.%20Population_data_ICPD30_BRIEF_050624_WEB.pdfEN_.pdf)
112. UNICEF. (2005). The 'rights' start to life: A statistical analysis of birth registration. *UNICEF*.  
[https://getinthepicture.org/sites/default/files/resources/The%20'Rights'%20Start%20to%20Life%20A%20statistical%20analysis%20of%20birth%20registration\\_0.pdf](https://getinthepicture.org/sites/default/files/resources/The%20'Rights'%20Start%20to%20Life%20A%20statistical%20analysis%20of%20birth%20registration_0.pdf)
113. UNICEF. (2020). Eswatini country office annual report 2019.  
<https://www.unicef.org/media/90376/file/Eswatini-2019-COAR.pdf>
114. UNICEF. (2023, June 14). *Q and A: What is birth registration? Why is it important for children in Sudan?* Interview with Musa Idris Omran. <https://www.unicef.org/sudan/stories/q-and-what-birth-registration-why-it-important-children-sudan>
115. UNICEF. (2024a, December 11). Birth registration steadily increases worldwide, but 150 million children are still invisible. *UNICEF*.
116. UNICEF. (2024b). The right start in life: Global levels and trends in birth registration 2024 update. *UNICEF*. <https://data.unicef.org/resources/the-right-start-in-life-2024-update/>
117. UNICEF. (n.d.). Birth report / Kalata ya chidziwitso cha kubadwa. *UNICEF Data*.  
<https://data.unicef.org/birthRegFormMalawi>
118. UNICEF. (2019). Birth registration for every child by 2030: Are we on track?  
<https://www.unicef.org/media/62981/file/Birth-registration-for-every-child-by-2030.pdf>
119. UNICEF. (2025, March). Birth registration in sub-Saharan Africa: Progress, challenges and opportunities. United Nations Children's Fund.
120. United Nations. (1989). *Convention on the Rights of the Child*. <https://www.ohchr.org/en/professionalinterest/pages/crc.aspx>
121. United Nations, Department of Economic and Social Affairs, Population Division. (2024). *World population prospects 2024: Highlights*. United Nations.
122. United Nations, Department of Economic and Social Affairs, Statistics Division. (2022). *Handbook on civil registration, vital statistics and identity management systems: Communication for development* (Studies in Methods Series F No. 121). United Nations. <https://doi.org/10.18356/9789214030997>
123. United Nations, Department of Economic and Social Affairs, Statistics Division. (2024). *Statistical Yearbook* (67th issue). United Nations.
124. United Nations Office for the Coordination of Humanitarian Affairs. (n.d.). *Data on casualties*. United Nations. Retrieved March 11, 2025, from <https://www.ochaopt.org/data/casualties>
125. US Centers for Disease Control and Prevention. (n.d.). Civil registration and vital statistics (CRVS) improvement project. *United States National Center for Health Statistics*. Retrieved February 24, 2015, from [http://www.cdc.gov/nchs/isp/isp\\_crvs.htm](http://www.cdc.gov/nchs/isp/isp_crvs.htm)
126. Van der Straaten, J. (2022). Legal identity for all, or not? On the measurement of birth registration completeness. [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=4061656](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4061656)
127. Wendt, A., Hellwig, F., Saad, G. E., et al. (2022). Birth registration coverage according to the sex of the head of household: An analysis of national surveys from 93 low- and middle-income countries. *BMC Public Health*, 22, 1942.
128. Withers, M., Kharazmi, N., & Lim, E. (2018). Traditional beliefs and practices in pregnancy, childbirth and postpartum: A review of the evidence from Asian countries. *Midwifery*, 56, 158–170.  
<https://doi.org/10.1016/j.midw.2017.10.019>
129. World Bank. (2020). *Poverty and equity brief: Sierra Leone*. [https://databankfiles.worldbank.org/public/ddpext\\_download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global\\_POVEQ\\_SLE.pdf](https://databankfiles.worldbank.org/public/ddpext_download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global_POVEQ_SLE.pdf)
130. World Bank. (2023). World Bank country and lending groups.
131. World Health Organization (WHO) Regional Office for Africa. (2023). *Vital statistics report 2022*. <https://www.afro.who.int/sites/default/files/2023-10/Vital%20Statistics%20Report%202022%20%281%29.pdf>
132. Xu, L., Ai, C., & Hamilton, J. (2024). *Gender preference in China: A study with indirect utility function*. *Journal of Asian Economics*, 94, 101780. <https://doi.org/10.1016/j.asieco.2024.101780>

133. Yan, Y., Xing, C., Chen, J., Zheng, Y., Li, X., Liu, Y. & Gong, K. (2024). *Provincial Maternal and Child Information System in Inner Mongolia, China: Descriptive Implementation Study*. *JMIR Pediatrics and Parenting*, 7, e46813.
134. Yokobori, Y., Obara, H., Sugiura, Y., & Kitamura, T. (2021). *Gaps in the civil registration and vital statistics systems of low- and middle-income countries and the health sector's role in improving the situation*. *Global Health & Medicine*, 3(4), 243–245. <https://doi.org/10.35772/ghm.2020.01103>
135. Zhang, X., Lou, H., Tang, X., et al. (2021). *Socio-demographic characteristics and outcomes of pregnant women who delivered before and after the termination of the one-child policy in China: A comparative study*. *BMC Pregnancy and Childbirth*, 21, 318. <https://doi.org/10.1186/s12884-021-03740-6>
136. Zhao, L., Cao, B., Borghi, E., Chatterji, S., García-Saiso, S., & et al. (2022). *Data gaps towards health development goals in 47 low- and middle-income countries*. *Bulletin of the World Health Organization*, 100(1), 40–49. <https://doi.org/10.2471/BLT.21.286254>

# Appendices

## Contents

|          |                                                                                                                                    |           |
|----------|------------------------------------------------------------------------------------------------------------------------------------|-----------|
| <b>1</b> | <b>Appendix A: Historical Birth Registration and Current UNICEF BR Data, Figures Referenced in the Text, Data Cleaning Process</b> | <b>2</b>  |
| <b>2</b> | <b>Appendix B: MICS 2013-2023 Sample Frequencies Distribution</b>                                                                  | <b>35</b> |
| <b>3</b> | <b>Appendix C: Model Configurations</b>                                                                                            | <b>39</b> |
| 3.1      | Preliminary Assessment of Variance Inflation Factor (VIF) Prior to Main Analysis                                                   | 39        |
| 3.2      | Null Model . . . . .                                                                                                               | 39        |
| 3.3      | Intraclass Correlation . . . . .                                                                                                   | 39        |
| 3.4      | Child and Maternal Characteristics Model within the Household . . . . .                                                            | 40        |
| 3.5      | Household Structure and Access Model . . . . .                                                                                     | 41        |
| 3.6      | Household Structure and Access Model with Interaction Terms . . . . .                                                              | 43        |
| <b>4</b> | <b>Appendix D: MICS Afghanistan 2022-2023</b>                                                                                      | <b>44</b> |
| <b>5</b> | <b>Appendix F: MICS Democratic People’s Republic of the Congo 2017</b>                                                             | <b>50</b> |
| <b>6</b> | <b>Appendix G: MICS Madagascar 2018</b>                                                                                            | <b>56</b> |
| <b>7</b> | <b>Appendix H: MICS Lao People’s Democratic Republic 2017</b>                                                                      | <b>61</b> |
| <b>8</b> | <b>Appendix I. MICS Sudan 2014</b>                                                                                                 | <b>67</b> |
| <b>9</b> | <b>Appendix J: Part Two Country Analysis</b>                                                                                       | <b>72</b> |
| 9.1      | Null Model: Multilevel Logistic Regression (Household, Cluster, Country) . . . .                                                   | 72        |
| 9.2      | Determinants of Birth Certificate Ownership: Multilevel Logistic Regression Model (Household, Cluster, Country) . . . . .          | 73        |

## **Appendix A**

### **A BRIEF SUMMARY OF THE EVOLUTION OF BIRTH REGISTRATION: FROM INFORMAL TO MODERN PRACTICUM**

The evolution of BR from local, informal practices to a universal, legal requirement represents a significant shift in how societies have managed identity, citizenship, and demographic data. The transition from unregulated practices to a globally recognised standard is of great consequence for access to services, maintenance of legal status, and assurance of accurate population statistics.

The history of demographic theories, population policies, and the institutions responsible for their implementation is deeply interconnected when addressing demographic metabolism, transition, and dividend (Lutz 2021). For example, the relationship between BR and multidimensional demography lies in the foundational role that accurate population data plays in understanding and shaping demographic theories. Ideally, universal BR would provide precise population counts, enabling the application of quantitative approaches to forecasts and the management of societal shifts, such as changes in fertility, mortality, and migration. By tracking births, governments can better plan for demographic transitions, predict future population dividends, and manage the societal impacts of ageing or youth bulges. This positions demographic data at the centre of social science and policymaking. Universal BR has yet to be achieved.

Historically, the modern formalisation of birth documentation practices can be traced to early 14th-century France, when governments initiated vital records systems as part of broader civil registration efforts (Durand, 1977). This system supported the development of a nationwide social security framework and facilitated labour and capital mobility, playing a key role in early economic development (Szreter, 2007).

Scholars Jewkes and Wood (1998) established that the use of registration systems for statistical purposes originated in 17th-century London, when John Gaunt analysed Bills of Mortality, records of burials, to make demographic observations. Another significant turning point came with the enactment of the United Kingdom's Registration Act of 1837, which mandated the state registration of births, marriages, and deaths spurred on by the employment of registrars during

a pivotal instrument for public health and governance, reflecting a global tendency toward augmented administrative capabilities (Szreter, 2007). This legislation marked a key moment in the institutionalisation of BR in rapidly industrialised countries experiencing economic development, along with population “booms.” However, rural populations were often underrepresented and undereducated; additionally, in certain circumstances, they were excluded, except for agricultural purposes. This implementation was not exclusive to Europe. Globally, population registrars became increasingly commonplace.

## **HISTORICAL DICHOTOMY IN BR RATES**

The urban-rural divide of BR is not merely a modern dilemma; instead, it is an issue with deep historical roots. From the 16th century until the mid-20th century, BR systems in urban areas underwent rapid enhancements. In British India (1858–1947), the Dutch East Indies (1600–1942), and French Indochina (1858–1954), birth records were selectively enforced among targeted groups, such as urban populations or those engaged in colonial administration, while indigenous populations were often left unregistered or left out of official records (Burbank & Cooper, 2010; Cohn, 1996). In other places, such as French West Africa (1895–1960) and the Belgian Congo (1908–1960), BR was primarily implemented for those within the colonial economy, reinforcing racial hierarchies and restricting access to rights for local populations (Sow et al., 2014; Mamdani, 1996). BR was also used to manage labour and conscription, with colonial authorities using it to track and control the labour force (Conklin, 1997).

In other regions of the world, BR systems were central to governance, which often reflected the complexities of newly independent nations. For example, the Japanese *koseki* (“family register”) system, institutionalised during the Meiji era (1868–1912) and continuing through the post-war period, was used to define citizenship and reinforce national identity. In countries like Myanmar (after its independence in 1948) and Thailand (which was never formally colonised but established its registration systems early in the 20th century), BR was used to exclude ethnic minorities, such as the Rohingya in Myanmar and the hill tribes in Thailand, from legal recognition, making them stateless and denying them access to education, healthcare, and employment (Salisbury et al., 2016).

## **MODERN INTERCONNECTION OF POLICY, INSTITUTIONS, AND DEMOGRAPHIC INFLUENCE**

In 2003, Paul-André Rosental emphasised the need to examine how “demographic thought, population policies, and the institutions in charge of implementing them” have evolved together (Rosenthal & Mandelbaum, 2003, p. 99). The intricate connections between political, social, and economic forces shape policy decisions and institutional practices. Rosenthal highlighted the challenge of understanding the relationships between population policies and the institutions that enforce them.

The challenge is illustrated by China's One-Child Policy (1979–2015), initially implemented by the State to address the issue of overpopulation. However, this policy resulted in an imbalanced sex ratio at birth, which reached its peak in 2004 with 121.18 boys born for every 100 girls (Xu et al., 2024). In response to this imbalance, the government initiated a policy shift in 2016, allowing families to have a second child. China's policy exemplifies the capacity of state institutions to directly influence demographic outcomes through the utilisation of data, with the policy being implemented through legal mandates, economic incentives, and social pressures.

Notably, China's Hukou system, initiated in 1958 as a permanent household registration system, continues to play a pivotal role in population management within both urban and rural communities. Previous records indicate that a child's Hukou status is contingent upon their family's place of residence. The absence of a Hukou identity card, which formally establishes their permanent residence, results in their exclusion from accessing essential services and legal recognition. This highlights the crucial role that institutional frameworks play in enforcing demographic policies and regulating population growth and decline (Tan et al., 2022).

Concerning Rosental's argument, this case study illustrates the intricate interplay between policy, institutions, and demographic shifts. In this context, the child's ability to access essential services, including social welfare and educational opportunities, is contingent on possessing the necessary documentation and a valid BR. The absence of these documents can result in the child's exclusion from these services and their subsequent exclusion from the education system.

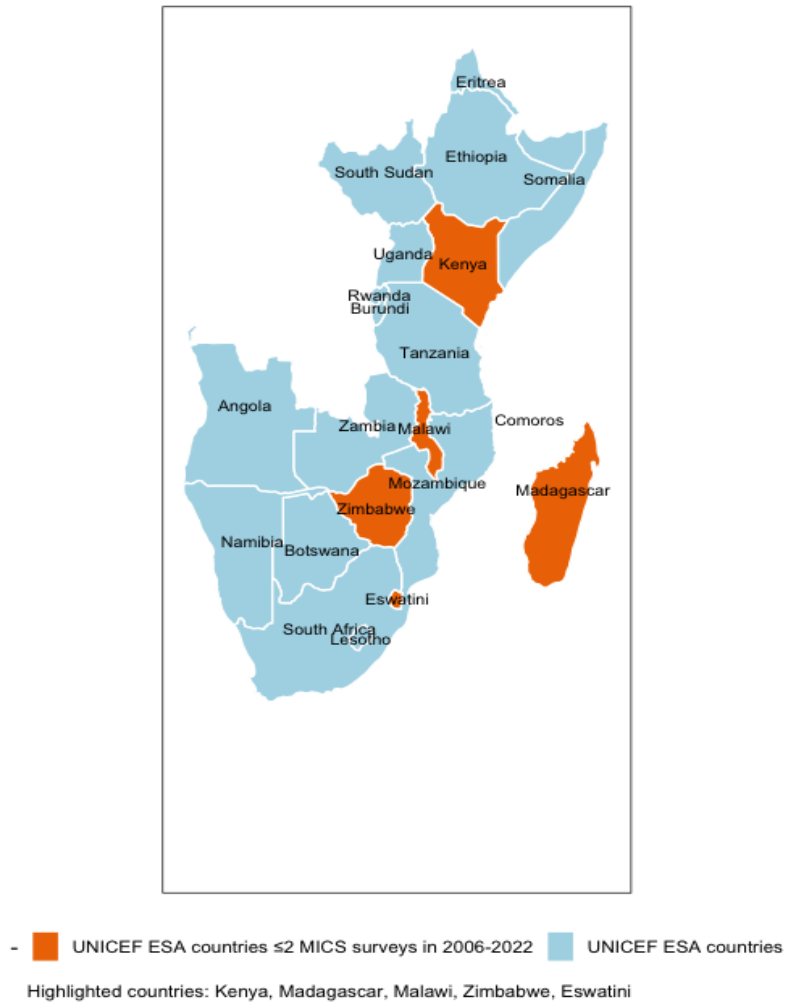
In contrast to China's birth limitations, France's pro-natalist policies, such as family allowances and parental leave benefits, evolved through a mix of government intervention and societal

debates over declining birth rates. In this case, BR interplays with their national policies and the benefits of registering the child at birth.

## UNICEF REGIONS AND COUNTRIES WITH TWO MICS SURVEYS BETWEEN 2006-2022

Figure A1.

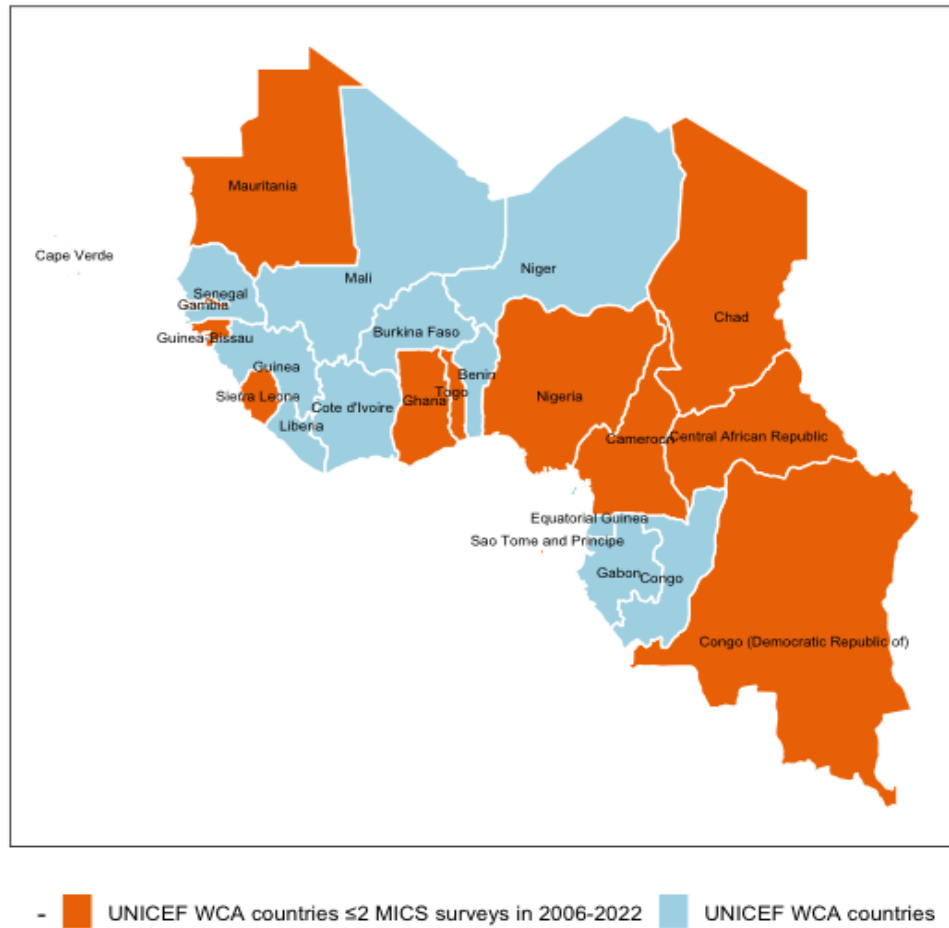
### UNICEF: Eastern and Southern Africa



Source: Tierney McCue

Figure A2

**UNICEF: West and Central Africa**



Source: Tierney McCue

Figure A3

**UNICEF: South Asia**



- ■ UNICEF South Asia countries ≤2 MICS surveys in 2006-2022 ■ UNICEF South Asia countries

Source: Tierney McCue

**Figure A4.**

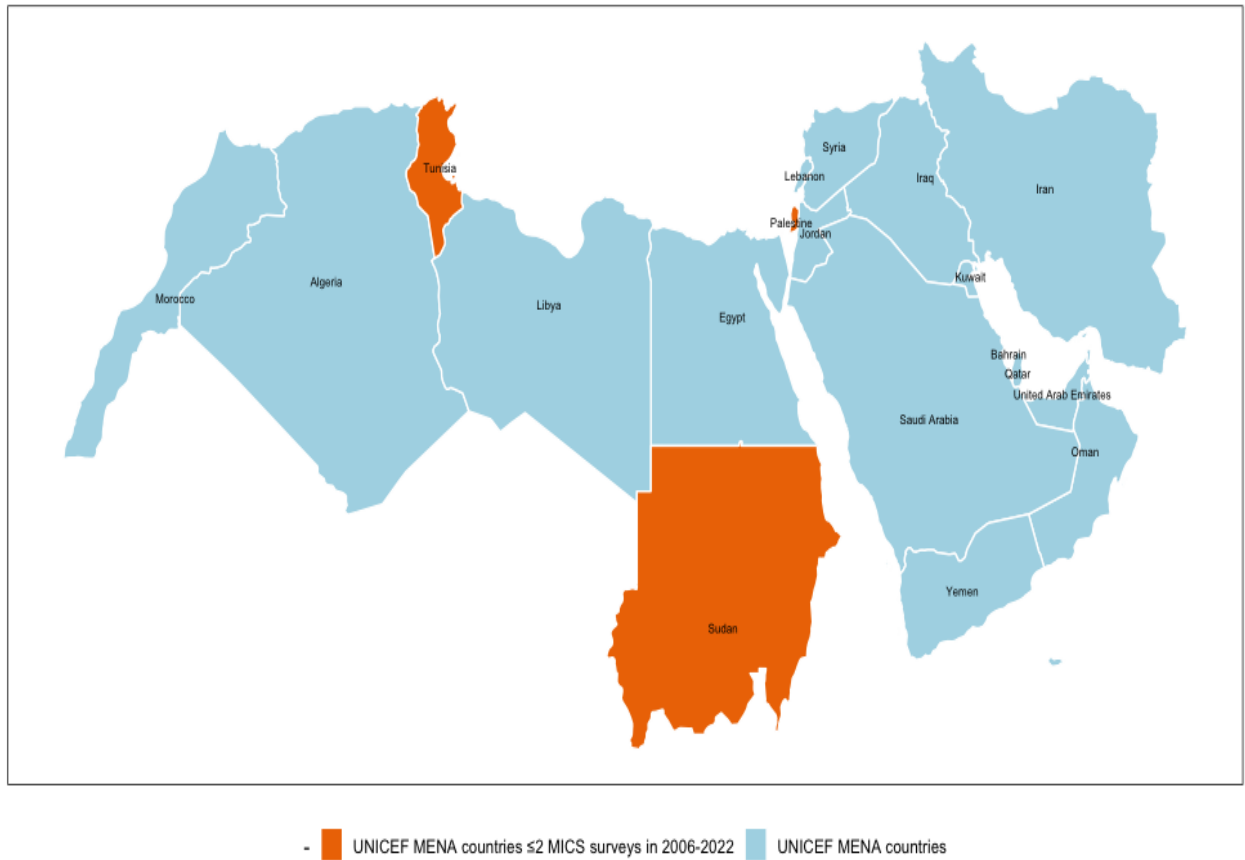
**UNICEF: East Asia and Pacific**



**Source: Tierney McCue**

**Figure A5.**

**UNICEF: Middle East and North Africa**



**Source: Tierney McCue**

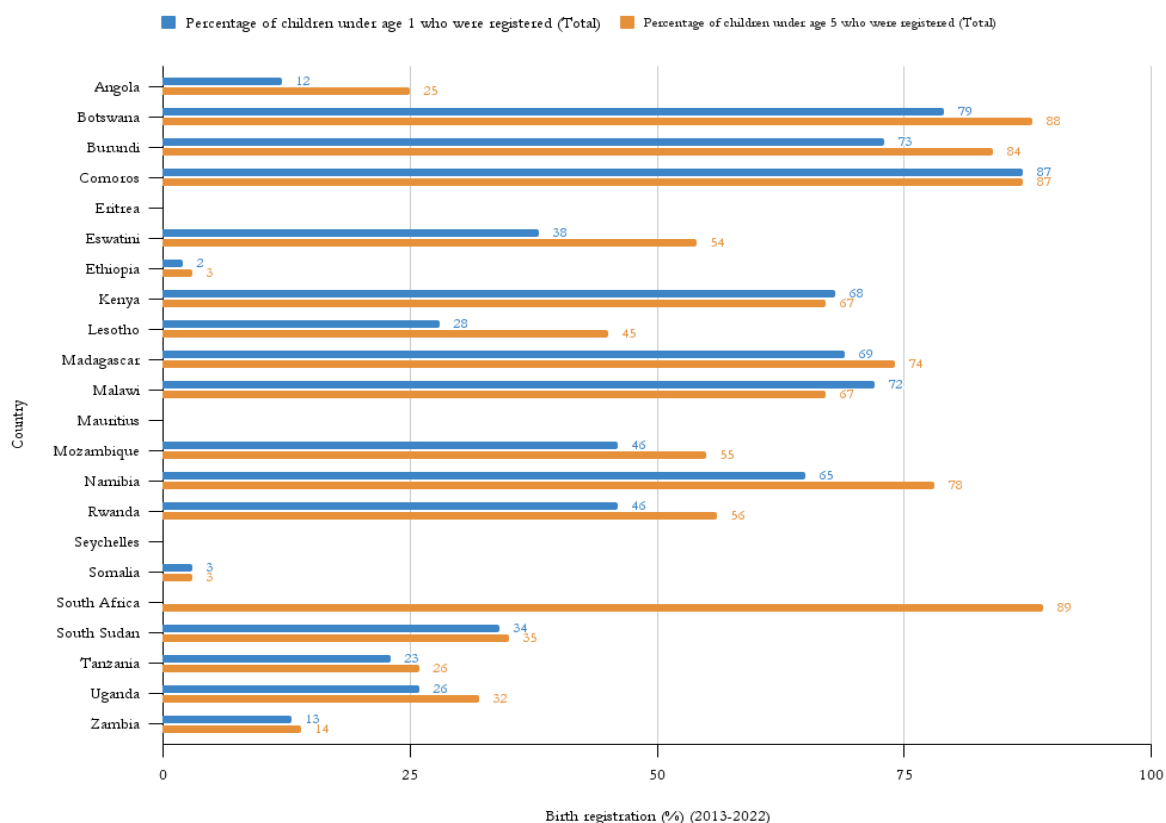
## REGIONAL BIRTH REGISTRATION PRACTICES AND TRENDS

### UNICEF EASTERN AND SOUTHERN AFRICA BR PRACTICES

**Figure A6. MICS Eastern and Southern Africa**

#### UNICEF Birth Registration Coverage for Children Under 1 and Total Children Under 5 (2013-2022)- Eastern and Southern Africa

Updated June 2023 (Accessed March 2024)



**Source:** Graph made by Tierney McCue using the data from the UNICEF Data Portal; **Note:** Data for Eritrea, Seychelles, and Mauritius is unavailable.

The most recent UNICEF data for Eastern and Southern Africa (Figure 6) show substantial regional variation by country. For example, the easternmost and southern regions have some of

the most disproportionately low BR rates (total no. of children <5 years old registered) across the board/for the continent: Ethiopia (2%), Somalia (3%), Zambia (14%), Angola (25%), Tanzania (26%), Uganda (32%), and South Sudan (35%). Overall trends indicate that low BR rates are increasing with age. Currently, this region continues to experience low registration rates, particularly in rural and economically disadvantaged clusters.

An essential study within this region is Onagoruwa and Wodon's (2021) investigation into the correlations between BR in East and Southern Africa, utilising the DHS surveys from Malawi (2015), Mozambique (2011), Uganda (2016), Tanzania (2015), and Zambia (2013–2014). Their results showed that children from wealthier households were considerably more likely to be registered and attributed this primarily to the out-of-pocket costs and opportunity costs of accessing registration services (Onagoruwa and Wodon, 2021). A key finding was that individuals from less affluent backgrounds, particularly those in rural areas, encountered financial and logistical challenges in completing the BR process. Where the percentages in their study were particularly low, it was difficult to ascertain whether this data was representative of the larger population sample, such as clusters in hard-to-reach areas.

Similarly, in the study by Aboagye et al. (2023), maternal education was found to be statistically significant when correlated with BR rates. They concluded that better-educated mothers were more likely to understand the significant importance of registration in relation to the population trends being studied and were more likely to complete the process. In many of their results, children born to mothers with secondary or tertiary education (college or vocational school) were more likely to be registered, which illustrates the role of education in increasing registration rates, as shown by the odds ratios (Aboagye et al., 2023).

Registration service accessibility was also an essential factor. In numerous sub-regions, particularly those designated as rural, the provision of BR services was either nonexistent or inaccessible due to the considerable distances involved or the lack of adequate infrastructure (Aboagye et al., 2023), albeit this varied from country to country. The work of Clarke-Deelder et al. (2022) substantiates this theory, where, for example, mothers in Zambia were required to walk many kilometres (~5-10 kilometres) between clinics; even then, not every clinic acted as a

registration point and leaves families guessing as to where to find a registrar (Clarke-Deelder et al., 2022). When healthcare facilities were utilised as registration points, children born there were more likely to be registered. The absence of registration facilities or inadequate staffing levels in numerous rural hospitals hinders the utilisation of healthcare facilities as viable solutions for registering births on a broader scale (Aboagye et al., 2023).

A correlating concept by Onagoruwa and Wodon (2021) emphasises the necessity of considering both demand- and supply-side factors in policy formulation when addressing BR rates. They proposed bundling services, such as linking BR with immunisation in healthcare delivery, as an effective strategy for improving registration rates.

## **CASE STUDY KENYA**

Pelowski et al. (2015) identified a complex interplay of socioeconomic and psychological factors influencing parents' decisions not to register their children's births in Kenya, as determined through a cross-sectional survey conducted between 2010 and 2011. Despite the apparent availability of resources and knowledge, the non-registration of births was more prevalent among rural residents, individuals of advanced age (60- 80+), and those with limited educational attainment (ceasing schooling at primary school), particularly those who had given birth at home. This was particularly pronounced in instances where the family unit was deeply engaged in the birthing process.

The barriers included the costs associated with registration fees, penalties for delays, and travel expenses, in addition to bureaucratic hurdles such as the lack of identification cards, as well as perceived low utility (cost-benefit analysis). There was a perceived low utility, which demotivated participants from registering. In this case study, many parents expressed uncertainty about the registration process, often relying on intermediaries that charged additional fees. These practical and informational obstacles were compounded by a broader issue of parental cost-benefit deliberation: Should this money be allocated towards essentials (i.e., food and shelter) or registration data? Many parents weighed the inconveniences of registration against its perceived lack of immediate utility, particularly in the absence of tangible incentives, until school enrollment or other government requirements arose, leading to adverse outcomes. This deliberate

assessment highlighted the necessity of simultaneously addressing structural and psychological disincentives (Pelowski et al., 2015).

Since the study, BR for the country has increased from 60% in 2009 to 77% by 2023, showing cumulative growth. A possible reason for this could be attributed to governmental efforts that have resulted in a gradual improvement in the registration rates of children under five and positive attitudes toward utilisation. Nevertheless, current challenges remain the most prominent in rural areas, where registration rates lag considerably behind urban centres as of 2025.

## **CASE STUDY MALAWI**

There have been multiple impeding factors inhibiting the improvement of Malawi's CRVS system, according to the National Registration Bureau (NRB). In 2007, the Ministry of Home Affairs and Internal Security introduced a decentralised registration system using paper-based village registers (*Kalata Ya Chidziwitso Cha Kubadwa* or "birth report"), which was distributed nationwide by 2011. The Village Headman (*Nyankwawa*) and Senior Member of the Village (*Wachikulire wa m'mudzi*), or the most senior village head persons (VH), maintained these registers through verification on each document (UNICEF, n.d). This was done to document their population's data, including births and deaths, while offering a potential source for vital statistics (Gadabu et al., 2018).

However, the system's functionality to date remains unclear, with limited evidence on whether VHS have functional registers or maintain them adequately. Regardless of these registrations being compulsory, each one signed with either the signature or thumbprint of the VHS, it is difficult to ascertain whether all live births have been accurately documented. A study in one Traditional Authority (TA) in rural Malawi evaluated the characteristics of VH using these registers, their usage and content, and their reliability in accurately recording births and deaths. They concluded that "(i) insufficient supervision to ensure proper and complete documentation of data, (ii) no effective system in place to reconcile health facility and village-related data (births and deaths), and (iii) a high degree of illiteracy in VH" (Singogo et al., 2013, p.1023). This highlights the broader systemic issues that hinder the effectiveness of the CRVS framework.

In conjunction, Nichols et al.'s 2015 study on Malawi's civil registration and vital statistics (CRVS) system revealed several critical deficiencies across multiple areas, with scores ranging from 0% for completeness, data quality, and inadequate compliance with the International Classification of Diseases. Their results indicated that many non-functional components exist. The score of 67% was given for registration infrastructure and resources, which were deemed functional but inadequate. The overall score of 28% classified Malawi's CRVS system as "dysfunctional," indicating a need for improvements in all areas (Nichols et al., 2015). This study further highlighted challenges, including poor data coverage, insufficient infrastructure, and non-compliance with international standards. In conclusion, their findings emphasised the need for enhanced collaboration, stricter enforcement of registration laws, and significant structural reforms to strengthen the CRVS system and address its persistent shortcomings.

Despite enacting the National Registration Act in 2010 to mandate the registration of vital events, Malawi continues to struggle with widespread under-registration. As of 2020, the country had a backlog of 9 million unregistered births, amounting to nearly 50% of its population (Mitala, 2021). This shortfall highlights the limited reach and functionality of existing systems, which have affected the use of CRVS data for social services, health programs, and policy planning.

## **CASE STUDY ZIMBABWE**

The Zimbabwe study by Musizvingoza et al. (2023) examined both the trends and determinants of BR completeness in Zimbabwe from 2005 to 2015, revealing a significant decline of 31.6% in registration rates.

By 2015, the national completeness rate was only 44%, meaning that over half of all births were unregistered. This decline occurred concurrently with significant socio-economic and political upheavals, notably the 2008 economic crash, which resulted in the near-collapse of once-public services that had been privatised by President Robert Mugabe. Registration rates were particularly low among the most economically disadvantaged by an almost 89.7 sextillion ( $10^{21}$ ) % inflation rate (Hanke, 2017). Households in the "poorest" household wealth indicator in DHS and rural communities, where barriers such as pre-existing poverty, logistical challenges

and indirect costs associated with transport and accommodation impede access. Notwithstanding the official policy of free BR, these challenges had a particularly adverse impact on the 76% of Zimbabweans residing in rural areas. Weak governance, under-resourced registration offices, and systemic corruption further compounded this. Such corruption included demands for informal payments, which contributed to the decline.

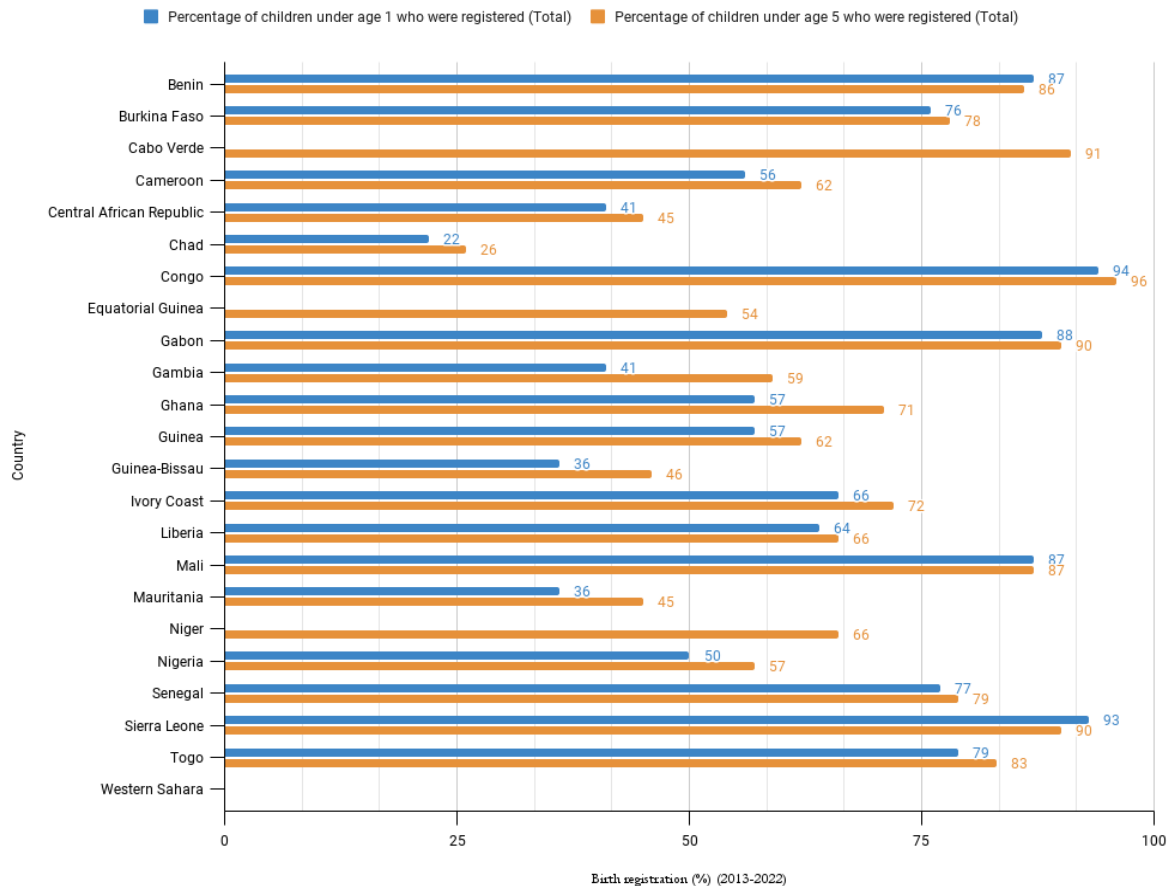
Furthermore, Musizvingoza et al. (2023) emphasised the existence of regional disparities, with improvements in provinces such as Matabeleland resulting from the implementation of targeted interventions, while other regions like Manicaland experienced a notable decline, which was attributed to high fertility rates and socio-cultural factors. The analysis revealed that factors such as household wealth, maternal education, and healthcare access emerged as strong predictors of registration, with children born in healthcare facilities more likely to be registered. However, the lack of emphasis on early registration, often postponed until school enrollment, has led to record errors and falsifications. A strong conclusion from this study is that it is necessary to implement targeted strategies to reduce barriers for poor and rural households, improve maternal healthcare linkages, and harmonise policies across government ministries.

## UNICEF WEST AND CENTRAL AFRICA BR PRACTICES

Figure A7. MICS West and Central Africa

### UNICEF Birth Registration Coverage for Children Under 1 and Total Children Under 5 (2013-2022)- West and Central Africa

Updated June 2023 (Accessed March 2024)



**Source:** Graph made by Tierney McCue using the data from the UNICEF Data Portal; **Note:** % of children under 1 for Cabo Verde, Equatorial Guinea, and Niger are unavailable.

Significant deficits exist in BR systems across West and Central Africa, with many countries facing technical and infrastructural challenges. The region spans approximately 12.7 million square kilometres, nearly three times the size of the European Union's 4.233 million square

kilometres. This vast geographic area presents substantial logistical difficulties for countries such as Chad, Gambia, Ghana, Guinea-Bissau, Mauritania, Nigeria, Sierra Leone, Togo, Cameroon, the Central African Republic (CAR), Congo, and São Tomé and Príncipe.

To provide a contextual framework for analysis, it is instructive to consider the rural versus urban divide and the disparity in BR. An important example is Ghana (Fagernäs & Odame, 2013); Ghanaian individuals residing in rural communities are less frequently registered than their urban counterparts. While Ghana has a higher number of Birth and Death Registry (BDR) offices per region (averaging 6+) compared to Eswatini, a disparity persists among those in the upper and lower echelons (BDR of Ghana, n.d). The augmentation of registries per km<sup>2</sup> in Eswatini might enhance BR, yet it fails to redress the existing divide in Ghana. Despite Ghana's campaigns to increase BR, children born to less educated mothers or in rural areas remain underrepresented (Amo-Adjei & Annim, 2015).

Political instability further exacerbates the problem in West Africa. Countries such as the Central African Republic (CAR) and Chad are experiencing conditions akin to civil war, making access to registration offices complex (Ebberts & Smits, 2022). Chad, for instance, operates under a restrictive military regime, which is known for regular serious human rights violations (Nagabhatla et al., 2021). In Nigeria, studies indicate that although mothers are aware of BR, misconceptions and cultural barriers prevent consistent practice (Adi et al., 2015). This issue is compounded by lower levels of education in certain regions, as demonstrated by studies from the Central African Republic and Guinea-Bissau (Aboagye et al., 2023).

Economic factors also play a significant role in this UNICEF-classified region. Registration often involves direct (delayed BR fees) and indirect costs, including travel expenses, which can render the system inaccessible to those without regular income or the means to travel long distances due to health, ability, etc. This is evident in Ghana and Nigeria, where late BR fees (child >1 year old) of GHS 10 and 3,000 Leones limit registration practices (National Revenue Authority, 2024; BDR, 2024). This is especially apparent in Sierra Leone, where, according to a World Bank poverty brief, upwards of 60% of the rural population lives well below the poverty line (Dake & Fuseini, 2018; World Bank, 2020). Moreover, in Mauritania and Sierra Leone, the

lack of coordination between health systems and registration offices results in unregistered births outside health facilities (Rahman et al., 2019).

Nigeria continues to face challenges with BR due to its predominantly rural population. State-issued proof of identity is often viewed as unnecessary and intrusive in these areas. Additionally, large family sizes de-prioritise individual documentation, especially in the North. Southern Nigeria, in contrast, is more urbanised and economically developed, placing greater value on formal education. Economic hardships in northern Nigeria make it difficult for low-income families to bear the indirect costs associated with registration (Makinde et al., 2016).

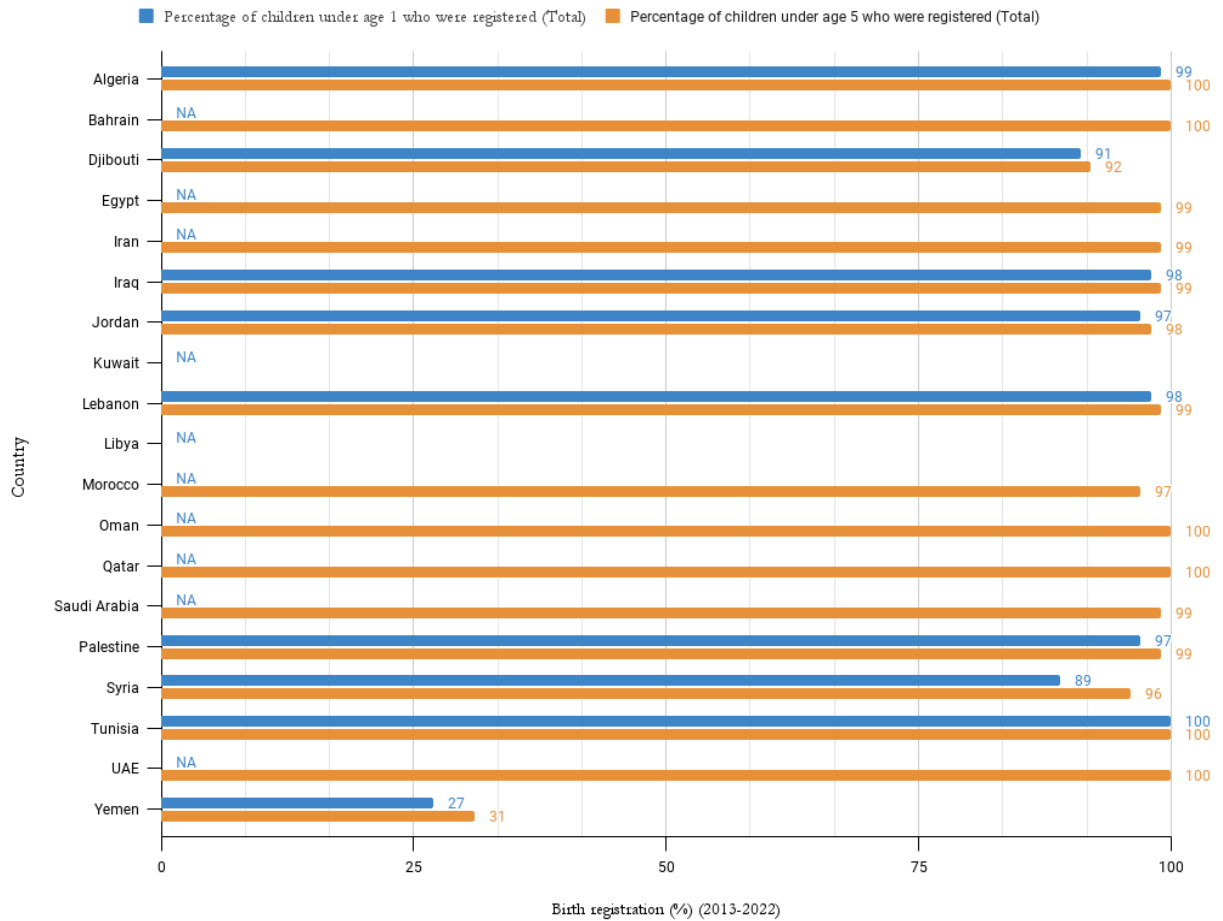
Guinea-Bissau struggles with an underfunded health infrastructure, limiting the ability to integrate other services with BR. Home-born children's registration rates are particularly low (Kasasa et al., 2021). Chad faces unique challenges due to a high level of nomadism. Several population groups, such as the Fulani and Toubou, migrate seasonally as part of their livelihoods, primarily herding livestock. These populations often move between remote areas with minimal government infrastructure. Traditional migration routes frequently cross-national borders, complicating registration, especially if a child is born in another country. Complementarily, nomadic ethnic groups seldom interact with state health facilities, relying instead on oral traditions to document ancestry and identity, which diminishes the perceived importance of formal BR. Establishing mobile registration centres has not yielded significant results (Ebberts & Smits, 2022). For São Tomé and Príncipe, challenges are associated with its geographical isolation. The islands' remoteness adds logistical difficulties to BR processes. However, community-driven initiatives have shown promise in addressing these gaps (Rahman et al., 2019).

## UNICEF MIDDLE EAST AND NORTH AFRICA BR

Figure A8. MICS Middle East and North Africa

### UNICEF Birth Registration Coverage for Children Under 1 and Total Children Under 5 (2013-2022)- Middle East and North Africa

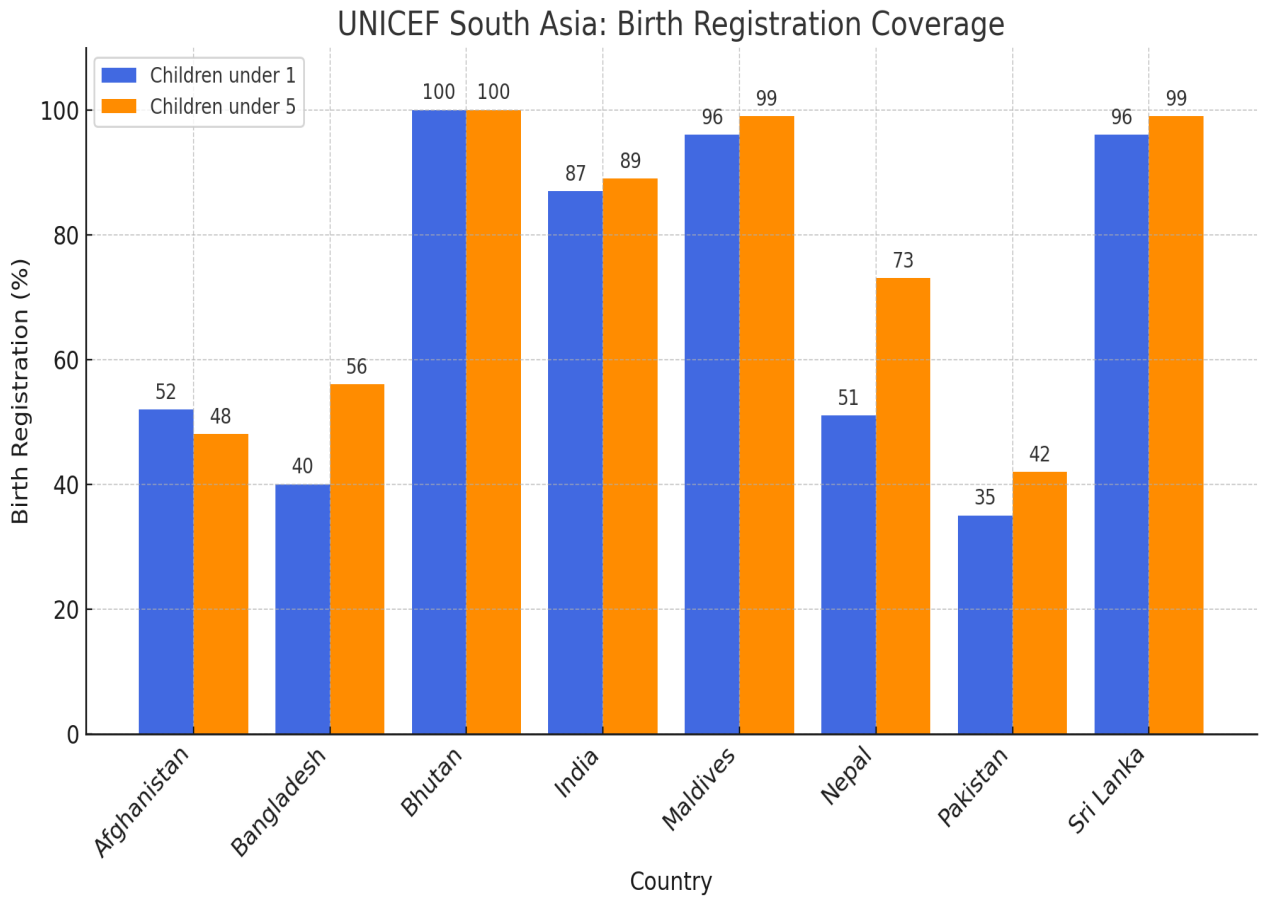
Updated June 2023 (Accessed March 2024)



**Source:** Graph made by Tierney McCue using the data from the UNICEF Data Portal; **Note:** Data is unavailable in the NA categories.

## UNICEF SOUTH ASIA BR PRACTICES

Figure A9. MICS South Asia



**Source:** Graph made by Tierney McCue using the data from the UNICEF Data Portal; **Note:** Data is unavailable in the NA categories.

UNICEF defined South Asia as incorporating Afghanistan, Pakistan, India, Nepal, Bhutan, Bangladesh, Sri Lanka, and the Maldives; it is a region characterised by diverse BR outcomes. This area is known for its high population density, approximately 323 per km<sup>2</sup> according to the Worldometer, accounting for 25.29% of the total world population (Worldometer, 2025). This region is also known for widespread poverty and, simultaneously, some of the largest economies globally (in the IT, manufacturing, and agricultural sectors). However, despite the ever-growing

population and economy, some countries in this region (Afghanistan, Bangladesh, Nepal, and Pakistan) struggle to reach the upper quartile (75%-100%) of overall birth registration for children <5 years old. This analysis examines common obstacles and specific difficulties in Afghanistan, Bangladesh, Nepal, and Pakistan.

Pakistan has experienced political instability and military influence in governance since the First Kashmir War. Internal and external political disputes among major civilian parties (including the Prime Minister and Tehrik-i-Taliban Pakistan (TTP)) and military power, in addition to corruption and mismanagement, have resulted in low BR rates, especially among marginalised groups (Idris, 2021).

Correspondingly, with the other UNICEF regions, socio-economic disparities significantly contribute to low BR rates in the region. Economic barriers such as indirect registration costs, limited resources in rural areas, and lack of awareness disproportionately affect poorer households. In all four aforementioned countries, unregistered children often come from disadvantaged communities, including migrants, refugees, and ethnic minorities (Sharma et al., 2023). The prevalence of conservative social norms and interpretations of gender roles further restricts registration efforts. In Afghanistan and Pakistan, societal expectations may limit women's ability to travel independently, hindering access to registration services as the primary persons responsible for completing this.

Additionally, female literacy rates are significantly lower than those of males, and restrictive cultural practices pose particular challenges for mothers (Mayhew et al., 2008). Across the region, coverage is hampered by missed opportunities to integrate BR with maternal and child health services. This issue is particularly evident in rural Nepal, where health centres often lack coordination with registration offices (Sharma et al., 2023).

There is a pronounced disparity in registration rates between urban and rural populations in Bangladesh. Urban areas have higher registration rates due to better access to services, while rural regions lag because of geographical and infrastructural inequalities. Bangladesh's high

population density, the 7th most densely populated country in the world, already burdens health and registration systems (Shonchoy et al., 2023).

Nepal has significantly improved BR rates, increasing from 58% in 2014 to 77% in 2019. However, stark disparities persist between provinces, profoundly impacting the achievement of universal BR. Some provinces continue to lag behind wealthier and more urbanised regions. The Multiple Indicator Cluster Surveys (MICS) of 2014 and 2019 indicate that while registration rates have improved nationwide, disadvantaged provinces (i.e. Karnali) have seen slower progress compared to provinces like Bagmati, which includes the capital Kathmandu (Sharma et al., 2023).

A strong urban-rural divide is evident, with urban areas benefiting from better access to registration centres, more awareness campaigns, and a more substantial government presence, leading to higher registration rates. In rural provinces characterised by vast mountainous terrain, geographical isolation, lack of infrastructure, and limited outreach programs contribute to lower registration rates. Access to registration facilities in these areas is often associated with logistical challenges, especially in unfavourable weather conditions.

Indigenous groups, called Dalits, and other marginalised communities overrepresented in provinces like Karnali, Nepal, face additional socio-economic barriers that hinder BR. Language barriers for those who speak Magar or Tamang and low levels of maternal education disproportionately affect these populations (vs. those who are versed in Nepali) (Sharma et al., 2023). Many families delay registering children until documentation is required for school enrollment or other services (aged 5+). This practice disproportionately affects young children, as MICS data shows lower registration rates for children under one year old than for older children (5+). The delay is more pronounced in provinces with limited health and administrative infrastructure, where the process is not integrated with immediate postnatal services (Sharma et al., 2023).

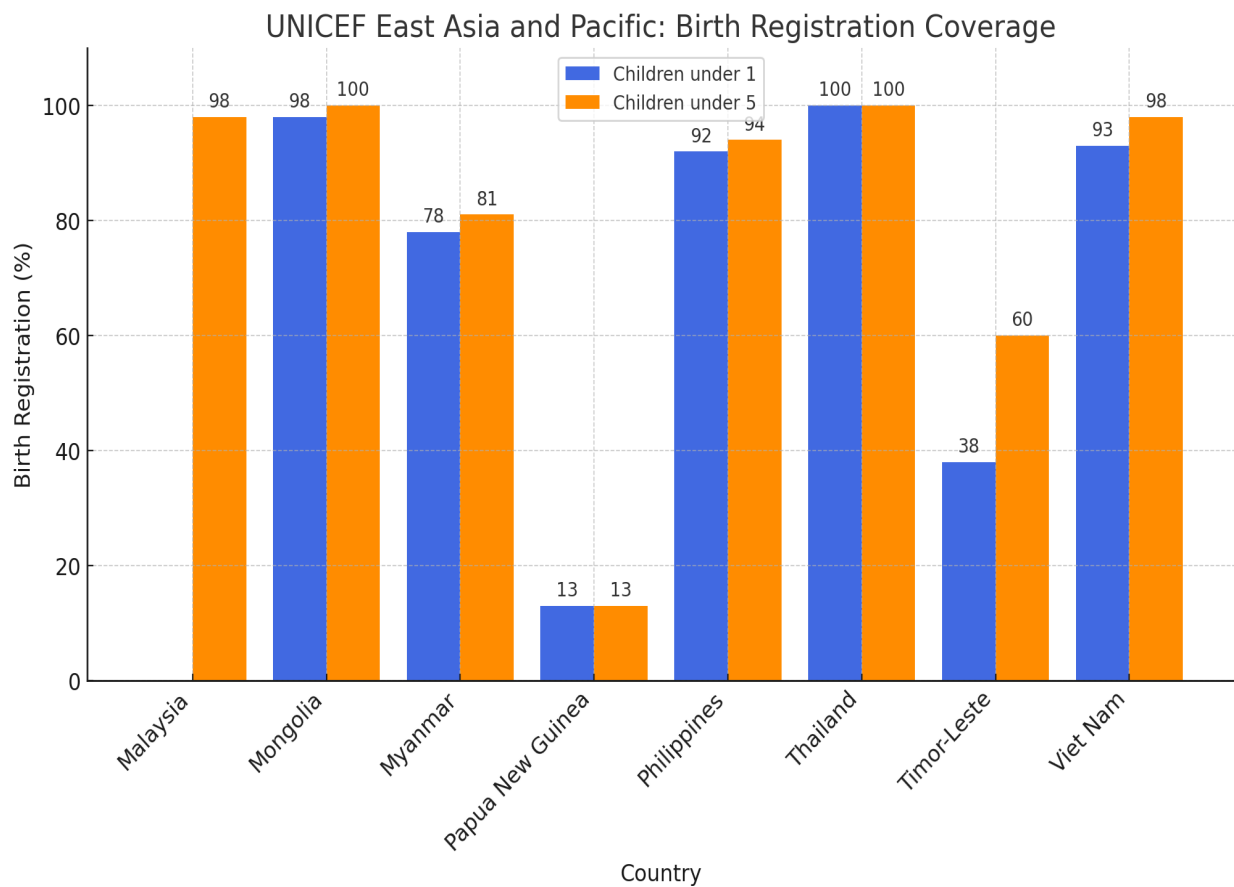
In Pakistan, discrimination against marginalised groups, including ethnic (Baloch, Sindhi, and Kalash) and religious (Christians, Hindus, Ahmadis, etc.) minorities, refugees, and children with

disabilities, hampers their access to BR. These systemic barriers are rooted in exclusionary social, cultural, and institutional practices, exacerbating these children's exclusion from vital services such as healthcare, legal protection, and educational attainment. Ethnic minorities often lack equal access to registration offices due to policies or practices that favour dominant groups (Punjabis and Muslim persons). For instance, Baloch and Pashtun persons may be geographically isolated with limited government presence, rendering registration inaccessible. Civil registration documents and procedures are often only available in dominant languages (e.g., Urdu), posing obstacles for non-native speakers.

Refugees, mainly Afghan and Rohingya populations in Pakistan, face unique challenges. Many are considered stateless or are not officially recognised by host governments, making it difficult to register the births of their children. Legal frameworks often exclude refugees or impose additional documentation requirements that they cannot meet. For example, Afghan refugees may be required to present residence permits or identity documents they do not possess. Moreover, discrimination against people with disabilities is prevalent, leading to the concealment of the identities of children with disabilities. Families may choose not to register these children due to fear of discrimination or social rejection (Idris, 2021).

## UNICEF EAST ASIA AND PACIFIC BR PRACTICES

**Figure A10. MICS East Asia and Pacific**



**Source:** Graph made by Tierney McCue using the data from the UNICEF Data Portal; **Note:** Data is unavailable in the NA categories.

Despite being one of the fastest-growing economic regions globally, East Asia and the Pacific include countries such as Laos, Vietnam, and Mongolia, which also experience incomplete BR rates. These countries face significant challenges in BR, similar to those observed in other low-income nations. This analysis highlights the common obstacles in these countries and emphasises unique difficulties.

All three countries are predominantly rural, and exhibit pronounced disparities between urban and rural areas. Remote rural regions often lack adequate administrative infrastructure, and ethnic-geographical factors significantly influence accessibility to BR services. This is particularly evident in Laos and Mongolia, where ethnic minorities and rural populations face the most significant challenges (Nomura et al., 2018).

Vietnam exhibits a pronounced urban-rural divide. While registration rates in urban areas have improved significantly in recent years, substantial gaps persist in rural regions. Despite overall progress, ethnic minorities (i.e. Tay, Thai, Hmong, Nung, Khmer-Krom, etc.) and individuals in geographically isolated, mountainous or highland areas continue to lag in registration rates (Giang et al., 2016). Rural residents can account for the gap (approximately 7%) for children registered <1 year old. The high level of poverty at 4.2% exacerbates this issue (Asian Development Bank, 2022). Although the Vietnamese government has waived official fees for BR, indirect costs, such as travel expenses to registration offices, loss of parents' daily wages, and costs associated with notarising documents, remain significant barriers for low-income families. These costs disproportionately affect low-income families in rural and remote areas, who may forego registration due to economic hardship. Families are often required to provide additional documentation, such as marriage certificates or household registry entries, which may not be readily available or may also be missing. This requirement mainly affects single parents and families in informal cohabitation. Marginalised groups, including migrants and ethnic minorities, are less likely to possess these documents, further complicating the registration process.

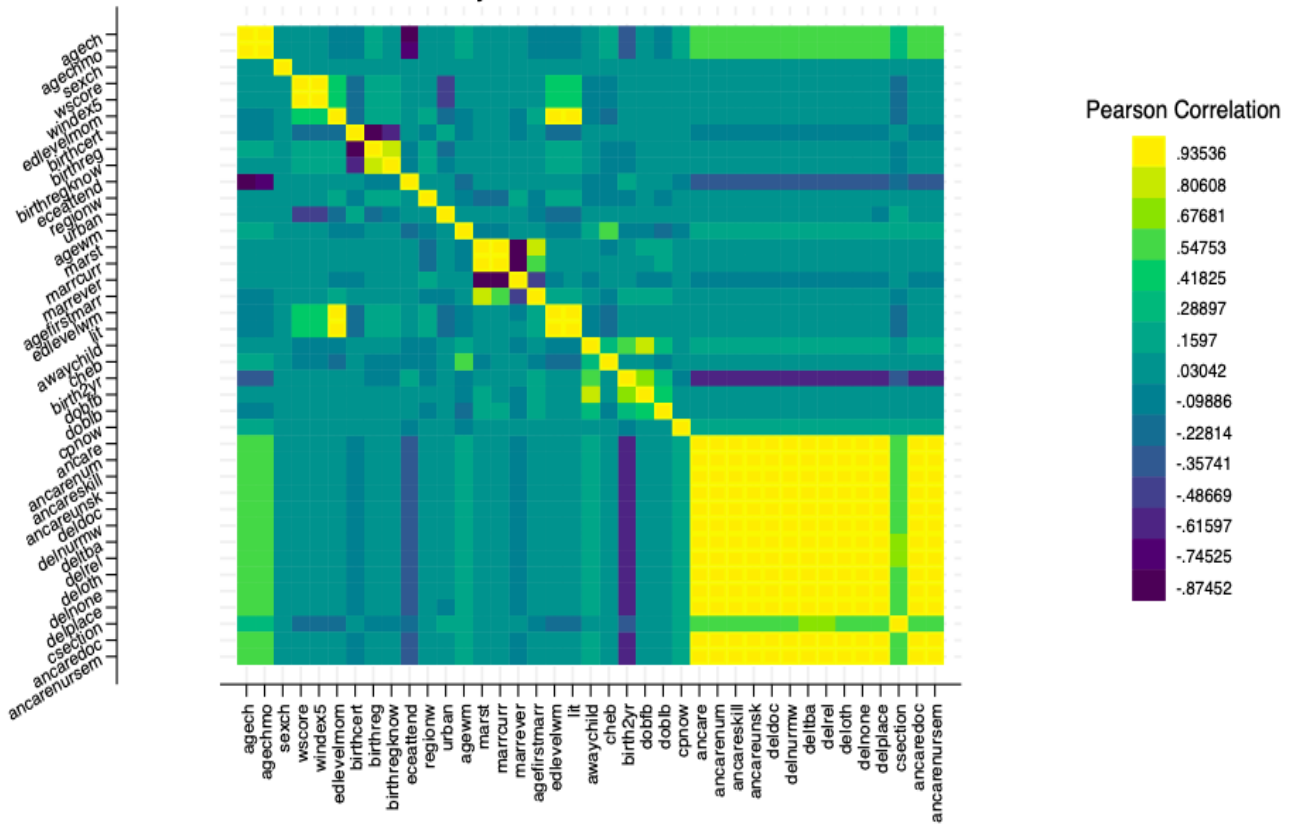
Mongolia is characterised by a sparse population density, which is indicative of a country with a low population density. Due to this nature, it faces unique challenges in BR. Many regions are remote and lack local registration offices. Additionally, unreliable internet connectivity in rural areas hinders the implementation of online registration systems. The nomadic population, in particular, has limited access to digital tools or platforms that could facilitate registration. Existing civil registration systems are paper-based and not fully integrated with digital platforms, leading to inefficiencies and reducing the potential for mobile or decentralised services (Spoorenberg, 2014). The nomadic lifestyle prevalent in Mongolia adds another layer of

complexity. Nomads often move long distances, searching for grazing land for their livestock, frequently crossing administrative borders. This mobility makes it challenging for families to access stationary registration offices in administrative centres (Yan et al., 2024). Seasonal migration disrupts BR schedules within the official period, leading to delays that may result in missed registrations.

Moreover, the registration systems are primarily designed for stationary populations, limiting their effectiveness for nomads who may not have an official address or temporarily reside in areas without registration facilities. Registration offices are concentrated in urban areas such as Ulaanbaatar, leaving rural regions underserved. Families in remote areas must travel long distances, often in harsh winters or challenging terrain, to access these services. Additionally, for many nomadic families, the benefits of BR are not immediately tangible. Access to education, healthcare, or government subsidies may not be relevant due to their remote lifestyle, reducing the perceived necessity of registration.

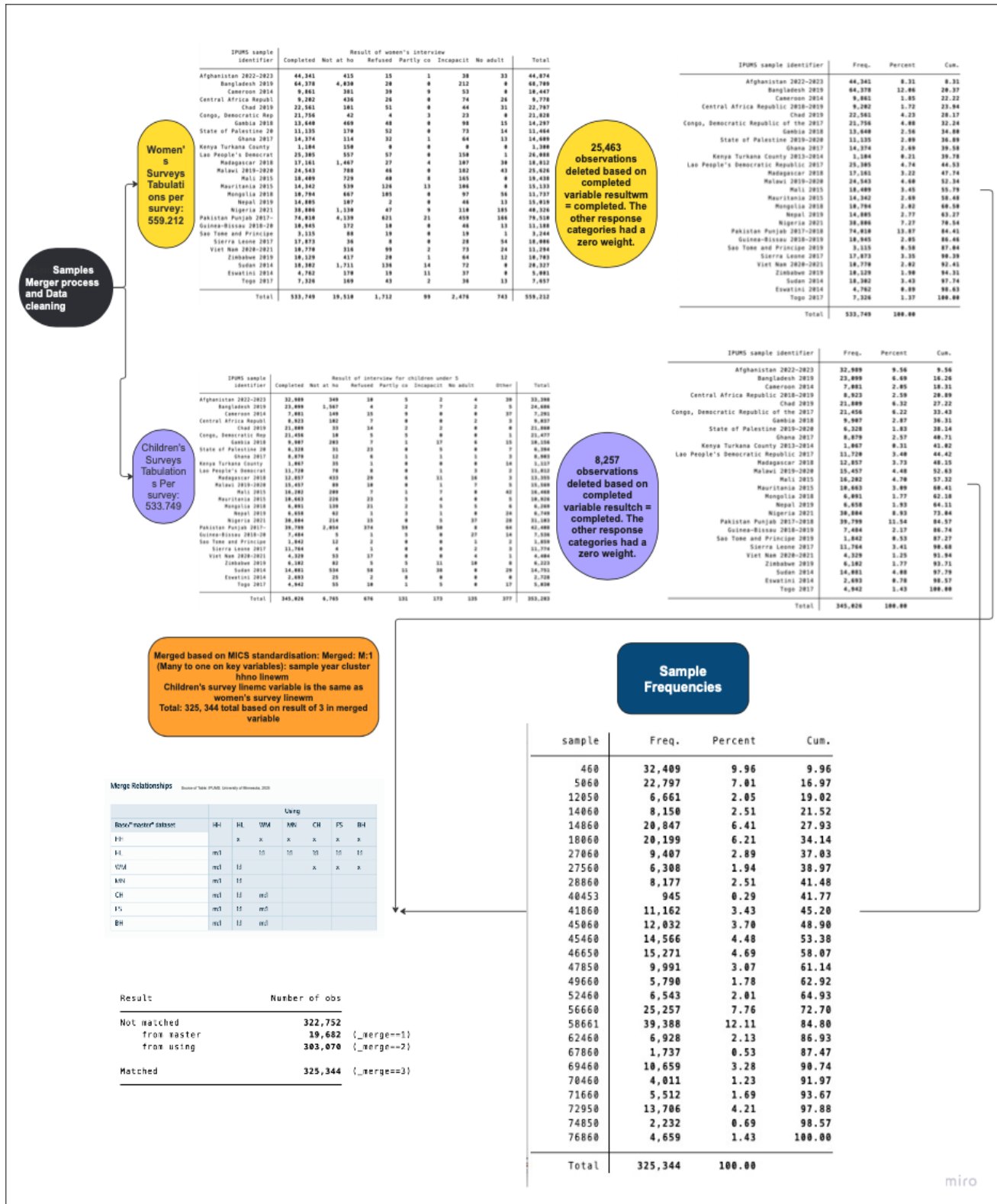
Figure A11.

Pearson Correlation Analysis of Raw Predictor Variables for Birth Certificate Data



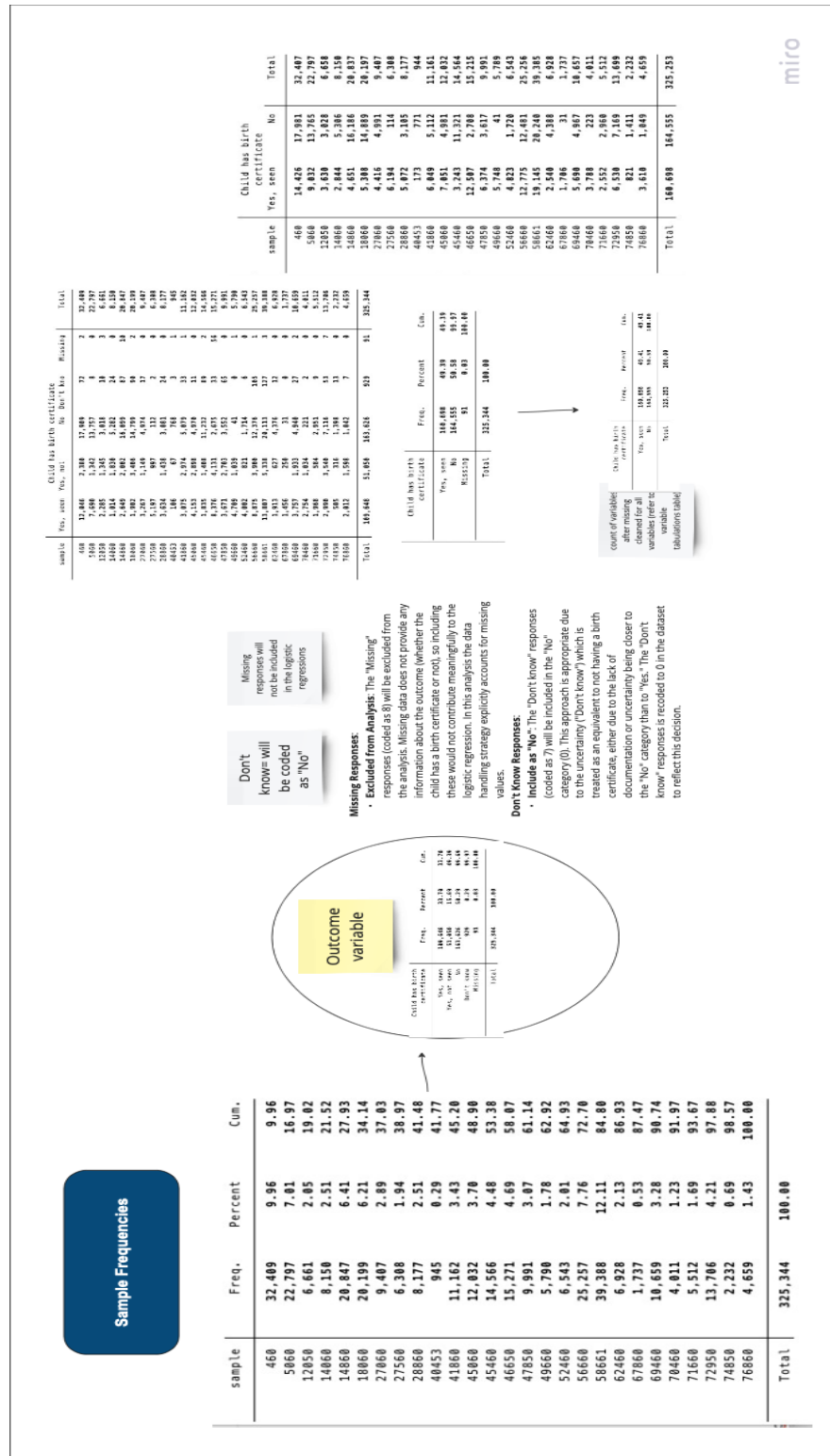
Source: Tierney McCue

Figure A12. 27 MICS Sample Merger Process (Women and Child Surveys)



Source: Tierney McCue

Figure A13. BIRTHCERT Outcome Variable Codification



**Figure A14. MICS Variable Coding**

| Variable Tabulations: unit analysis children 0-4 from merged MICS women/children survey |                                                        |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
|-----------------------------------------------------------------------------------------|--------------------------------------------------------|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|-------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|--------------------------------------|---------|-------|-------|-------------------------------|---------|-------|--------|-----------------|---------|--------|-------|-----------------|-----------------------------------------|--------|----------|-----------------|-------------------------------------------------------------------------------------------------------------|--------|-----------------------|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------|----------------------------------------------------------------|--|-----------|
| Source                                                                                  | Definition                                             | Variable   | Tabulation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Missing:                                             | Coded:                                                            | Recoded:                                                                                                                                                      | Reference Category |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| UNICEF Multiple Index Cluster Survey (MICS)                                             | Child's Age in Completed Years                         | agech      | <table><tr><th>Completed years</th><th>Freq.</th><th>Percent</th><th>Cum.</th></tr><tr><td>less than 1 year</td><td>10,000</td><td>30.00</td><td>29.4</td></tr><tr><td>1</td><td>10,000</td><td>30.00</td><td>59.4</td></tr><tr><td>2</td><td>10,000</td><td>30.00</td><td>89.4</td></tr><tr><td>3</td><td>10,000</td><td>30.00</td><td>100.0</td></tr><tr><td>Total</td><td>100,000</td><td>100.00</td><td></td></tr></table>                                                                                     | Completed years                                      | Freq.                                                             | Percent                                                                                                                                                       | Cum.               | less than 1 year                     | 10,000  | 30.00 | 29.4  | 1                             | 10,000  | 30.00 | 59.4   | 2               | 10,000  | 30.00  | 89.4  | 3               | 10,000                                  | 30.00  | 100.0    | Total           | 100,000                                                                                                     | 100.00 |                       | No missing           | less than 1 year= 0;<br>1=1;<br>2=2;<br>3=3,<br>4=4                                                                                                                                                |                                                                                                                                                        | less than 1           |            |                                                                |  |           |
| Completed years                                                                         | Freq.                                                  | Percent    | Cum.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| less than 1 year                                                                        | 10,000                                                 | 30.00      | 29.4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| 1                                                                                       | 10,000                                                 | 30.00      | 59.4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| 2                                                                                       | 10,000                                                 | 30.00      | 89.4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| 3                                                                                       | 10,000                                                 | 30.00      | 100.0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Total                                                                                   | 100,000                                                | 100.00     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| UNICEF Multiple Index Cluster Survey (MICS)                                             | Sex of the Child                                       | sexch      | <table><tr><th>Sex of child</th><th>Freq.</th><th>Percent</th><th>Cum.</th></tr><tr><td>Female</td><td>157,523</td><td>49.11</td><td>49.11</td></tr><tr><td>Male</td><td>163,246</td><td>50.89</td><td>100.00</td></tr><tr><td>Total</td><td>320,769</td><td>100.00</td><td></td></tr></table>                                                                                                                                                                                                                     | Sex of child                                         | Freq.                                                             | Percent                                                                                                                                                       | Cum.               | Female                               | 157,523 | 49.11 | 49.11 | Male                          | 163,246 | 50.89 | 100.00 | Total           | 320,769 | 100.00 |       | Dropped missing | Male=1;<br>Female=2                     |        | Male=1   |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Sex of child                                                                            | Freq.                                                  | Percent    | Cum.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Female                                                                                  | 157,523                                                | 49.11      | 49.11                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Male                                                                                    | 163,246                                                | 50.89      | 100.00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Total                                                                                   | 320,769                                                | 100.00     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| UNICEF Multiple Index Cluster Survey (MICS)                                             | Wealth Index Quantile                                  | windex5    | <table><tr><th>Wealth index quantile</th><th>Freq.</th><th>Percent</th><th>Cum.</th></tr><tr><td>Poorest</td><td>62,480</td><td>19.48</td><td>19.48</td></tr><tr><td>Second</td><td>70,973</td><td>22.15</td><td>41.63</td></tr><tr><td>Middle</td><td>62,176</td><td>19.39</td><td>61.02</td></tr><tr><td>Fourth</td><td>66,960</td><td>20.88</td><td>81.90</td></tr><tr><td>Richest</td><td>59,180</td><td>18.40</td><td>100.00</td></tr><tr><td>Total</td><td>320,769</td><td>100.00</td><td></td></tr></table> | Wealth index quantile                                | Freq.                                                             | Percent                                                                                                                                                       | Cum.               | Poorest                              | 62,480  | 19.48 | 19.48 | Second                        | 70,973  | 22.15 | 41.63  | Middle          | 62,176  | 19.39  | 61.02 | Fourth          | 66,960                                  | 20.88  | 81.90    | Richest         | 59,180                                                                                                      | 18.40  | 100.00                | Total                | 320,769                                                                                                                                                                                            | 100.00                                                                                                                                                 |                       | No missing | Poorest=1;<br>Second=2;<br>Middle=3;<br>Fourth=4;<br>Richest=5 |  | Poorest=1 |
| Wealth index quantile                                                                   | Freq.                                                  | Percent    | Cum.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Poorest                                                                                 | 62,480                                                 | 19.48      | 19.48                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Second                                                                                  | 70,973                                                 | 22.15      | 41.63                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Middle                                                                                  | 62,176                                                 | 19.39      | 61.02                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Fourth                                                                                  | 66,960                                                 | 20.88      | 81.90                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Richest                                                                                 | 59,180                                                 | 18.40      | 100.00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Total                                                                                   | 320,769                                                | 100.00     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| UNICEF Multiple Index Cluster Survey (MICS)                                             | Highest level of school attended by mother/caretaker   | edlevelmom | <table><tr><th>Highest level of school attended by mother/caretaker</th><th>Freq.</th><th>Percent</th><th>Cum.</th></tr><tr><td>Primary</td><td>100,000</td><td>31.18</td><td>31.18</td></tr><tr><td>Lower secondary</td><td>100,000</td><td>31.18</td><td>62.36</td></tr><tr><td>Upper secondary</td><td>100,000</td><td>31.18</td><td>93.54</td></tr><tr><td>Technical</td><td>100,000</td><td>31.18</td><td>100.00</td></tr><tr><td>Total</td><td>320,769</td><td>100.00</td><td></td></tr></table>             | Highest level of school attended by mother/caretaker | Freq.                                                             | Percent                                                                                                                                                       | Cum.               | Primary                              | 100,000 | 31.18 | 31.18 | Lower secondary               | 100,000 | 31.18 | 62.36  | Upper secondary | 100,000 | 31.18  | 93.54 | Technical       | 100,000                                 | 31.18  | 100.00   | Total           | 320,769                                                                                                     | 100.00 |                       | Dropped unknown, NIU | Less than primary= 10;<br>primary=20; lower secondary=30;<br>secondary or higher=40;<br>secondary=41; tertiary/ higher/<br>university=42; vocational/<br>technical = 50; Koranic or<br>Madrasa= 61 | Less than primary= 10;<br>primary=20; lower<br>secondary=30; secondary or<br>higher=40,41,42; vocational/<br>technical = 50; Koranic or<br>Madrasa= 61 | Less than primary= 10 |            |                                                                |  |           |
| Highest level of school attended by mother/caretaker                                    | Freq.                                                  | Percent    | Cum.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Primary                                                                                 | 100,000                                                | 31.18      | 31.18                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Lower secondary                                                                         | 100,000                                                | 31.18      | 62.36                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Upper secondary                                                                         | 100,000                                                | 31.18      | 93.54                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Technical                                                                               | 100,000                                                | 31.18      | 100.00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Total                                                                                   | 320,769                                                | 100.00     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| UNICEF Multiple Index Cluster Survey (MICS)                                             | Urban Status                                           | urban      | <table><tr><th>Urban Status (categorical)</th><th>Freq.</th><th>Percent</th><th>Cum.</th></tr><tr><td>Urban</td><td>86,489</td><td>26.96</td><td>26.96</td></tr><tr><td>Rural</td><td>234,280</td><td>73.04</td><td>100.00</td></tr><tr><td>Total</td><td>320,769</td><td>100.00</td><td></td></tr></table>                                                                                                                                                                                                        | Urban Status (categorical)                           | Freq.                                                             | Percent                                                                                                                                                       | Cum.               | Urban                                | 86,489  | 26.96 | 26.96 | Rural                         | 234,280 | 73.04 | 100.00 | Total           | 320,769 | 100.00 |       | No missing      | Rural= 2<br>Urban= 1<br>Refugee Camp= 5 |        | Rural= 2 |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Urban Status (categorical)                                                              | Freq.                                                  | Percent    | Cum.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Urban                                                                                   | 86,489                                                 | 26.96      | 26.96                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Rural                                                                                   | 234,280                                                | 73.04      | 100.00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Total                                                                                   | 320,769                                                | 100.00     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| UNICEF Multiple Index Cluster Survey (MICS)                                             | Currently married or in a union                        | marrcurr   | <table><tr><th>Currently married or in a union</th><th>Freq.</th><th>Percent</th><th>Cum.</th></tr><tr><td>Yes, currently married or in a union</td><td>100,000</td><td>31.18</td><td>31.18</td></tr><tr><td>No, not married or in a union</td><td>100,000</td><td>31.18</td><td>62.36</td></tr><tr><td>NIU</td><td>100,000</td><td>31.18</td><td>93.54</td></tr><tr><td>Total</td><td>320,769</td><td>100.00</td><td></td></tr></table>                                                                           | Currently married or in a union                      | Freq.                                                             | Percent                                                                                                                                                       | Cum.               | Yes, currently married or in a union | 100,000 | 31.18 | 31.18 | No, not married or in a union | 100,000 | 31.18 | 62.36  | NIU             | 100,000 | 31.18  | 93.54 | Total           | 320,769                                 | 100.00 |          | Dropped missing | Yes, currently married= 11, Yes, living with a partner/union= 12;<br>No, not in a union=20,<br>Missing = 98 |        | No, not in a union=20 |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Currently married or in a union                                                         | Freq.                                                  | Percent    | Cum.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Yes, currently married or in a union                                                    | 100,000                                                | 31.18      | 31.18                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| No, not married or in a union                                                           | 100,000                                                | 31.18      | 62.36                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| NIU                                                                                     | 100,000                                                | 31.18      | 93.54                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| Total                                                                                   | 320,769                                                | 100.00     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                      |                                                                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| UNICEF Multiple Index Cluster Survey (MICS)                                             | Assistance at delivery: doctor                         | deldoc     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                      | No=0; Yes, doctor=1;<br>NIU (not in universe)=9                   |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| UNICEF Multiple Index Cluster Survey (MICS)                                             | Assistance at delivery: nurse/midwife                  | delnrmw    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                      | No=0; Yes, nurse/midwife=1; NIU (not in universe)=9               |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| UNICEF Multiple Index Cluster Survey (MICS)                                             | Assistance at delivery: traditional birth attendant    | deltba     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                      | No=0; Yes, traditional birth attendant=1; NIU (not in universe)=9 | delivery assistance<br>1= Doctor; 2= Nurse/Midwife; 3= Traditional Birth Attendant; 4= Relative/Friend; 5= Other; 6= No one assisted; 9=NIU (not in Universe) | 1= Doctor          |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| UNICEF Multiple Index Cluster Survey (MICS)                                             | Assistance at delivery: relative, friend               | delrel     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                      | No=0; Yes, relative/friend=1; NIU (not in universe)=9             |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| UNICEF Multiple Index Cluster Survey (MICS)                                             | Assistance at delivery: other attendant, not specified | deloth     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                      | No=0; Yes, other=1; NIU (not in universe)=9                       |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |
| UNICEF Multiple Index Cluster Survey (MICS)                                             | Assistance at delivery: no one                         | delnone    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                      | No=0; Yes, no one assisted=1; NIU (not in universe)=9             |                                                                                                                                                               |                    |                                      |         |       |       |                               |         |       |        |                 |         |        |       |                 |                                         |        |          |                 |                                                                                                             |        |                       |                      |                                                                                                                                                                                                    |                                                                                                                                                        |                       |            |                                                                |  |           |

Source: Tierney McCue

Figure A15. Global Variables

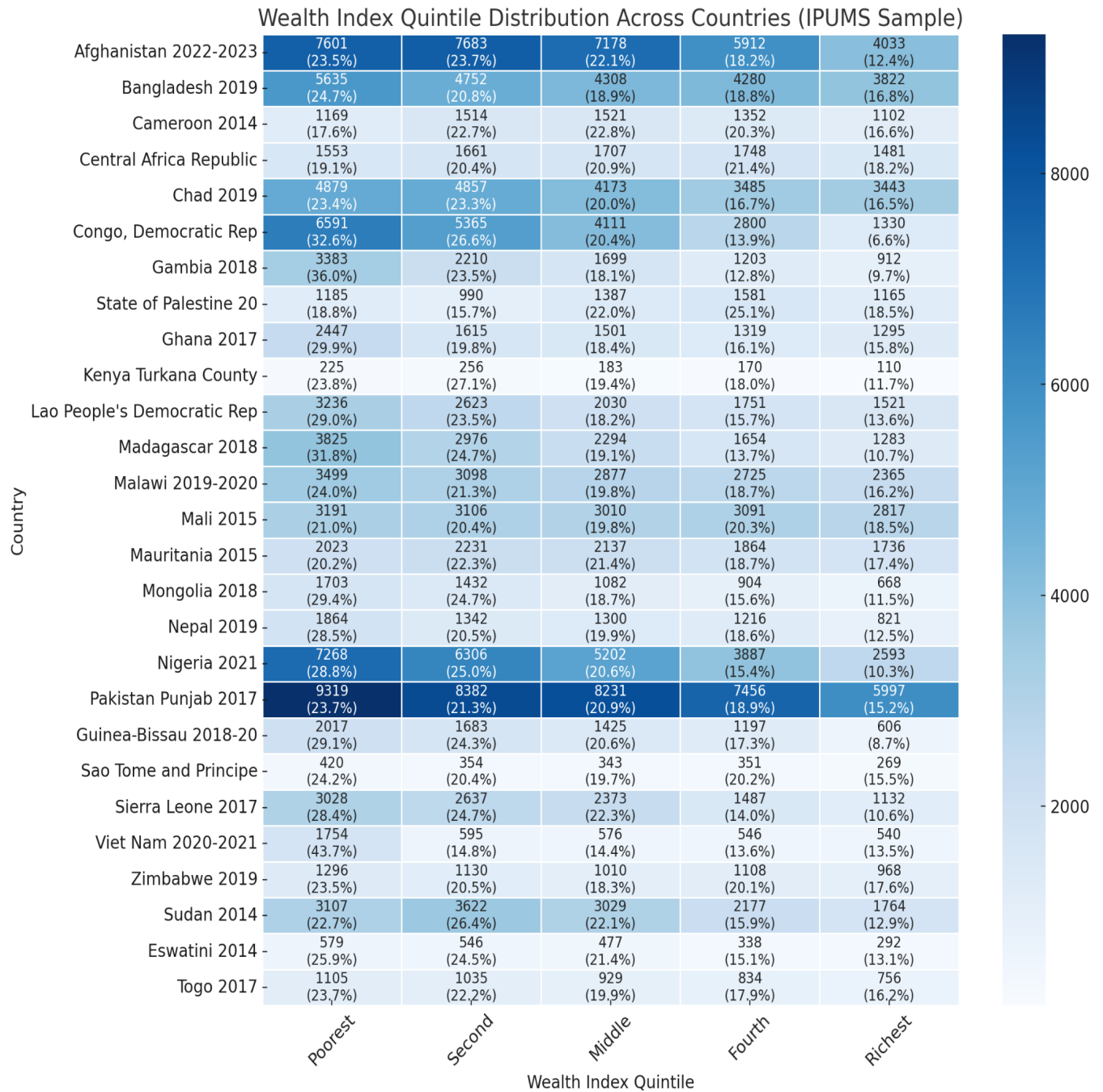
| Variable Tabulations: unit analysis children 0-4 from merged MICS women/children survey |                                                         |                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
|-----------------------------------------------------------------------------------------|---------------------------------------------------------|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|--|--|--|------|-------|---------|-----|---------|---------|-------|-------|--------------|--------|-------|--------|-----------|---------|--------|--------|-------|---------|--------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|--------|-------|---------------------------------------------------------------------------------------------------------------------------|--------|------|-------|---|--------|------|-------|---|--------|------|-------|---|--------|------|-------|----|--------|------|-------|----|--------|------|-------|----|--------|------|-------|----|--------|------|-------|----|--------|------|--------|-------|---------|--------|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Source                                                                                  | Definition                                              | Variable                    | Tabulation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Notes                                 |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| Statistical Performance Indicators, The World Bank                                      | Civil Registration and Vital Statistics (CRVS) Complete | SPI.D4.2.3.CRVS             | <table><tr><th colspan="4">CRVS MICS Categories</th></tr><tr><th>CRVS</th><th>Freq.</th><th>Percent</th><th>Gr.</th></tr><tr><td>No CRVS</td><td>232,145</td><td>93.28</td><td>89.19</td></tr><tr><td>Partial CRVS</td><td>14,447</td><td>5.72</td><td>100.00</td></tr><tr><td>Full CRVS</td><td>248,799</td><td>100.00</td><td></td></tr><tr><td>Total</td><td>324,799</td><td>100.00</td><td></td></tr></table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | CRVS MICS Categories                  |  |  |  | CRVS | Freq. | Percent | Gr. | No CRVS | 232,145 | 93.28 | 89.19 | Partial CRVS | 14,447 | 5.72  | 100.00 | Full CRVS | 248,799 | 100.00 |        | Total | 324,799 | 100.00 |        | Indicator: Birth Registrations 90% complete and death registration 75% complete according to UNSD. Scoring is as follows: 1 Points. Both of at least 90% of births registered and at least 75% of deaths registered 0.5 Points. One of at least 90% of births registered or at least 75% of deaths registered 0 Points. Neither                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| CRVS MICS Categories                                                                    |                                                         |                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| CRVS                                                                                    | Freq.                                                   | Percent                     | Gr.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| No CRVS                                                                                 | 232,145                                                 | 93.28                       | 89.19                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| Partial CRVS                                                                            | 14,447                                                  | 5.72                        | 100.00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| Full CRVS                                                                               | 248,799                                                 | 100.00                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| Total                                                                                   | 324,799                                                 | 100.00                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| World Bank Group, CPIA database                                                         | CPIA gender equality rating (1=low to 6=high)           | CPIA.Combined               | <table><tr><th colspan="4">CPIA Combined</th></tr><tr><th>Gr.</th><th>Freq.</th><th>Percent</th><th>Gr.</th></tr><tr><td>Low</td><td>224,576</td><td>89.27</td><td>89.19</td></tr><tr><td>Low-Medium</td><td>24,417</td><td>7.51</td><td>100.00</td></tr><tr><td>High</td><td>47,407</td><td>14.92</td><td>100.00</td></tr><tr><td>Total</td><td>324,799</td><td>100.00</td><td></td></tr></table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | CPIA Combined                         |  |  |  | Gr.  | Freq. | Percent | Gr. | Low     | 224,576 | 89.27 | 89.19 | Low-Medium   | 24,417 | 7.51  | 100.00 | High      | 47,407  | 14.92  | 100.00 | Total | 324,799 | 100.00 |        | Unweighted average; Gender equality evaluates a country's institutions and programs ensuring equal access for men and women in education, health, the economy, and legal protection.                                                                                                                                                                                         |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| CPIA Combined                                                                           |                                                         |                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| Gr.                                                                                     | Freq.                                                   | Percent                     | Gr.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| Low                                                                                     | 224,576                                                 | 89.27                       | 89.19                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| Low-Medium                                                                              | 24,417                                                  | 7.51                        | 100.00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| High                                                                                    | 47,407                                                  | 14.92                       | 100.00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| Total                                                                                   | 324,799                                                 | 100.00                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| United Nations Sustainable Development Goal Database                                    | Dimension 3.1: Social Statistics                        | SPI.DIM3.1.INDEX            | <table><tr><th colspan="4">SDG Target 3.1</th></tr><tr><th>Gr.</th><th>Freq.</th><th>Percent</th><th>Gr.</th></tr><tr><td>Low</td><td>28,023</td><td>8.60</td><td>8.99</td></tr><tr><td>Low-Medium</td><td>89,144</td><td>27.43</td><td>100.00</td></tr><tr><td>High</td><td>40,141</td><td>12.32</td><td>100.00</td></tr><tr><td>Total</td><td>324,799</td><td>100.00</td><td></td></tr></table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | SDG Target 3.1                        |  |  |  | Gr.  | Freq. | Percent | Gr. | Low     | 28,023  | 8.60  | 8.99  | Low-Medium   | 89,144 | 27.43 | 100.00 | High      | 40,141  | 12.32  | 100.00 | Total | 324,799 | 100.00 |        | Average score for Goal 1-6 indicators from the UN SDG database, supplemented for OECD countries with data per <i>Measuring Distance to the SDG Targets 2019</i> . Scores may reflect data submission willingness rather than performance. Unweighted average of indicators in this dimension. Scores range from 0-1, with a score of 1 representing the best possible score. |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| SDG Target 3.1                                                                          |                                                         |                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| Gr.                                                                                     | Freq.                                                   | Percent                     | Gr.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| Low                                                                                     | 28,023                                                  | 8.60                        | 8.99                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| Low-Medium                                                                              | 89,144                                                  | 27.43                       | 100.00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| High                                                                                    | 40,141                                                  | 12.32                       | 100.00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| Total                                                                                   | 324,799                                                 | 100.00                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| Statistical Performance Indicators, The World Bank                                      | SPI Overall Score                                       | SPI_Quartile                | <table><tr><th colspan="4">4 Quartiles of SPI_Quartile</th></tr><tr><th>Gr.</th><th>Freq.</th><th>Percent</th><th>Gr.</th></tr><tr><td>1</td><td>79,109</td><td>24.35</td><td>24.35</td></tr><tr><td>2</td><td>89,144</td><td>27.43</td><td>51.69</td></tr><tr><td>3</td><td>40,141</td><td>12.32</td><td>64.01</td></tr><tr><td>4</td><td>61,205</td><td>18.89</td><td>100.00</td></tr><tr><td>Total</td><td>324,799</td><td>100.00</td><td></td></tr></table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 4 Quartiles of SPI_Quartile           |  |  |  | Gr.  | Freq. | Percent | Gr. | 1       | 79,109  | 24.35 | 24.35 | 2            | 89,144 | 27.43 | 51.69  | 3         | 40,141  | 12.32  | 64.01  | 4     | 61,205  | 18.89  | 100.00 | Total                                                                                                                                                                                                                                                                                                                                                                        | 324,799 | 100.00 |       | Weighted average of all statistical performance indicators. Scores range from 0-100 with 100 representing the best score. |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 4 Quartiles of SPI_Quartile                                                             |                                                         |                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| Gr.                                                                                     | Freq.                                                   | Percent                     | Gr.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 1                                                                                       | 79,109                                                  | 24.35                       | 24.35                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 2                                                                                       | 89,144                                                  | 27.43                       | 51.69                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 3                                                                                       | 40,141                                                  | 12.32                       | 64.01                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 4                                                                                       | 61,205                                                  | 18.89                       | 100.00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| Total                                                                                   | 324,799                                                 | 100.00                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| World Health Organization Global Health Expenditure database                            | Current health expenditure per capita (current US\$)    | health_expenditure_category | <table><tr><th colspan="4">Current Health Expenditure per Capita</th></tr><tr><th>Gr.</th><th>Freq.</th><th>Percent</th><th>Gr.</th></tr><tr><td>1</td><td>11,436</td><td>3.52</td><td>3.52</td></tr><tr><td>2</td><td>24,417</td><td>7.51</td><td>11.03</td></tr><tr><td>3</td><td>24,417</td><td>7.51</td><td>18.54</td></tr><tr><td>4</td><td>24,417</td><td>7.51</td><td>26.05</td></tr><tr><td>5</td><td>24,417</td><td>7.51</td><td>33.56</td></tr><tr><td>6</td><td>24,417</td><td>7.51</td><td>41.07</td></tr><tr><td>7</td><td>24,417</td><td>7.51</td><td>48.58</td></tr><tr><td>8</td><td>24,417</td><td>7.51</td><td>56.09</td></tr><tr><td>9</td><td>24,417</td><td>7.51</td><td>63.60</td></tr><tr><td>10</td><td>24,417</td><td>7.51</td><td>71.11</td></tr><tr><td>11</td><td>24,417</td><td>7.51</td><td>78.62</td></tr><tr><td>12</td><td>24,417</td><td>7.51</td><td>86.13</td></tr><tr><td>13</td><td>24,417</td><td>7.51</td><td>93.64</td></tr><tr><td>14</td><td>24,417</td><td>7.51</td><td>100.00</td></tr><tr><td>Total</td><td>324,799</td><td>100.00</td><td></td></tr></table> | Current Health Expenditure per Capita |  |  |  | Gr.  | Freq. | Percent | Gr. | 1       | 11,436  | 3.52  | 3.52  | 2            | 24,417 | 7.51  | 11.03  | 3         | 24,417  | 7.51   | 18.54  | 4     | 24,417  | 7.51   | 26.05  | 5                                                                                                                                                                                                                                                                                                                                                                            | 24,417  | 7.51   | 33.56 | 6                                                                                                                         | 24,417 | 7.51 | 41.07 | 7 | 24,417 | 7.51 | 48.58 | 8 | 24,417 | 7.51 | 56.09 | 9 | 24,417 | 7.51 | 63.60 | 10 | 24,417 | 7.51 | 71.11 | 11 | 24,417 | 7.51 | 78.62 | 12 | 24,417 | 7.51 | 86.13 | 13 | 24,417 | 7.51 | 93.64 | 14 | 24,417 | 7.51 | 100.00 | Total | 324,799 | 100.00 |  | The WHO's Global Health Expenditure Database, based on the SHA 2011 Framework, standardizes health expenditure data for international comparison. Estimates of current health expenditures per capita in current US dollars cover healthcare goods and services consumed annually. |
| Current Health Expenditure per Capita                                                   |                                                         |                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| Gr.                                                                                     | Freq.                                                   | Percent                     | Gr.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 1                                                                                       | 11,436                                                  | 3.52                        | 3.52                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 2                                                                                       | 24,417                                                  | 7.51                        | 11.03                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 3                                                                                       | 24,417                                                  | 7.51                        | 18.54                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 4                                                                                       | 24,417                                                  | 7.51                        | 26.05                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 5                                                                                       | 24,417                                                  | 7.51                        | 33.56                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 6                                                                                       | 24,417                                                  | 7.51                        | 41.07                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 7                                                                                       | 24,417                                                  | 7.51                        | 48.58                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 8                                                                                       | 24,417                                                  | 7.51                        | 56.09                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 9                                                                                       | 24,417                                                  | 7.51                        | 63.60                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 10                                                                                      | 24,417                                                  | 7.51                        | 71.11                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 11                                                                                      | 24,417                                                  | 7.51                        | 78.62                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 12                                                                                      | 24,417                                                  | 7.51                        | 86.13                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 13                                                                                      | 24,417                                                  | 7.51                        | 93.64                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| 14                                                                                      | 24,417                                                  | 7.51                        | 100.00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |
| Total                                                                                   | 324,799                                                 | 100.00                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                       |  |  |  |      |       |         |     |         |         |       |       |              |        |       |        |           |         |        |        |       |         |        |        |                                                                                                                                                                                                                                                                                                                                                                              |         |        |       |                                                                                                                           |        |      |       |   |        |      |       |   |        |      |       |   |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |       |    |        |      |        |       |         |        |  |                                                                                                                                                                                                                                                                                    |

miro

miro

Source: Tierney McCue

**Figure A16. Wealth Index Quintile Distribution Across Countries (IPUMS Sample)**



**Source: Tierney McCue**

# 1 Appendix A: Historical Birth Registration and Current UNICEF BR Data, Figures Referenced in the Text, Data Cleaning Process

| Survey                       | Table A1: Data Cleaning Steps - Household Level                                                                                                                                                                                                                                                                                                     |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Afghanistan 2022–2023</b> | <ul style="list-style-type: none"> <li>• Removed 2 observations with missing 'Currently married or in a union'.</li> <li>• Dropped 35 outliers with 'Number of Children' &gt; 11.</li> <li>• Removed 20 observations with missing/invalid 'Mobile Phone Ownership'.</li> <li>• One child randomly selected per household.</li> </ul>                |
| <b>DR Congo 2017</b>         | <ul style="list-style-type: none"> <li>• Merged 4th and 5th Wealth Index quantiles.</li> <li>• Reclassified 154 'Other' responses in wealth index as missing.</li> <li>• Applied household weights (one child per household).</li> </ul>                                                                                                            |
| <b>Madagascar 2018</b>       | <ul style="list-style-type: none"> <li>• Removed 2 missing values in 'Married Currently'.</li> <li>• Collapsed Wealth Index into fewer categories.</li> <li>• Reclassified 'Number of Children' into '4+'.</li> <li>• Applied weights at child, determinant, and household levels.</li> </ul>                                                       |
| <b>Lao PDR 2017</b>          | <ul style="list-style-type: none"> <li>• Merged 4th and 5th Wealth Index quantiles.</li> <li>• Ensured consistent variable coding.</li> <li>• Applied child weights for child-level variables and household weights for household-level variables.</li> </ul>                                                                                       |
| <b>Sudan 2014</b>            | <ul style="list-style-type: none"> <li>• Merged 4th and 5th wealth quintiles (1,764 changes).</li> <li>• Reclassified 'Number of Children' <math>\geq 5</math> into one category (36 changes).</li> <li>• Removed 15 missing observations on mother's education.</li> <li>• Deleted 12 observations with missing mobile phone ownership.</li> </ul> |

| Variable                                               | Table A2: Data Cleaning Steps- Country-Level                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Urban/Rural Division                                   | <ul style="list-style-type: none"> <li>Excluded 1,157 observations from refugee camps.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                  |
| Mother/Caretaker's Level of Education                  | <ul style="list-style-type: none"> <li>Recoded into three final categories: <ul style="list-style-type: none"> <li>Low Education: less than primary and primary.</li> <li>Middle Education: lower secondary.</li> <li>High Education: secondary and above.</li> </ul> </li> <li>Excluded 3,418 observations from small subcategories (e.g., Koranic/Madrasa, Vocational/Technical).</li> <li>Merged Primary and Lower Secondary into a single category.</li> </ul> |
| SPI (Statistical Performance Indicators) Overall Score | <ul style="list-style-type: none"> <li>Re-categorised into quartiles: <ul style="list-style-type: none"> <li>First, Second, Third, and Fourth Quartile.</li> </ul> </li> </ul>                                                                                                                                                                                                                                                                                     |
| CPIA Gender Equality Rating                            | <ul style="list-style-type: none"> <li>Recategorised into three groups: <ul style="list-style-type: none"> <li>Group 1 (Low): Ratings 1–2.</li> <li>Group 2 (Medium): Ratings 3–4.</li> <li>Group 3 (High): Ratings 5–6.</li> </ul> </li> </ul>                                                                                                                                                                                                                    |
| Dimension 3.1: Social Statistics                       | <ul style="list-style-type: none"> <li>Divided into four ordinal groups: <ul style="list-style-type: none"> <li>Group 1 (Low): 0.61</li> <li>Group 2 (Low-Medium): 0.61–0.70</li> <li>Group 3 (Medium-High): 0.70–0.73</li> <li>Group 4 (High): &gt; 0.73</li> </ul> </li> </ul>                                                                                                                                                                                   |
| Health Expenditure (per Capita)                        | <ul style="list-style-type: none"> <li>Categorised into five groups: <ul style="list-style-type: none"> <li>Group 1: &lt; 29.7</li> <li>Group 2: 29.7–43.49</li> <li>Group 3: 43.5–54.8</li> <li>Group 4: 54.8–83.8</li> <li>Group 5: &gt; 83.8</li> </ul> </li> </ul>                                                                                                                                                                                             |

## 2 Appendix B: MICS 2013-2023 Sample Frequencies Distribution

**\*Table B1:** Sample Frequencies and Percentages

| Sample                                | Freq.   | Percent | Cum.   |
|---------------------------------------|---------|---------|--------|
| Afghanistan 2022-2023                 | 32,407  | 10.10   | 10.10  |
| Bangladesh 2017-2018                  | 22,797  | 7.11    | 17.21  |
| Cameroon 2014                         | 6,658   | 2.08    | 19.29  |
| Central Africa Republic 2018          | 8,150   | 2.54    | 21.83  |
| Chad 2019                             | 20,837  | 6.50    | 28.32  |
| Democratic Republic of the Congo      | 20,197  | 6.30    | 34.62  |
| Gambia 2018                           | 9,407   | 2.93    | 37.55  |
| State of Palestine 2019-2020          | 5,242   | 1.63    | 39.19  |
| Ghana 2017                            | 8,177   | 2.55    | 41.73  |
| Kenya Turkana County 2013-2014        | 944     | 0.29    | 42.03  |
| Lao People's Democratic Republic 2017 | 10,844  | 3.38    | 45.41  |
| Madagascar 2018                       | 12,032  | 3.75    | 49.16  |
| Malawi 2019-2020                      | 14,544  | 4.53    | 53.69  |
| Mali 2015                             | 15,215  | 4.74    | 58.44  |
| Mauritania 2015                       | 7,891   | 2.46    | 60.90  |
| Mongolia 2018                         | 5,064   | 1.58    | 62.48  |
| Nepal 2019                            | 6,543   | 2.04    | 64.52  |
| Nigeria 2021                          | 25,256  | 7.87    | 72.39  |
| Pakistan Punjab 2017-2018             | 39,385  | 12.28   | 84.67  |
| Guinea-Bissau 2018-2019               | 6,877   | 2.14    | 86.81  |
| São Tomé and Príncipe                 | 1,737   | 0.54    | 87.35  |
| Sierra Leone 2017                     | 10,657  | 3.32    | 90.68  |
| Viet Nam 2020-2021                    | 3,806   | 1.19    | 91.86  |
| Zimbabwe 2019                         | 5,512   | 1.72    | 93.58  |
| Sudan 2014                            | 13,699  | 4.27    | 97.85  |
| Eswatini 2014                         | 2,232   | 0.70    | 98.55  |
| Togo 2017                             | 4,659   | 1.45    | 100.00 |
| Total                                 | 320,769 | 100.00  |        |

**\*Table B2:** MICS Sampling Design

| Country               | Survey Year | Strata                                                             | Population Size (UN) |
|-----------------------|-------------|--------------------------------------------------------------------|----------------------|
| Afghanistan           | 2022-2023   | Urban/rural within each province                                   | 41,128,771           |
| Bangladesh            | 2019        | Urban/rural within each district                                   | 163,046,161          |
| Cameroon              | 2014        | Urban/rural and provincial divisions                               | 22,300,000           |
| CAR                   | 2018-2019   | Urban-rural and regional divisions                                 | 4,666,000            |
| Chad                  | 2019        | Urban and rural areas within each province, selected in two stages | 16,425,864           |
| Dem. Rep. Congo       | 2017        | Urban-rural and regional divisions                                 | 81,398,764           |
| Gambia                | 2018        | Urban/rural areas within each Local Government Area (LGA)          | 2,280,000            |
| State of Palestine    | 2019-2020   | Urban/rural/camp within each region                                | 4,780,978            |
| Ghana                 | 2017        | Urban-rural and administrative regions                             | 29,121,465           |
| Kenya (Turkana)       | 2013-2014   | Urban-rural and regional stratification                            | 926,976              |
| Lao                   | 2017        | Urban-rural and provincial divisions                               | 6,858,160            |
| Madagascar            | 2018        | Urban-rural and regional divisions                                 | 26,262,313           |
| Malawi                | 2019-2020   | Urban-rural and regional divisions                                 | 18,628,747           |
| Mali                  | 2015        | Urban-rural and regional divisions                                 | 17,600,000           |
| Mauritania            | 2015        | Urban-rural and regional divisions                                 | 3,984,000            |
| Mongolia              | 2018        | Urban-rural and regional divisions                                 | 3,179,997            |
| Nepal                 | 2019        | Urban-rural and provincial divisions                               | 28,608,710           |
| Nigeria               | 2021        | Urban-rural and state divisions                                    | 213,401,323          |
| Pakistan (Punjab)     | 2017-2018   | Urban-rural and district divisions within Punjab province          | 110,012,442          |
| Guinea-Bissau         | 2018-2019   | Urban-rural and regional divisions                                 | 1,874,309            |
| Sao Tome and Principe | 2019        | Urban-rural and regional divisions                                 | 215,056              |
| Sierra Leone          | 2017        | Urban-rural and regional divisions                                 | 7,557,212            |
| Viet Nam              | 2020-2021   | Urban-rural and regional divisions                                 | 97,338,579           |
| Zimbabwe              | 2019        | Urban-rural and provincial divisions                               | 14,645,468           |
| Sudan                 | 2014        | Urban/rural areas within each state                                | 37,289,406           |
| Eswatini              | 2014        | Urban/rural within each region                                     | 1,093,238            |
| Togo                  | 2017        | Urban/rural in each zone                                           | 7,606,374            |

**\*Table B3:** Child Birth Certificate Ownership by Country

| Country                          | No (%)                 | Yes (%)                | Total          |
|----------------------------------|------------------------|------------------------|----------------|
| Afghanistan 2022-2023            | 17,981 (55.5%)         | 14,426 (44.5%)         | 32,407         |
| Bangladesh 2017-2018             | 13,765 (60.4%)         | 9,032 (39.6%)          | 22,797         |
| Cameroon 2014                    | 3,028 (45.5%)          | 3,630 (54.5%)          | 6,658          |
| Central African Republic         | 5,306 (65.1%)          | 2,844 (34.9%)          | 8,150          |
| Chad 2019                        | 16,186 (77.7%)         | 4,651 (22.3%)          | 20,837         |
| Democratic Republic of Congo     | 14,889 (73.7%)         | 5,308 (26.3%)          | 20,197         |
| Gambia 2018                      | 4,991 (53.1%)          | 4,416 (46.9%)          | 9,407          |
| State of Palestine 2019-2020     | 94 (1.8%)              | 5,148 (98.2%)          | 5,242          |
| Ghana 2017                       | 3,105 (38.0%)          | 5,072 (62.0%)          | 8,177          |
| Kenya Turkana County             | 771 (81.7%)            | 173 (18.3%)            | 944            |
| Lao People's Democratic Republic | 5,067 (46.7%)          | 5,777 (53.3%)          | 10,844         |
| Madagascar 2018                  | 4,981 (41.4%)          | 7,051 (58.6%)          | 12,032         |
| Malawi 2019-2020                 | 11,306 (77.8%)         | 3,238 (22.2%)          | 14,544         |
| Mali 2015                        | 2,708 (17.8%)          | 12,507 (82.2%)         | 15,215         |
| Mauritania 2015                  | 2,698 (34.2%)          | 5,193 (65.8%)          | 7,891          |
| Mongolia 2018                    | 34 (0.7%)              | 5,030 (99.3%)          | 5,064          |
| Nepal 2019                       | 1,720 (26.3%)          | 4,823 (73.7%)          | 6,543          |
| Nigeria 2021                     | 12,481 (49.4%)         | 12,775 (50.6%)         | 25,256         |
| Pakistan Punjab 2017-2018        | 20,240 (51.4%)         | 19,145 (48.6%)         | 39,385         |
| Guinea-Bissau 2018-2019          | 4,372 (63.6%)          | 2,505 (36.4%)          | 6,877          |
| São Tomé and Príncipe 2019       | 31 (1.8%)              | 1,706 (98.2%)          | 1,737          |
| Sierra Leone 2017                | 4,967 (46.6%)          | 5,690 (53.4%)          | 10,657         |
| Viet Nam 2020-2021               | 219 (5.8%)             | 3,587 (94.2%)          | 3,806          |
| Zimbabwe 2019                    | 2,960 (53.7%)          | 2,552 (46.3%)          | 5,512          |
| Sudan 2014                       | 7,169 (52.3%)          | 6,530 (47.7%)          | 13,699         |
| Eswatini 2014                    | 1,411 (63.2%)          | 821 (36.8%)            | 2,232          |
| Togo 2017                        | 1,049 (22.5%)          | 3,610 (77.5%)          | 4,659          |
| <b>Total</b>                     | <b>163,529 (51.0%)</b> | <b>157,240 (49.0%)</b> | <b>320,769</b> |

**\*Table B4:** Urban Status by Wealth Index Quintile (with percentages)

| Urban Status | Wealth Index Quintile |                |                |                |                | Total          |
|--------------|-----------------------|----------------|----------------|----------------|----------------|----------------|
|              | Poorest               | Second         | Middle         | Fourth         | Richest        |                |
| Urban        | 6,412 (7.4%)          | 7,780 (9.0%)   | 14,486 (16.8%) | 25,281 (29.2%) | 32,530 (37.6%) | 86,489 (100%)  |
| Rural        | 76,191 (32.5%)        | 65,197 (27.8%) | 50,690 (21.6%) | 30,384 (13.0%) | 11,818 (5.0%)  | 234,280 (100%) |
| Total        | 82,603 (25.8%)        | 72,977 (22.8%) | 65,176 (20.3%) | 55,665 (17.4%) | 44,348 (13.8%) | 320,769 (100%) |

**\*Table B5:** Cross Table Distribution of Mothers' Educational Attainment and BC Outcomes

| Highest Level of<br>School Attended by<br>Mother/Caretaker | Child has Birth Certificate |         | Total   | Percentage |         |
|------------------------------------------------------------|-----------------------------|---------|---------|------------|---------|
|                                                            | No                          | Yes     |         | No (%)     | Yes (%) |
| Less than primary                                          | 79,762                      | 53,801  | 133,563 | 59.7       | 40.3    |
| Primary + Lower Secondary                                  | 55,348                      | 51,017  | 106,365 | 52.0       | 48.0    |
| Secondary or higher                                        | 28,380                      | 52,386  | 80,766  | 35.1       | 64.9    |
| Unknown                                                    | 39                          | 36      | 75      | 52.0       | 48.0    |
| Total                                                      | 163,529                     | 157,240 | 320,769 | 51.0       | 49.0    |

### 3 Appendix C: Model Configurations

#### 3.1 Preliminary Assessment of Variance Inflation Factor (VIF) Prior to Main Analysis

#### 3.2 Null Model

$$\text{logit}(\text{birthcert}) = \beta_0 + u_{\text{imicscluster}} + v_{\text{hhno}} + \epsilon.$$

$$u_{\text{imicscluster}} \sim N(0, \sigma_{\text{imicscluster}}^2).$$

$$v_{\text{hhno}} \sim N(0, \sigma_{\text{hhno}}^2).$$

$$\epsilon \sim N(0, \sigma^2).$$

- $\beta_0$  is the *overall intercept* (average log-odds of having a birth certificate).
- $u_{\text{imicscluster}} \sim N(0, \sigma_{\text{imicscluster}}^2)$  represents the *random intercept* for each cluster (e.g., community/district).
- $v_{\text{hhno}} \sim N(0, \sigma_{\text{hhno}}^2)$  represents the *random intercept* for each household.
- $\epsilon \sim N(0, \sigma^2)$  is the individual-level residual error.

#### 3.3 Intraclass Correlation

$$\text{ICC} = \frac{\sigma_{\text{imicscluster}}^2 + \sigma_{\text{hhno}}^2}{\sigma_{\text{imicscluster}}^2 + \sigma_{\text{hhno}}^2 + \sigma^2}.$$

### 3.4 Child and Maternal Characteristics Model within the Household

$$\begin{aligned} \log\left(\frac{P(Y_{ijk} = 1)}{1 - P(Y_{ijk} = 1)}\right) = & \beta_0 + \beta_1 \text{Age}_{ijk} + \beta_2 \text{Sex}_{ijk} + \beta_3 \text{Wealth}_{ijk} \\ & + \beta_4 \text{DeliveryAssistance}_{ijk} + \beta_5 \text{Urban}_{ijk} + \beta_6 \text{MotherEd}_{ijk} \\ & + \beta_7 \text{Marriage}_{ijk} + \beta_8 \text{SexHead}_{ijk} + u_k + v_{jk} + \epsilon_{ijk}. \end{aligned}$$

**Where:**

- $Y_{ijk}$  is the binary outcome variable (birth certificate possession).
- $i$  represents the child level,  $j$  represents the household level, and  $k$  represents the cluster level.
- $\beta_0$  is the intercept.
- $\beta_1, \beta_2, \dots, \beta_8$  are the fixed-effect coefficients for predictors:
  - $\text{Age}_{ijk}$ : Child's age (categorical: `i.agech`)
  - $\text{Sex}_{ijk}$ : Child's sex (categorical: `i.sexch`)
  - $\text{Wealth}_{ijk}$ : Wealth index (categorical: `i.windex5`)
  - $\text{DeliveryPlace}_{ijk}$ : Birth Delivery Assistance (categorical: `i.delivery_assistance`)
  - $\text{Urban}_{ijk}$ : Urban–rural factor (categorical: `i.urban_factor`)
  - $\text{MotherEd}_{ijk}$ : Mother's education level (categorical: `i.edlevelmom`)
  - $\text{Marriage}_{ijk}$ : Mother's current marital status (categorical: `i.marrcurr`)
  - $\text{SexHead}_{ijk}$ : Sex of household head (categorical: `i.sexhhead`)
- **Random Effects:**
  - $u_k \sim N(0, \sigma_u^2)$  is the cluster-level random intercept (variation across clusters: `imicscluster`).
  - $v_{jk} \sim N(0, \sigma_v^2)$  is the household-level random intercept (variation across households: `hhno`).
  - $\epsilon_{ijk}$  is the residual error term.
- **Weighting:**
  - The model applies probability weights `pweight = weightch`, meaning individual-level observations are weighted accordingly with `weightch` for the child level; this was done according to the sample structures of the MICS survey which already accounts for the household weight.
- **Variance–Covariance Estimation:**
  - The model uses robust standard errors `vce(robust)`, which adjust for heteroskedasticity or model misspecification.

$$u_k \sim N(0, \sigma_u^2).$$

$$v_{jk} \sim N(0, \sigma_v^2).$$

### 3.5 Household Structure and Access Model

$$\log\left(\frac{P(Y_{ijk} = 1)}{1 - P(Y_{ijk} = 1)}\right) = \beta_0 + \sum_m \beta_m X_{ijk}^m + u_k + v_{jk} + \epsilon_{ijk}.$$

**Where:**

- $Y_{ijk}$ : Binary outcome (child has a birth certificate).
- $i$ : Individual/child level,  $j$ : Household level,  $k$ : Cluster level.
- $\beta_0$ : Intercept.
- $X_{ijk}$ : Fixed-effect predictors:
  - `i.agech`: Child’s age (categorical)
  - `i.sexch`: Child’s sex (categorical)
  - `i.windex5`: Wealth index (categorical)
  - `i.delivery_assistance`: Assistance of delivery (categorical)
  - `i.urban_factor`: Urban–rural status (categorical)
  - `i.edlevelmom`: Mother’s education level (categorical)
  - `i.marrcurr`: Mother’s marital status (categorical)
  - `i.sexhhead`: Household head’s sex (categorical)
  - `i.numch`: Number of children in the household (categorical)
  - `i.agehead`: Age of the household head (categorical)
  - `i.mobphone_gh`: Mobile phone ownership in the household (categorical)

**Random Effects:**

- $u_k \sim N(0, \sigma_u^2)$ : Cluster-level variation (`imicscluster`).
- $v_{jk} \sim N(0, \sigma_v^2)$ : Household-level variation (`hhno`).
- $\epsilon_{ijk}$ : Residual error term.

**Weighting:**

- The model applies probability weights `pweight = weightch`, meaning individual-level observations are weighted accordingly with `weightch` for the child level; this was done according to the sample structures of the MICS survey which already accounts for the household weight.

Where:

- $\gamma_1$  is the coefficient for the interaction between wealth index and mother’s education level, (`WealthIndex5ijk × EducationLevelMotherijk`).
- $\gamma_2$  is the coefficient for the interaction between urban factor and wealth index, (`UrbanFactorijk × WealthIndex5ijk`).
- $\gamma_3$  is the coefficient for the interaction between current marital status and sex of household head,
- $v_{jk}$  is the random effect at the household level, capturing unobserved heterogeneity across households within clusters.
- $\epsilon_{ijk}$  is the error term at the individual level, capturing unobserved heterogeneity at the individual level.

**Random Effects:**

- $u_k \sim N(0, \sigma_u^2)$ : Cluster-level variation (`imicscluster`).
- $v_{jk} \sim N(0, \sigma_v^2)$ : Household-level variation (`hhno`).
- $\epsilon_{ijk}$ : Residual error term.

### 3.6 Household Structure and Access Model with Interaction Terms

$$\log\left(\frac{P(Y_{ijk} = 1)}{1 - P(Y_{ijk} = 1)}\right) = \beta_0 + \sum_m \beta_m X_{ijk}^m + u_k + v_{jk} + \epsilon_{ijk}.$$

**Where:**

- $Y_{ijk}$ : Binary outcome (child has a birth certificate).
- $i$ : Individual/child level,  $j$ : Household level,  $k$ : Cluster level.
- $\beta_0$ : Intercept.
- $X_{ijk}$ : Fixed-effect predictors:
  - `i.agech`: Child's age (categorical)
  - `i.sexch`: Child's sex (categorical)
  - `ib3.windex5`: Wealth index (categorical, baseline = 3)
  - `i.delivery_assistance`: Assistance of delivery (categorical)
  - `i.urban_factor`: Urban-rural status (categorical)
  - `i.edlevelmom`: Mother's education level (categorical)
  - `i.marrcurr`: Mother's marital status (categorical)
  - `i.sexhhead`: Household head's sex (categorical)
  - `i.numch`: Number of children in the household (categorical)
  - `i.mobphone_gh`: Mobile phone ownership in the household (categorical)

**Interaction Terms:**

- `i.windex5`  $\times$  `i.edlevelmom`: Wealth index and mother's education level.
- `i.marrcurr`  $\times$  `i.sexhhead`: Marital status and household head's sex.

**Random Effects:**

- $u_k \sim N(0, \sigma_u^2)$ : Cluster-level variation (`imicscluster`).
- $v_{jk} \sim N(0, \sigma_v^2)$ : Household-level variation (`hhno`).
- $\epsilon_{ijk}$ : Residual error term.

**Weighting:**

- The model applies probability weights `pweight = weightch`, meaning individual-level observations are weighted accordingly with `weightch` for the child level; this was done according to the sample structures of the MICS survey which already accounts for the household weight.

**Where:**

- $\gamma_1$  is the coefficient for the interaction between wealth index and mother's education level, (`WealthIndex5ijk`  $\times$  `EducationLevelMotherijk`).
- $\gamma_2$  is the coefficient for the interaction between marital status and sex of household head, (`MaritalStatusijk`  $\times$  `SexHeadijk`).
- $v_{jk}$  is the random effect at the household level, capturing unobserved heterogeneity across households within clusters.
- $\epsilon_{ijk}$  is the error term at the individual level, capturing unobserved heterogeneity at the individual level.

## 4 Appendix D: MICS Afghanistan 2022-2023

**\*Table D1:** Afghanistan 2022-2023: Model Fit Statistics

| Model      | Log Pseudo-likelihood | AIC       | BIC       | ICC (Imicscluster) | ICC (hhno) | Wald Chi <sup>2</sup> | DoF |
|------------|-----------------------|-----------|-----------|--------------------|------------|-----------------------|-----|
| Null Model | -14895.631            | 30,849.40 | 30,874.55 | 0.414682           | 0.76512    | -                     | -   |
| Model 2    | -14515.01             | 29,072.03 | 29,248.20 | 0.4105             | 0.4336     | 343.10                | 24  |
| Model 3    | -14487.71             | 29,037.42 | 29,297.49 | 0.4036             | 0.4317     | 380.21                | 34  |
| Model 4    | -14476.52             | 29,041.04 | 29,409.70 | 0.4060             | 0.4344     | 413.05                | 47  |

### Statistical Summary

|                                          |               |
|------------------------------------------|---------------|
| Number of observations                   | 32,350        |
| Wald chi-square (31)                     | 380.21        |
| Prob > chi-square                        | 0.0000        |
| Observations per group (Min / Avg / Max) | 8 / 33.3 / 68 |
| Integration points                       | 10            |

**\*Table D2:** Afghanistan 2022-2023: VIF Table

| Variable         | VIF         | 1/VIF    |
|------------------|-------------|----------|
| agech 1          | 1.59        | 0.629589 |
| agech 2          | 1.94        | 0.516738 |
| agech 3          | 1.82        | 0.548243 |
| agech 4          | 1.93        | 0.518902 |
| 1.sexch          | 1.00        | 0.998764 |
| windex5 2        | 1.65        | 0.605817 |
| windex5 3        | 1.75        | 0.570697 |
| windex5 4        | 1.81        | 0.552127 |
| windex5 5        | 2.01        | 0.496852 |
| delivery_a ~ e 2 | 5.09        | 0.196333 |
| delivery_a ~ e 3 | 2.23        | 0.447591 |
| delivery_a ~ e 4 | 4.07        | 0.245968 |
| delivery_a ~ e 5 | 1.15        | 0.868606 |
| delivery_a ~ e 6 | 1.30        | 0.769259 |
| delivery_a ~ e 9 | 5.43        | 0.184240 |
| 2.urban_fa ~ r   | 1.32        | 0.759123 |
| edlevelmom 20    | 1.04        | 0.960999 |
| edlevelmom 30    | 1.03        | 0.971965 |
| edlevelmom 40    | 1.11        | 0.901880 |
| marrcurr 20      | 1.06        | 0.944622 |
| marrcurr 98      | 1.00        | 0.947854 |
| 2.sexhhead       | 1.06        | 0.947854 |
| numch 2          | 1.97        | 0.508426 |
| numch 3          | 1.86        | 0.537679 |
| numch 4          | 1.41        | 0.710980 |
| numch 5          | 1.22        | 0.820880 |
| numch 6          | 1.15        | 0.869484 |
| numch 7          | 1.08        | 0.923340 |
| numch 8          | 1.04        | 0.962704 |
| numch 9          | 1.04        | 0.963613 |
| numch 10         | 1.02        | 0.982179 |
| 1.mobphone~ h    | 1.24        | 0.807675 |
| <b>Mean VIF</b>  | <b>1.75</b> |          |

**\*Table D3: Descriptive Statistics-Variable Distributions (MICS Afghanistan 2022-2023, N= 32,350)**

| Variable                                           | No Birth Certificate | Has Birth Certificate | Total           |
|----------------------------------------------------|----------------------|-----------------------|-----------------|
| <b>Child's age in completed years</b>              |                      |                       |                 |
| Less than 1 year                                   | 3,239 (50.5%)        | 3,176 (49.5%)         | 6,415 (100.0%)  |
| 1 year                                             | 3,042 (50.2%)        | 3,021 (49.8%)         | 6,063 (100.0%)  |
| 2 years                                            | 3,615 (57.9%)        | 2,620 (42.1%)         | 6,235 (100.0%)  |
| 3 years                                            | 3,840 (57.9%)        | 2,791 (42.1%)         | 6,631 (100.0%)  |
| 4 years                                            | 4,221 (60.3%)        | 2,785 (39.7%)         | 7,006 (100.0%)  |
| <b>Total</b>                                       | 17,957 (55.5%)       | 14,393 (44.5%)        | 32,350 (100.0%) |
| <b>Sex of child</b>                                |                      |                       |                 |
| Female                                             | 8,894 (56.3%)        | 6,915 (43.7%)         | 15,809 (100.0%) |
| Male                                               | 9,063 (54.7%)        | 7,478 (45.3%)         | 16,541 (100.0%) |
| <b>Total</b>                                       | 17,957 (55.5%)       | 14,393 (44.5%)        | 32,350 (100.0%) |
| <b>Wealth index quintile</b>                       |                      |                       |                 |
| Poorest                                            | 5,209 (68.6%)        | 2,382 (31.4%)         | 7,591 (100.0%)  |
| Second                                             | 4,557 (59.4%)        | 3,115 (40.6%)         | 7,672 (100.0%)  |
| Middle                                             | 3,821 (53.3%)        | 3,356 (46.7%)         | 7,177 (100.0%)  |
| Fourth                                             | 2,799 (47.5%)        | 3,091 (52.5%)         | 5,890 (100.0%)  |
| Richest                                            | 1,571 (39.1%)        | 2,449 (60.9%)         | 4,020 (100.0%)  |
| <b>Total</b>                                       | 17,957 (55.5%)       | 14,393 (44.5%)        | 32,350 (100.0%) |
| <b>Delivery Assistance</b>                         |                      |                       |                 |
| Doctor                                             | 655 (38.7%)          | 1,037 (61.3%)         | 1,692 (100.0%)  |
| Nurse/Midwife                                      | 5,349 (46.7%)        | 6,112 (53.3%)         | 11,461 (100.0%) |
| Traditional Birth Att                              | 1,605 (73.7%)        | 571 (26.3%)           | 2,176 (100.0%)  |
| Relative/Friend                                    | 4,381 (66.6%)        | 2,197 (33.4%)         | 6,578 (100.0%)  |
| Other                                              | 148 (58.7%)          | 104 (41.3%)           | 252 (100.0%)    |
| No one assisted                                    | 295 (58.0%)          | 214 (42.0%)           | 509 (100.0%)    |
| Missing                                            | 5,524 (57.1%)        | 4,158 (42.9%)         | 9,682 (100.0%)  |
| <b>Total</b>                                       | 17,957 (55.5%)       | 14,393 (44.5%)        | 32,350 (100.0%) |
| <b>Urban Status</b>                                |                      |                       |                 |
| Urban                                              | 2,281 (46.5%)        | 2,627 (53.5%)         | 4,908 (100.0%)  |
| Rural                                              | 15,676 (57.2%)       | 11,766 (42.8%)        | 27,442 (100.0%) |
| <b>Total</b>                                       | 17,957 (55.5%)       | 14,393 (44.5%)        | 32,350 (100.0%) |
| <b>Mother's education level</b>                    |                      |                       |                 |
| Less than primary                                  | 15,581 (58.4%)       | 11,097 (41.6%)        | 26,678 (100.0%) |
| Primary                                            | 1,141 (45.9%)        | 1,341 (54.1%)         | 2,482 (100.0%)  |
| Lower secondary                                    | 422 (40.3%)          | 625 (59.7%)           | 1,047 (100.0%)  |
| Secondary or higher                                | 813 (37.9%)          | 1,330 (62.1%)         | 2,143 (100.0%)  |
| <b>Total</b>                                       | 17,957 (55.5%)       | 14,393 (44.5%)        | 32,350 (100.0%) |
| <b>Currently married or in a union</b>             |                      |                       |                 |
| Yes, currently married                             | 17,715 (55.5%)       | 14,237 (44.5%)        | 31,952 (100.0%) |
| No, not in a union                                 | 242 (60.8%)          | 156 (39.2%)           | 398 (100.0%)    |
| <b>Total</b>                                       | 17,957 (55.5%)       | 14,393 (44.5%)        | 32,350 (100.0%) |
| <b>Sex of household head</b>                       |                      |                       |                 |
| Male                                               | 17,418 (55.7%)       | 13,872 (44.3%)        | 31,290 (100.0%) |
| Female                                             | 539 (50.8%)          | 521 (49.2%)           | 1,060 (100.0%)  |
| <b>Total</b>                                       | 17,957 (55.5%)       | 14,393 (44.5%)        | 32,350 (100.0%) |
| <b>HH has mobile phone</b>                         |                      |                       |                 |
| No                                                 | 4,223 (72.3%)        | 1,612 (27.7%)         | 5,835 (100.0%)  |
| Yes                                                | 13,734 (51.8%)       | 12,781 (48.2%)        | 26,515 (100.0%) |
| <b>Total</b>                                       | 17,957 (55.5%)       | 14,393 (44.5%)        | 32,350 (100.0%) |
| <b>Number of children under age 5 in household</b> |                      |                       |                 |
| 1 child                                            | 3,405 (51.4%)        | 3,208 (48.6%)         | 6,613 (100.0%)  |
| 2 children                                         | 7,102 (54.7%)        | 5,899 (45.3%)         | 13,001 (100.0%) |
| 3 children                                         | 3,945 (58.1%)        | 2,847 (41.9%)         | 6,792 (100.0%)  |
| 4 children                                         | 1,633 (57.9%)        | 1,185 (42.1%)         | 2,818 (100.0%)  |
| 5 children                                         | 784 (58.0%)          | 570 (42.0%)           | 1,354 (100.0%)  |
| 6 children                                         | 512 (57.7%)          | 376 (42.3%)           | 888 (100.0%)    |
| 7 children                                         | 294 (64.9%)          | 159 (35.1%)           | 453 (100.0%)    |
| 8 children                                         | 104 (59.8%)          | 70 (40.2%)            | 174 (100.0%)    |
| 9 children                                         | 126 (66.0%)          | 62 (34.0%)            | 188 (100.0%)    |
| 10 children                                        | 52 (75.4%)           | 17 (24.6%)            | 69 (100.0%)     |
| <b>Total</b>                                       | 17,957 (55.5%)       | 14,393 (44.5%)        | 32,350 (100.0%) |

## \*Table D4: Null Model-ICC

### Null Model Results

Integration Method: mvaghermite

Integration Points: 7

Wald  $\chi^2$  (0): .

Log Pseudolikelihood: -14895.631

Prob >  $\chi^2$ : .

(Standard errors adjusted for 972 clusters in imicscluster)

| Model Coefficients          |           |           |       |           |                       |
|-----------------------------|-----------|-----------|-------|-----------|-----------------------|
| Variable                    | Odds      | Std. Err. | z     | $P >  z $ | [95% Conf. Interval]  |
| _cons                       | 0.6623546 | 0.0540188 | -5.05 | 0.000     | [0.5645081, 0.777161] |
| <b>imicscluster</b>         |           |           |       |           |                       |
| var(_cons)                  | 5.8083    | 0.4600438 |       |           | [4.973132, 6.783722]  |
| <b>imicscluster&gt;hhno</b> |           |           |       |           |                       |
| var(_cons)                  | 4.908468  | 0.4048322 |       |           | [4.175822, 5.769656]  |

Note: Estimates are transformed only in the first equation to odds.

## \*Table D5: Intraclass Correlation Coefficients (ICC)

| Intraclass Correlation |           |           |                        |
|------------------------|-----------|-----------|------------------------|
| Level                  | ICC       | Std. Err. | [95% Conf. Interval]   |
| imicscluster           | 0.414682  | 0.0146249 | [0.3863362, 0.4436041] |
| hhno > imicscluster    | 0.7651208 | 0.0131772 | [0.7383187, 0.7899586] |

**\*Table D6: Afghanistan Model 2: Birth Certificate Determinants Model within the Household**

| Mixed-effects logistic regression                       |               |                        |                                   |         |                    |
|---------------------------------------------------------|---------------|------------------------|-----------------------------------|---------|--------------------|
| Number of observations = 32,350                         |               |                        |                                   |         |                    |
| Grouping Information                                    |               |                        |                                   |         |                    |
| Group variable                                          | No. of groups | Minimum                | Average                           | Maximum |                    |
| imicscluster                                            | 972           | 8                      | 33.3                              | 68      |                    |
| hhno                                                    | 16,749        | 1                      | 1.9                               | 10      |                    |
| Model Information                                       |               |                        |                                   |         |                    |
| Integration method: mvaghermite                         |               | Integration points = 7 |                                   |         |                    |
| Wald chi <sup>2</sup> (21) = 343.10                     |               |                        | Log pseudolikelihood = -14515.014 |         |                    |
| Prob > chi <sup>2</sup> = 0.0000                        |               |                        |                                   |         |                    |
| (Std. errors adjusted for 972 clusters in imicscluster) |               |                        |                                   |         |                    |
| Parameter Estimates                                     |               |                        |                                   |         |                    |
| Variable                                                | Odds Ratio    | Robust std. err.       | z                                 | P >  z  | 95% Conf. Interval |
| Child's Age (Ref: Age 0)                                |               |                        |                                   |         |                    |
| 1                                                       | 0.9470        | 0.0885                 | -0.58                             | 0.560   | [0.7885, 1.1374]   |
| 2                                                       | 0.4457        | 0.0456                 | -7.89                             | 0.000   | [0.3646, 0.5448]   |
| 3                                                       | 0.4139        | 0.0451                 | -8.18                             | 0.000   | [0.3343, 0.5124]   |
| 4                                                       | 0.3593        | 0.0405                 | -9.07                             | 0.000   | [0.2880, 0.4483]   |
| Sex of Child (Ref: Female)                              |               |                        |                                   |         |                    |
| Male                                                    | 1.0920        | 0.0555                 | 1.73                              | 0.083   | [0.9885, 1.2065]   |
| Household Wealth Index (Ref: Third Quintile)            |               |                        |                                   |         |                    |
| Poorest                                                 | 0.6690        | 0.0737                 | -3.65                             | 0.000   | [0.5390, 0.8302]   |
| Second                                                  | 0.8165        | 0.0724                 | -2.29                             | 0.022   | [0.6863, 0.9715]   |
| Fourth                                                  | 1.1621        | 0.1188                 | 1.47                              | 0.142   | [0.9511, 1.4199]   |
| Richest                                                 | 1.6991        | 0.2445                 | 3.68                              | 0.000   | [1.2816, 2.2527]   |
| Delivery Assistance (Ref: Doctor)                       |               |                        |                                   |         |                    |
| Nurse/Midwife                                           | 1.0955        | 0.1620                 | 0.63                              | 0.528   | [0.7933, 1.5139]   |
| Traditional Birth Attendant                             | 0.3628        | 0.0704                 | -5.23                             | 0.000   | [0.2481, 0.5306]   |
| Relative/Friend                                         | 0.3867        | 0.0635                 | -5.79                             | 0.000   | [0.2803, 0.5335]   |
| Other                                                   | 0.3086        | 0.1245                 | -2.92                             | 0.004   | [0.1400, 0.6803]   |
| No one assisted                                         | 0.6102        | 0.1954                 | -1.54                             | 0.123   | [0.3258, 1.1430]   |
| Missing                                                 | 0.8810        | 0.1441                 | -0.77                             | 0.439   | [0.6394, 1.2139]   |
| Urban/Rural Res (Ref: Urban)                            |               |                        |                                   |         |                    |
| Rural                                                   | 0.5315        | 0.1148                 | -2.93                             | 0.003   | [0.3480, 0.8117]   |
| Education Level Mother (Ref: Less than Primary)         |               |                        |                                   |         |                    |
| Primary                                                 | 1.3451        | 0.1455                 | 2.74                              | 0.006   | [1.0881, 1.6628]   |
| Lower secondary                                         | 1.6404        | 0.3029                 | 2.68                              | 0.007   | [1.1424, 2.3556]   |
| Secondary or higher                                     | 1.9456        | 0.2608                 | 4.97                              | 0.000   | [1.4962, 2.5302]   |
| Currently Married (Ref: Married)                        |               |                        |                                   |         |                    |
| No, not in a union                                      | 0.5610        | 0.1756                 | -1.85                             | 0.065   | [0.3038, 1.0360]   |
| Sex Head of Household (Ref: Male)                       |               |                        |                                   |         |                    |
| Female                                                  | 1.5213        | 0.2610                 | 2.45                              | 0.014   | [1.0869, 2.1293]   |
| Constant                                                |               |                        |                                   |         |                    |
| _cons                                                   | 2.3407        | 0.6389                 | 3.16                              | 0.002   | [1.3801, 3.9699]   |
| Random effects (variance components)                    |               |                        |                                   |         |                    |
| imicscluster                                            |               |                        |                                   |         |                    |
| var(_cons)                                              | 5.1960        | 0.4105                 |                                   |         | [4.4586, 6.0663]   |
| imicscluster>hhno                                       |               |                        |                                   |         |                    |
| var(_cons)                                              | 5.1894        | 0.4336                 |                                   |         | [4.4055, 6.1128]   |

**\*Table D7:Afghanistan for Model 3: Household Structure and Access Model**

| Mixed-effects logistic regression                       |               |                        |                                   |         |                    |
|---------------------------------------------------------|---------------|------------------------|-----------------------------------|---------|--------------------|
| Number of observations = 32,350                         |               |                        |                                   |         |                    |
| Grouping Information                                    |               |                        |                                   |         |                    |
| Group variable                                          | No. of groups | Minimum                | Average                           | Maximum |                    |
| imicscluster                                            | 972           | 8                      | 33.3                              | 68      |                    |
| hhno                                                    | 16,749        | 1                      | 1.9                               | 10      |                    |
| Model Information                                       |               |                        |                                   |         |                    |
| Integration method: mvaghermite                         |               | Integration points = 7 |                                   |         |                    |
| Wald chi²(31) = 380.21                                  |               |                        | Log pseudolikelihood = -14487.711 |         |                    |
| Prob > chi² = 0.0000                                    |               |                        |                                   |         |                    |
| (Std. errors adjusted for 972 clusters in imicscluster) |               |                        |                                   |         |                    |
| Parameter Estimates                                     |               |                        |                                   |         |                    |
| Variable                                                | Odds Ratio    | Robust std. err.       | z                                 | P >  z  | 95% Conf. Interval |
| Child's Age (Ref: Age 0)                                |               |                        |                                   |         |                    |
| 1                                                       | 0.9332        | 0.0924                 | -0.74                             | 0.460   | [0.7752, 1.1212]   |
| 2                                                       | 0.4614        | 0.0478                 | -7.46                             | 0.000   | [0.3766, 0.5653]   |
| 3                                                       | 0.4215        | 0.0463                 | -7.87                             | 0.000   | [0.3400, 0.5227]   |
| 4                                                       | 0.3719        | 0.0422                 | -8.71                             | 0.000   | [0.2977, 0.4646]   |
| Sex of Child (Ref: Female)                              |               |                        |                                   |         |                    |
| Male                                                    | 1.0909        | 0.0554                 | 1.71                              | 0.087   | [0.9875, 1.2051]   |
| Household Wealth Index (Ref: Third Quintile)            |               |                        |                                   |         |                    |
| Poorest                                                 | 0.7119        | 0.0815                 | -2.97                             | 0.003   | [0.5688, 0.8911]   |
| Second                                                  | 0.8186        | 0.0733                 | -2.23                             | 0.025   | [0.6863, 0.9757]   |
| Fourth                                                  | 1.3817        | 0.1245                 | 3.51                              | 0.000   | [1.1518, 1.6579]   |
| Richest                                                 | 2.7957        | 0.3235                 | 6.61                              | 0.000   | [2.2379, 3.4979]   |
| Delivery Assistance (Ref: Doctor)                       |               |                        |                                   |         |                    |
| Nurse/Midwife                                           | 0.9952        | 0.1600                 | -0.03                             | 0.976   | [0.7263, 1.3638]   |
| Traditional Birth Attendant                             | 0.3677        | 0.0712                 | -5.19                             | 0.000   | [0.2516, 0.5375]   |
| Relative/Friend                                         | 0.3677        | 0.0635                 | -5.79                             | 0.000   | [0.2603, 0.5199]   |
| Other                                                   | 0.3186        | 0.1254                 | -2.90                             | 0.004   | [0.1400, 0.7225]   |
| No one assisted                                         | 0.6164        | 0.1978                 | -1.51                             | 0.131   | [0.3286, 1.1560]   |
| Missing                                                 | 0.7813        | 0.1300                 | -1.48                             | 0.138   | [0.5638, 1.0826]   |
| Urban/Rural Res (Ref: Urban)                            |               |                        |                                   |         |                    |
| Rural                                                   | 0.5817        | 0.1251                 | -2.52                             | 0.012   | [0.3816, 0.8867]   |
| Education Level Mother (Ref: Less than Primary)         |               |                        |                                   |         |                    |
| Primary                                                 | 1.3147        | 0.1418                 | 2.54                              | 0.011   | [1.0643, 1.6241]   |
| Lower secondary                                         | 1.6076        | 0.2658                 | 2.63                              | 0.008   | [1.1332, 2.2839]   |
| Secondary or higher                                     | 1.9184        | 0.2559                 | 4.83                              | 0.000   | [1.4693, 2.4839]   |
| Currently Married (Ref: Married)                        |               |                        |                                   |         |                    |
| No, not in a union                                      | 0.5987        | 0.1881                 | -1.63                             | 0.103   | [0.3235, 1.1003]   |
| Sex Head of Household (Ref: Male)                       |               |                        |                                   |         |                    |
| Female                                                  | 1.4645        | 0.2588                 | 2.23                              | 0.026   | [1.0470, 2.0485]   |
| Number of Children (Ref: 1)                             |               |                        |                                   |         |                    |
| 2                                                       | 0.8188        | 0.0592                 | -2.67                             | 0.008   | [0.7093, 0.9450]   |
| 3                                                       | 0.6663        | 0.0635                 | -4.25                             | 0.000   | [0.5525, 0.8034]   |
| 4                                                       | 0.5517        | 0.0769                 | -4.26                             | 0.000   | [0.4199, 0.7252]   |
| 5                                                       | 0.4745        | 0.0877                 | -4.64                             | 0.000   | [0.3304, 0.6815]   |
| 6                                                       | 0.5360        | 0.1316                 | -2.54                             | 0.011   | [0.3312, 0.8673]   |
| 7                                                       | 0.3023        | 0.1120                 | -3.23                             | 0.001   | [0.1483, 0.6170]   |
| 8                                                       | 0.3674        | 0.1975                 | -1.73                             | 0.084   | [0.1483, 0.9149]   |
| 9                                                       | 0.4877        | 0.2025                 | -1.73                             | 0.084   | [0.2161, 1.1005]   |
| 10                                                      | 0.1822        | 0.1312                 | -2.36                             | 0.018   | [0.0444, 0.7474]   |
| Household Owns Mobile Phone (Ref: No)                   |               |                        |                                   |         |                    |
| Yes                                                     | 1.4342        | 0.1554                 | 3.33                              | 0.001   | [1.1597, 1.7736]   |
| Constant                                                |               |                        |                                   |         |                    |
| _cons                                                   | 2.8423        | 0.5832                 | 2.99                              | 0.003   | [1.1870, 6.7742]   |
| Random effects (variance components)                    |               |                        |                                   |         |                    |
| imicscluster                                            |               |                        |                                   |         |                    |
| var(_cons)                                              | 5.0632        | 0.4036                 |                                   |         | [4.3309, 5.9193]   |
| imicscluster>hhno                                       |               |                        |                                   |         |                    |
| var(_cons)                                              | 5.1550        | 0.4317                 |                                   |         | [4.3746, 6.0745]   |

**\*Table D8: Afghanistan for Model 4: Household Structure and Access Model with Interaction Terms**

| Mixed-effects logistic regression                       |            |                |                                   |       |                  |
|---------------------------------------------------------|------------|----------------|-----------------------------------|-------|------------------|
| Number of observations = 32,350                         |            |                |                                   |       |                  |
| Grouping Information                                    |            |                |                                   |       |                  |
| Group                                                   | Groups     | Min            | Avg                               | Max   |                  |
| imicscluster                                            | 972        | 8              | 33.3                              | 68    |                  |
| hhno                                                    | 16,749     | 1              | 1.9                               | 10    |                  |
| Model Information                                       |            |                |                                   |       |                  |
| Integration: mvaghermite                                |            | Points = 7     |                                   |       |                  |
| Wald chi <sup>2</sup> (44) = 413.05                     |            |                | Log pseudolikelihood = -14476.521 |       |                  |
| Prob > chi <sup>2</sup> = 0.0000                        |            |                |                                   |       |                  |
| (Std. errors adjusted for 972 clusters in imicscluster) |            |                |                                   |       |                  |
| Parameter Estimates                                     |            |                |                                   |       |                  |
| Variable                                                | Odds Ratio | Rob. Std. Err. | z                                 | P>  z | 95% CI           |
| Child's Age (Ref: Age 0)                                |            |                |                                   |       |                  |
| 1                                                       | 0.9349     | 0.0876         | -0.72                             | 0.473 | 0.7780, 1.1235   |
| 2                                                       | 0.4612     | 0.0477         | -7.48                             | 0.000 | 0.3766, 0.5648   |
| 3                                                       | 0.4219     | 0.0463         | -7.86                             | 0.000 | 0.3402, 0.5233   |
| 4                                                       | 0.3724     | 0.0422         | -8.71                             | 0.000 | 0.2982, 0.4652   |
| Sex of Child (Ref: Female)                              |            |                |                                   |       |                  |
| Male                                                    | 1.0949     | 0.0557         | 1.78                              | 0.075 | 0.9910, 1.2096   |
| Household Wealth Index (Ref: Third Quintile)            |            |                |                                   |       |                  |
| Poorest                                                 | 0.7668     | 0.0920         | -2.21                             | 0.027 | 0.6061, 0.9700   |
| Second                                                  | 0.8494     | 0.0829         | -1.67                             | 0.094 | 0.7015, 1.0284   |
| Fourth                                                  | 1.1833     | 0.1325         | 1.50                              | 0.133 | 0.9502, 1.4736   |
| Richest                                                 | 1.9237     | 0.3149         | 4.00                              | 0.000 | 1.3958, 2.6513   |
| Delivery Assistance (Ref: Doctor)                       |            |                |                                   |       |                  |
| Nurse/Midwife                                           | 0.9909     | 0.1590         | -0.06                             | 0.955 | 0.7234, 1.3572   |
| Traditional                                             | 0.3588     | 0.0695         | -5.29                             | 0.000 | 0.2455, 0.5244   |
| Relative/Friend                                         | 0.3886     | 0.0635         | -5.78                             | 0.000 | 0.2821, 0.5353   |
| Other                                                   | 0.3114     | 0.1259         | -2.89                             | 0.004 | 0.1410, 0.6877   |
| No one                                                  | 0.6080     | 0.1958         | -1.55                             | 0.122 | 0.3234, 1.1429   |
| Missing                                                 | 0.7747     | 0.1287         | -1.54                             | 0.124 | 0.5595, 1.0728   |
| Urban/Rural Residence (Ref: Urban)                      |            |                |                                   |       |                  |
| Rural                                                   | 0.5741     | 0.1236         | -2.58                             | 0.010 | 0.3764, 0.8756   |
| Mother's Education Level (Ref: None)                    |            |                |                                   |       |                  |
| Primary                                                 | 1.5157     | 0.3340         | 1.89                              | 0.059 | 0.9841, 2.3346   |
| Lower Sec.                                              | 1.3843     | 0.4680         | 0.96                              | 0.336 | 0.7136, 2.6854   |
| Sec. or Higher                                          | 2.9979     | 0.9043         | 3.64                              | 0.000 | 1.6598, 5.4147   |
| Marital Status (Ref: Never Married)                     |            |                |                                   |       |                  |
| No, not in a union                                      | 0.7788     | 0.3069         | -0.63                             | 0.526 | 0.3597, 1.6860   |
| Sex of Household Head (Ref: Male)                       |            |                |                                   |       |                  |
| Female                                                  | 1.5926     | 0.2817         | 2.63                              | 0.009 | 1.1260, 2.2526   |
| Number of Children (Ref: 1)                             |            |                |                                   |       |                  |
| 2                                                       | 0.8094     | 0.0592         | -2.89                             | 0.004 | 0.7013, 0.9343   |
| 3                                                       | 0.6660     | 0.0637         | -4.25                             | 0.000 | 0.5521, 0.8033   |
| 4                                                       | 0.5533     | 0.0769         | -4.26                             | 0.000 | 0.4214, 0.7266   |
| 5                                                       | 0.4766     | 0.0880         | -4.01                             | 0.000 | 0.3318, 0.6845   |
| 6                                                       | 0.5344     | 0.1315         | -2.55                             | 0.011 | 0.3299, 0.8657   |
| 7                                                       | 0.3005     | 0.1114         | -3.24                             | 0.001 | 0.1453, 0.6214   |
| 8                                                       | 0.3714     | 0.2165         | -1.70                             | 0.089 | 0.1185, 1.1643   |
| 9                                                       | 0.4854     | 0.2025         | -1.73                             | 0.083 | 0.2143, 1.0996   |
| 10                                                      | 0.1838     | 0.1323         | -2.35                             | 0.019 | 0.0448, 0.7534   |
| Mobile Phone Ownership (Ref: No)                        |            |                |                                   |       |                  |
| Yes                                                     | 1.4383     | 0.1568         | 3.33                              | 0.001 | 1.1616, 1.7808   |
| Interaction: Wealth Index & Mother's Education Level    |            |                |                                   |       |                  |
| Poorest#Primary                                         | 0.7177     | 0.2776         | -0.86                             | 0.391 | 0.3364, 1.5315   |
| Poorest#Lower Sec.                                      | 0.4924     | 0.2517         | -1.39                             | 0.166 | 0.1808, 1.3412   |
| Poorest#Sec. or Higher                                  | 0.4071     | 0.2621         | -1.40                             | 0.163 | 0.1152, 1.4380   |
| Second#Primary                                          | 0.9100     | 0.2924         | -0.29                             | 0.769 | 0.4847, 1.7084   |
| Second#Lower Sec.                                       | 0.8105     | 0.3856         | -0.44                             | 0.659 | 0.3190, 2.0592   |
| Second#Sec. or Higher                                   | 0.6026     | 0.2605         | -1.17                             | 0.241 | 0.2583, 1.4059   |
| Fourth#Primary                                          | 0.7463     | 0.2282         | -0.96                             | 0.339 | 0.4099, 1.3589   |
| Fourth#Lower Sec.                                       | 2.0048     | 1.0315         | 1.35                              | 0.176 | 0.7314, 5.4955   |
| Fourth#Sec. or Higher                                   | 0.8902     | 0.3446         | -0.30                             | 0.764 | 0.4169, 1.9009   |
| Richest#Primary                                         | 0.9286     | 0.3254         | -0.21                             | 0.833 | 0.4672, 1.8456   |
| Richest#Lower Sec.                                      | 1.4171     | 0.7213         | 0.68                              | 0.493 | 0.5225, 3.8431   |
| Richest#Sec. or Higher                                  | 0.4662     | 0.1682         | -2.12                             | 0.034 | 0.2299, 0.9454   |
| Interaction: Marital Status & Sex of Household Head     |            |                |                                   |       |                  |
| No, not in a union#Female                               | 0.3972     | 0.2244         | -1.63                             | 0.102 | 0.1312, 1.2020   |
| Constant                                                |            |                |                                   |       |                  |
| _cons                                                   | 2.0052     | 0.5741         | 2.43                              | 0.015 | 1.1441, 3.5145   |
| Random effects (variance components)                    |            |                |                                   |       |                  |
| imicscluster                                            |            |                |                                   |       |                  |
| var(_cons)                                              | 5.0743     | 0.4060         |                                   |       | [4.3378, 5.9358] |
| imicscluster>hhno                                       |            |                |                                   |       |                  |
| var(_cons)                                              | 5.1671     | 0.4344         |                                   |       | [4.3821, 6.0926] |

## 5 Appendix F: MICS Democratic People's Republic of the Congo 2017

**\*Table F1:** Model Fit Statistics

| Model      | Log Pseudo-likelihood | AIC      | BIC      | ICC (Imicscluster) | ICC (hhno) | Wald Chi <sup>2</sup> | DoF |
|------------|-----------------------|----------|----------|--------------------|------------|-----------------------|-----|
| Null Model | -7392.7097            | 14971.99 | 14995.73 | 0.4529             | 0.8674     | -                     | -   |
| Model 2    | -7182.75              | 14411.51 | 14593.52 | 0.3562             | 0.8432     | 205.47                | 20  |
| Model 3    | -7189.98              | 14401.96 | 14647.27 | 0.3575             | 0.8419     | 668.20                | 28  |
| Model 4    | -7158.53              | 14401.06 | 14733.41 | 0.3562             | 0.8413     | 706.79                | 39  |

### Statistical Summary

|                                          |               |
|------------------------------------------|---------------|
| Number of observations                   | 20,195        |
| Wald chi-square (31)                     | 380.21        |
| Prob > chi-square                        | 0.0000        |
| Observations per group (Min / Avg / Max) | 8 / 33.3 / 68 |
| Integration points                       | 10            |

**\*Table F2:** DRC VIF

| Variable         | VIF         | 1/VIF    |
|------------------|-------------|----------|
| agech 1          | 1.55        | 0.644368 |
| agech 2          | 1.88        | 0.532974 |
| agech 3          | 1.72        | 0.582526 |
| agech 4          | 1.74        | 0.575344 |
| 1.sexch          | 1.00        | 0.998495 |
| windex5 2        | 1.40        | 0.715257 |
| windex5 3        | 1.52        | 0.660047 |
| windex5 4        | 2.73        | 0.365877 |
| delivery_a ~ e 2 | 22.85       | 0.043769 |
| delivery_a ~ e 3 | 9.54        | 0.104801 |
| delivery_a ~ e 4 | 6.84        | 0.146172 |
| delivery_a ~ e 6 | 2.88        | 0.346981 |
| delivery_a ~ e 9 | 19.15       | 0.052216 |
| 2.urban_fa ~ r   | 1.98        | 0.505276 |
| edlevelmom 20    | 1.66        | 0.601301 |
| edlevelmom 30    | 1.47        | 0.679214 |
| edlevelmom 40    | 1.95        | 0.512525 |
| marrcurr 12      | 1.04        | 0.963686 |
| marrcurr 20      | 1.18        | 0.845965 |
| 2.sexhhead       | 1.17        | 0.856226 |
| numch 2          | 1.67        | 0.598148 |
| numch 3          | 1.64        | 0.609908 |
| numch 4          | 1.15        | 0.872791 |
| numch 5          | 1.04        | 0.965176 |
| numch 6          | 1.01        | 0.987559 |
| numch 7          | 1.01        | 0.992049 |
| mobphone_gh 1    | 1.54        | 0.650634 |
| mobphone_gh 8    | 1.00        | 0.996960 |
| <b>Mean VIF</b>  | <b>3.40</b> |          |

**\*Table F3 for Null Model-ICC**

### Null Model Results

Integration Method: mvaghermite

Integration Points: 7

Wald chi<sup>2</sup> (0): .

Log Pseudolikelihood: -7392.7097

Prob > chi<sup>2</sup>: .

(Standard errors adjusted for 709 clusters in imicscluster)

| Model Coefficients |          |           |        |        |                        |
|--------------------|----------|-----------|--------|--------|------------------------|
| Variable           | Odds     | Std. Err. | z      | P >  z | [95% Conf. Interval]   |
| _cons              | 0.056377 | 0.0099793 | -16.26 | 0.000  | [0.0398501, 0.0797579] |

| Model Coefficients (Continued) |          |           |   |                    |                      |
|--------------------------------|----------|-----------|---|--------------------|----------------------|
| Variable                       | Odds     | Std. Err. | z | P <sub>t</sub> —z— | [95% Conf. Interval] |
| <b>imicscluster</b>            |          |           |   |                    |                      |
| var(_cons)                     | 11.24502 | 1.303465  |   |                    | [8.959697, 14.11325] |
| <b>imicscluster&gt;hhno</b>    |          |           |   |                    |                      |
| var(_cons)                     | 10.28893 | 1.433476  |   |                    | [7.830313, 13.51953] |

*Note: Estimates are transformed only in the first equation to odds.*

**\*Table F4: Intraclass Correlation Coefficients (ICC)**

| Intraclass Correlation        |           |           |                        |
|-------------------------------|-----------|-----------|------------------------|
| Level                         | ICC       | Std. Err. | [95% Conf. Interval]   |
| <b>imicscluster</b>           | 0.4529931 | 0.0155983 | [0.4226356, 0.4837043] |
| <b>hhno &gt; imicscluster</b> | 0.8674713 | 0.014026  | [0.8374891, 0.8926311] |

**\*Table F5: Descriptive Statistics-Variable Distributions (MICS DRC 2017, N= 20,195)**

| Variable                                           | No Birth Certificate | Has Birth Certificate | Total           |
|----------------------------------------------------|----------------------|-----------------------|-----------------|
| <b>Child's age in completed years</b>              |                      |                       |                 |
| Less than 1 year                                   | 3,288 (74.7%)        | 1,115 (25.3%)         | 4,403 (100.0%)  |
| 1 year                                             | 2,962 (71.9%)        | 1,154 (28.1%)         | 4,116 (100.0%)  |
| 2 years                                            | 2,832 (72.8%)        | 1,053 (27.2%)         | 3,885 (100.0%)  |
| 3 years                                            | 3,052 (74.9%)        | 1,019 (25.1%)         | 4,071 (100.0%)  |
| 4 years                                            | 2,753 (73.9%)        | 967 (26.1%)           | 3,720 (100.0%)  |
| <b>Total</b>                                       | 14,887 (73.7%)       | 5,308 (26.3%)         | 20,195 (100.0%) |
| <b>Sex of child</b>                                |                      |                       |                 |
| Female                                             | 7,568 (74.2%)        | 2,645 (25.8%)         | 10,213 (100.0%) |
| Male                                               | 7,319 (73.3%)        | 2,663 (26.7%)         | 9,982 (100.0%)  |
| <b>Total</b>                                       | 14,887 (73.7%)       | 5,308 (26.3%)         | 20,195 (100.0%) |
| <b>Wealth index quintile</b>                       |                      |                       |                 |
| Poorest                                            | 5,606 (85.1%)        | 984 (14.9%)           | 6,590 (100.0%)  |
| Second                                             | 4,279 (79.7%)        | 1,086 (20.3%)         | 5,365 (100.0%)  |
| Middle                                             | 2,916 (71.0%)        | 1,195 (29.0%)         | 4,111 (100.0%)  |
| Fourth + Fifth                                     | 2,086 (50.4%)        | 2,043 (49.6%)         | 4,129 (100.0%)  |
| <b>Total</b>                                       | 14,887 (73.7%)       | 5,308 (26.3%)         | 20,195 (100.0%) |
| <b>Delivery Assistance</b>                         |                      |                       |                 |
| Doctor                                             | 940 (40.9%)          | 1360 (59.1%)          | 2300 (100.0%)   |
| Nurse/Midwife                                      | 7,280 (69.5%)        | 3,204 (30.5%)         | 10,484 (100.0%) |
| Traditional Birth Attendant                        | 1,824 (85.5%)        | 309 (14.5%)           | 2,133 (100.0%)  |
| Relative/Friend                                    | 1,240 (88.6%)        | 160 (11.4%)           | 1,400 (100.0%)  |
| No one assisted                                    | 383 (89.5%)          | 45 (10.5%)            | 428 (100.0%)    |
| Missing                                            | 3,220 (93.3%)        | 230 (6.67%)           | 3,450 (100.0%)  |
| <b>Total</b>                                       | 14,887 (73.7%)       | 5,308 (26.3%)         | 20,195 (100.0%) |
| <b>Urban Status</b>                                |                      |                       |                 |
| Urban                                              | 3,155 (57.9%)        | 2,291 (42.1%)         | 5,446 (100.0%)  |
| Rural                                              | 11,732 (79.6%)       | 3,017 (20.4%)         | 14,749 (100.0%) |
| <b>Total</b>                                       | 14,887 (73.7%)       | 5,308 (26.3%)         | 20,195 (100.0%) |
| <b>Mother's education level</b>                    |                      |                       |                 |
| Less than primary                                  | 3,748 (79.7%)        | 958 (20.3%)           | 4,706 (100.0%)  |
| Primary                                            | 6,279 (78.7%)        | 1,689 (21.3%)         | 7,968 (100.0%)  |
| Lower secondary                                    | 2,097 (74.4%)        | 716 (25.6%)           | 2,813 (100.0%)  |
| Secondary or higher                                | 2,763 (58.6%)        | 1,945 (41.4%)         | 4,708 (100.0%)  |
| <b>Total</b>                                       | 14,887 (73.7%)       | 5,308 (26.3%)         | 20,195 (100.0%) |
| <b>Currently married or in a union</b>             |                      |                       |                 |
| Yes, currently married                             | 11,205 (73.9%)       | 3,956 (26.1%)         | 15,161 (100.0%) |
| Yes, living with a partner                         | 1,933 (74.9%)        | 648 (25.1%)           | 2,581 (100.0%)  |
| No, not in a union                                 | 1,749 (71.3%)        | 704 (28.7%)           | 2,453 (100.0%)  |
| <b>Total</b>                                       | 14,887 (73.7%)       | 5,308 (26.3%)         | 20,195 (100.0%) |
| <b>Sex of household head</b>                       |                      |                       |                 |
| Male                                               | 11,237 (73.4%)       | 4,081 (26.6%)         | 15,318 (100.0%) |
| Female                                             | 3,650 (74.9%)        | 1,227 (25.1%)         | 4,877 (100.0%)  |
| <b>Total</b>                                       | 14,887 (73.7%)       | 5,308 (26.3%)         | 20,195 (100.0%) |
| <b>HH has mobile phone</b>                         |                      |                       |                 |
| No                                                 | 10,408 (80.4%)       | 2,554 (19.6%)         | 12,962 (100.0%) |
| Yes                                                | 4,478 (62.0%)        | 2,754 (38.0%)         | 7,233 (100.0%)  |
| <b>Total</b>                                       | 14,887 (73.7%)       | 5,308 (26.3%)         | 20,195 (100.0%) |
| <b>Number of children under age 5 in household</b> |                      |                       |                 |
| 1 child                                            | 3,841 (72.4%)        | 1,462 (27.6%)         | 5,303 (100.0%)  |
| 2 children                                         | 7,660 (74.7%)        | 2,596 (25.3%)         | 10,256 (100.0%) |
| 3 children                                         | 2,662 (73.0%)        | 983 (27.0%)           | 3,645 (100.0%)  |
| 4 children                                         | 537 (72.9%)          | 200 (27.1%)           | 737 (100.0%)    |
| 5+ children                                        | 187 (73.6%)          | 67 (26.4%)            | 254 (100.0%)    |
| <b>Total</b>                                       | 14,887 (73.7%)       | 5,308 (26.3%)         | 20,195 (100.0%) |

**Table F6 DRC Model 2: Child and Maternal Characteristics Model within the Household**

| Mixed-effects logistic regression                       |               |                        |                                   |         |                    |
|---------------------------------------------------------|---------------|------------------------|-----------------------------------|---------|--------------------|
| Number of observations = 20,195                         |               |                        |                                   |         |                    |
| Grouping Information                                    |               |                        |                                   |         |                    |
| Group variable                                          | No. of groups | Minimum                | Average                           | Maximum |                    |
| imicscluster                                            | 709           | 1                      | 28.5                              | 58      |                    |
| hhno                                                    | 11,966        | 1                      | 1.7                               | 7       |                    |
| Model Information                                       |               |                        |                                   |         |                    |
| Integration method: avaghermite                         |               | Integration points = 7 |                                   |         |                    |
| Wald chi²(26) = 266.47                                  |               |                        | Log pseudolikelihood = -7182.7562 |         |                    |
| Prob > chi² = 0.0000                                    |               |                        |                                   |         |                    |
| (Std. errors adjusted for 709 clusters in imicscluster) |               |                        |                                   |         |                    |
| Parameter Estimates                                     |               |                        |                                   |         |                    |
| Variable                                                | Odds Ratio    | Robust Std. Err.       | z                                 | P>  z   | 95% Conf. Interval |
| Child's Age (Ref: Age 0)                                |               |                        |                                   |         |                    |
| 1                                                       | 0.9991        | 0.2011                 | -0.00                             | 0.996   | [0.6734, 1.4823]   |
| 2                                                       | 0.8072        | 0.1721                 | -1.06                             | 0.315   | [0.5315, 1.3259]   |
| 3                                                       | 0.6618        | 0.1519                 | -1.69                             | 0.092   | [0.4220, 1.0379]   |
| 4                                                       | 0.6564        | 0.1438                 | -1.93                             | 0.054   | [0.4301, 1.0035]   |
| Sex of Child (Ref: Female)                              |               |                        |                                   |         |                    |
| Male                                                    | 1.2858        | 0.1260                 | 2.57                              | 0.010   | [1.0612, 1.5580]   |
| Household Wealth Index (Ref: Third Quintile)            |               |                        |                                   |         |                    |
| Poorest                                                 | 0.3987        | 0.0739                 | -4.96                             | 0.000   | [0.2773, 0.5733]   |
| Second                                                  | 0.5476        | 0.0889                 | -3.71                             | 0.000   | [0.3984, 0.7527]   |
| Fourth + Fifth                                          | 3.5538        | 0.8161                 | 5.52                              | 0.000   | [2.2658, 5.5738]   |
| Delivery Assistance (Ref: Doctor)                       |               |                        |                                   |         |                    |
| Nurse/Midwife                                           | 0.2695        | 0.1076                 | -3.04                             | 0.002   | [0.0765, 0.3735]   |
| Traditional Birth Attendant                             | 0.0717        | 0.0407                 | -4.65                             | 0.000   | [0.0236, 0.2180]   |
| Relative/Friend                                         | 0.0644        | 0.0379                 | -4.66                             | 0.000   | [0.0203, 0.2041]   |
| No one assisted                                         | 0.0167        | 0.0117                 | -5.83                             | 0.000   | [0.0042, 0.0662]   |
| Missing                                                 | 0.1878        | 0.0957                 | -3.28                             | 0.001   | [0.0691, 0.5100]   |
| Urban/Rural Residence (Ref: Urban)                      |               |                        |                                   |         |                    |
| Rural                                                   | 0.2253        | 0.0614                 | -5.47                             | 0.000   | [0.1321, 0.3844]   |
| Mother's Education Level (Ref: Less than Primary)       |               |                        |                                   |         |                    |
| Primary                                                 | 1.1223        | 0.1915                 | 0.66                              | 0.499   | [0.8033, 1.5680]   |
| Lower Secondary                                         | 1.1144        | 0.2630                 | 0.46                              | 0.646   | [0.7017, 1.7697]   |
| Secondary or Higher                                     | 2.5588        | 0.4853                 | 4.92                              | 0.000   | [1.7568, 3.7037]   |
| Marital Status (Ref: Yes, Currently Married)            |               |                        |                                   |         |                    |
| Yes, living with a partner/in a union                   | 1.3322        | 0.3436                 | 1.11                              | 0.266   | [0.8036, 2.2086]   |
| No, not in a union                                      | 1.2254        | 0.2738                 | 0.91                              | 0.363   | [0.7909, 1.8986]   |
| Sex of Household Head (Ref: Male)                       |               |                        |                                   |         |                    |
| Female                                                  | 0.7516        | 0.0981                 | -2.19                             | 0.029   | [0.5819, 0.9708]   |
| Random effects (variance components)                    |               |                        |                                   |         |                    |
| imicscluster                                            |               |                        |                                   |         |                    |
| var(_cons)                                              | 7.4733        | 0.8690                 |                                   |         | [5.9502, 9.3863]   |
| imicscluster>hhno                                       |               |                        |                                   |         |                    |
| var(_cons)                                              | 10.2167       | 1.4541                 |                                   |         | [7.7296, 13.5839]  |

Table F7 DRC Model 3: Household Structure and Access Model

| Mixed-effects logistic regression                       |               |                        |                                   |         |                    |
|---------------------------------------------------------|---------------|------------------------|-----------------------------------|---------|--------------------|
| Number of observations = 20,195                         |               |                        |                                   |         |                    |
| Grouping Information                                    |               |                        |                                   |         |                    |
| Group variable                                          | No. of groups | Minimum                | Average                           | Maximum |                    |
| imicscluster                                            | 789           | 1                      | 28.5                              | 58      |                    |
| hhno                                                    | 11,966        | 1                      | 1.7                               | 7       |                    |
| Model Information                                       |               |                        |                                   |         |                    |
| Integration method: mvaghermite                         |               | Integration points = 7 |                                   |         |                    |
| Wald chi <sup>2</sup> (28) = 668.20                     |               |                        | Log pseudolikelihood = -7189.9884 |         |                    |
| Prob > chi <sup>2</sup> = 0.0000                        |               |                        |                                   |         |                    |
| (Std. errors adjusted for 789 clusters in imicscluster) |               |                        |                                   |         |                    |
| Parameter Estimates                                     |               |                        |                                   |         |                    |
| Variable                                                | Odds Ratio    | Robust Std. Err.       | z                                 | P >  z  | 95% Conf. Interval |
| Child's Age (Ref: Age 0)                                |               |                        |                                   |         |                    |
| 1                                                       | 0.9853        | 0.1982                 | -0.07                             | 0.941   | [0.6642, 1.4616]   |
| 2                                                       | 0.8247        | 0.1764                 | -0.90                             | 0.369   | [0.5448, 1.2471]   |
| 3                                                       | 0.6747        | 0.1544                 | -1.73                             | 0.083   | [0.4392, 1.0345]   |
| 4                                                       | 0.6740        | 0.1459                 | -1.82                             | 0.069   | [0.4499, 1.0103]   |
| Sex of Child (Ref: Female)                              |               |                        |                                   |         |                    |
| Male                                                    | 1.2834        | 0.1260                 | 2.54                              | 0.011   | [1.0587, 1.5556]   |
| Household Wealth Index (Ref: Third Quintile)            |               |                        |                                   |         |                    |
| Poorest                                                 | 0.4846        | 0.0904                 | -3.88                             | 0.000   | [0.3362, 0.6985]   |
| Second                                                  | 0.6158        | 0.1000                 | -2.99                             | 0.003   | [0.4472, 0.8457]   |
| Fourth + Fifth                                          | 3.1824        | 0.7283                 | 5.06                              | 0.000   | [2.0321, 4.9837]   |
| Delivery Assistance (Ref: Doctor)                       |               |                        |                                   |         |                    |
| Nurse/Midwife                                           | 0.2354        | 0.1119                 | -2.96                             | 0.003   | [0.0778, 0.5968]   |
| Traditional Birth Attendant                             | 0.0755        | 0.0430                 | -4.54                             | 0.000   | [0.0247, 0.2304]   |
| Relative/Friend                                         | 0.0673        | 0.0398                 | -4.56                             | 0.000   | [0.0211, 0.2148]   |
| No one assisted                                         | 0.0187        | 0.0132                 | -5.64                             | 0.000   | [0.0047, 0.0747]   |
| Missing                                                 | 0.1744        | 0.0898                 | -3.39                             | 0.001   | [0.0636, 0.4784]   |
| Urban/Rural Residence (Ref: Urban)                      |               |                        |                                   |         |                    |
| Rural                                                   | 0.2427        | 0.0661                 | -5.20                             | 0.000   | [0.1423, 0.4139]   |
| Mother's Education Level (Ref: Less than Primary)       |               |                        |                                   |         |                    |
| Primary                                                 | 1.0853        | 0.1840                 | 0.48                              | 0.629   | [0.7785, 1.5131]   |
| Lower Secondary                                         | 1.0385        | 0.2431                 | 0.16                              | 0.872   | [0.6584, 1.6438]   |
| Secondary or Higher                                     | 2.2806        | 0.4247                 | 4.43                              | 0.000   | [1.5663, 3.3306]   |
| Marital Status (Ref: Yes, Currently Married)            |               |                        |                                   |         |                    |
| Yes, living with a partner/in a union                   | 1.3332        | 0.3405                 | 1.13                              | 0.260   | [0.8081, 2.1994]   |
| No, not in a union                                      | 1.2342        | 0.2763                 | 0.94                              | 0.347   | [0.7958, 1.9141]   |
| Sex of Household Head (Ref: Male)                       |               |                        |                                   |         |                    |
| Female                                                  | 0.7708        | 0.0999                 | -2.01                             | 0.044   | [0.5970, 0.9938]   |
| Number of Children (Ref: 1)                             |               |                        |                                   |         |                    |
| 2                                                       | 0.7678        | 0.0927                 | -2.19                             | 0.029   | [0.6060, 0.9727]   |
| 3                                                       | 0.7288        | 0.1286                 | -1.84                             | 0.066   | [0.5073, 1.0461]   |
| 4                                                       | 0.7619        | 0.1815                 | -1.28                             | 0.200   | [0.4799, 1.2107]   |
| 5+                                                      | 1.7683        | 1.0137                 | 0.98                              | 0.328   | [0.5631, 5.5631]   |
| Mobile Phone (Ref: No)                                  |               |                        |                                   |         |                    |
| Yes                                                     | 1.7447        | 0.2412                 | 4.03                              | 0.000   | [1.3306, 2.2876]   |
| Constant                                                |               |                        |                                   |         |                    |
| _cons                                                   | 0.8595        | 0.5207                 | -0.25                             | 0.803   | [0.2622, 2.8176]   |
| Random effects (variance components)                    |               |                        |                                   |         |                    |
| imicscluster                                            |               |                        |                                   |         |                    |
| var(_cons)                                              | 7.4395        | 0.8624                 |                                   |         | [5.9276, 9.3371]   |
| imicscluster>hhno                                       |               |                        |                                   |         |                    |
| var(_cons)                                              | 10.0813       | 1.4245                 |                                   |         | [7.6427, 13.2981]  |

**\*Table F8: DRC Model 4: Household Structure and Access Model with Interaction Terms**

| Mixed-effects logistic regression                       |               |                        |                                   |         |                    |
|---------------------------------------------------------|---------------|------------------------|-----------------------------------|---------|--------------------|
| Number of observations = 20,195                         |               |                        |                                   |         |                    |
| Grouping Information                                    |               |                        |                                   |         |                    |
| Group variable                                          | No. of groups | Minimum                | Average                           | Maximum |                    |
| imicscluster                                            | 709           | 1                      | 28.5                              | 58      |                    |
| hhno                                                    | 11,966        | 1                      | 1.7                               | 7       |                    |
| Model Information                                       |               |                        |                                   |         |                    |
| Integration method: mvaghermite                         |               | Integration points = 7 |                                   |         |                    |
| Wald chi <sup>2</sup> (39) = 706.79                     |               |                        | Log pseudolikelihood = -7158.5293 |         |                    |
| Prob > chi <sup>2</sup> = 0.0000                        |               |                        |                                   |         |                    |
| (Std. errors adjusted for 709 clusters in imicscluster) |               |                        |                                   |         |                    |
| Parameter Estimates                                     |               |                        |                                   |         |                    |
| Variable                                                | Odds Ratio    | Std. Err.              | z                                 | P >  z  | 95% Conf. Interval |
| Child's Age (Ref: Age 0)                                |               |                        |                                   |         |                    |
| 1                                                       | 0.9909        | 0.1979                 | -0.05                             | 0.963   | [0.6699, 1.4657]   |
| 2                                                       | 0.8249        | 0.1777                 | -0.89                             | 0.372   | [0.5408, 1.2583]   |
| 3                                                       | 0.6741        | 0.1546                 | -1.72                             | 0.085   | [0.4301, 1.0565]   |
| 4                                                       | 0.6777        | 0.1470                 | -1.79                             | 0.073   | [0.4429, 1.0368]   |
| Sex of Child (Ref: Female)                              |               |                        |                                   |         |                    |
| Male                                                    | 1.2875        | 0.1264                 | 2.57                              | 0.010   | [1.0620, 1.5607]   |
| Household Wealth Index (Ref: Third Quintile)            |               |                        |                                   |         |                    |
| Poorest                                                 | 0.4833        | 0.1666                 | -2.11                             | 0.035   | [0.2460, 0.9498]   |
| Second                                                  | 0.8644        | 0.2753                 | -0.46                             | 0.647   | [0.4631, 1.6135]   |
| Fourth + Fifth                                          | 4.9197        | 2.7175                 | 2.88                              | 0.004   | [1.6664, 14.5248]  |
| Delivery Assistance (Ref: Doctor/Health Worker)         |               |                        |                                   |         |                    |
| Nurse/Midwife                                           | 0.2204        | 0.1074                 | -3.10                             | 0.002   | [0.0848, 0.5729]   |
| Traditional Birth Attendant                             | 0.0780        | 0.0416                 | -4.79                             | 0.000   | [0.0275, 0.2216]   |
| Relative/Friend                                         | 0.0676        | 0.0381                 | -4.79                             | 0.000   | [0.0224, 0.2038]   |
| No one assisted                                         | 0.0190        | 0.0132                 | -5.73                             | 0.000   | [0.0049, 0.0737]   |
| Missing                                                 | 0.1801        | 0.0861                 | -3.58                             | 0.000   | [0.0706, 0.4599]   |
| Urban/Rural Res (Ref: Urban)                            |               |                        |                                   |         |                    |
| Rural                                                   | 0.2452        | 0.0670                 | -5.14                             | 0.000   | [0.1435, 0.4189]   |
| Education Level Mother (Ref: Less than Primary)         |               |                        |                                   |         |                    |
| Primary                                                 | 1.2391        | 0.3941                 | 0.67                              | 0.500   | [0.6643, 2.3113]   |
| Lower secondary                                         | 1.7614        | 0.7629                 | 1.31                              | 0.191   | [0.7537, 4.1165]   |
| Secondary or higher                                     | 2.5009        | 0.9165                 | 2.50                              | 0.012   | [1.2194, 5.1291]   |
| Currently Married (Ref: Yes, Currently Married)         |               |                        |                                   |         |                    |
| Yes, living with a partner/in a union                   | 1.6379        | 0.4541                 | 1.78                              | 0.075   | [0.9512, 2.8201]   |
| No, not in a union                                      | 1.2748        | 0.3794                 | 0.82                              | 0.415   | [0.7114, 2.2845]   |
| Sex Head of Household (Ref: Male)                       |               |                        |                                   |         |                    |
| Female                                                  | 0.9238        | 0.1510                 | -0.48                             | 0.628   | [0.6706, 1.2728]   |
| Number of Children (Ref: 1)                             |               |                        |                                   |         |                    |
| 2                                                       | 0.7617        | 0.0915                 | -2.27                             | 0.024   | [0.6018, 0.9640]   |
| 3                                                       | 0.7250        | 0.1297                 | -1.80                             | 0.072   | [0.5106, 1.0294]   |
| 4                                                       | 0.8321        | 0.2635                 | -0.58                             | 0.562   | [0.4473, 1.5479]   |
| 5+                                                      | 1.8179        | 1.0768                 | 1.01                              | 0.313   | [0.5693, 5.8046]   |
| Household Owns Mobile Phone (Ref: No)                   |               |                        |                                   |         |                    |
| Yes                                                     | 1.7676        | 0.2462                 | 4.09                              | 0.000   | [1.3453, 2.3223]   |
| Unknown                                                 | 0.0436        | 0.0162                 | -8.42                             | 0.000   | [0.0211, 0.0905]   |
| Interaction: Wealth Index & Education Level Mother      |               |                        |                                   |         |                    |
| Poorest # Primary                                       | 1.2139        | 0.5010                 | 0.47                              | 0.639   | [0.5406, 2.7258]   |
| Poorest # Lower secondary                               | 1.0161        | 0.5676                 | 0.03                              | 0.977   | [0.3400, 3.0366]   |
| Poorest # Secondary or higher                           | 0.6308        | 0.3190                 | -0.91                             | 0.362   | [0.2341, 1.6998]   |
| Second # Primary                                        | 0.7385        | 0.2946                 | -0.76                             | 0.447   | [0.3379, 1.6141]   |
| Second # Lower secondary                                | 0.4750        | 0.2623                 | -1.35                             | 0.178   | [0.1610, 1.4018]   |
| Second # Secondary or higher                            | 0.5601        | 0.2753                 | -1.18                             | 0.238   | [0.2137, 1.4675]   |
| Fourth + Fifth # Primary                                | 0.5234        | 0.3322                 | -1.02                             | 0.308   | [0.1509, 1.8160]   |
| Fourth + Fifth # Lower secondary                        | 0.2922        | 0.2162                 | -1.66                             | 0.096   | [0.0685, 1.2461]   |
| Fourth + Fifth # Secondary or higher                    | 0.8128        | 0.4801                 | -0.35                             | 0.726   | [0.2554, 2.5868]   |
| Interaction: Married & Sex Head of Household            |               |                        |                                   |         |                    |
| Yes, living with a partner/in a union # Female          | 0.4170        | 0.1746                 | -2.09                             | 0.037   | [0.1836, 0.9473]   |
| No, not in a union # Female                             | 0.8201        | 0.3296                 | -0.49                             | 0.622   | [0.3730, 1.8031]   |
| Constant                                                |               |                        |                                   |         |                    |
| _cons                                                   | 0.6861        | 0.4104                 | -0.63                             | 0.529   | [0.2124, 2.2162]   |
| Random effects (variance components)                    |               |                        |                                   |         |                    |
| imicscluster                                            |               |                        |                                   |         |                    |
| var(_cons)                                              | 7.3856        | 0.8697                 |                                   |         | [5.8634, 9.3028]   |
| imicscluster>hhno                                       |               |                        |                                   |         |                    |
| var(_cons)                                              | 10.0567       | 1.4397                 |                                   |         | [7.5963, 13.3141]  |

## 6 Appendix G: MICS Madagascar 2018

**\*Table G1:** Model Comparison Statistics

| Model      | AIC      | BIC      | Log Pseudo-likelihood | Wald Chi <sup>2</sup> | DoF | ICC (Imicscluster) | ICC (hhno — Imicscluster) |
|------------|----------|----------|-----------------------|-----------------------|-----|--------------------|---------------------------|
| Null Model | 11646.50 | 11668.68 | -5541.4459            | —                     | —   | 0.477234           | 0.7527                    |
| Model 2    | 10135.17 | 10305.25 | -5044.5844            | 370.59                | 24  | 0.3579             | 0.350                     |
| Model 3    | 10120.82 | 10320.47 | -5033.4084            | 379.40                | 28  | 0.360              | 0.348                     |
| Model 4    | 10133.39 | 10392.21 | -5031.6963            | 385.02                | 32  | 0.360              | 0.348                     |

**\*Table G2:** Madagascar VIF

| Variable         | VIF         | 1/VIF    |
|------------------|-------------|----------|
| agech 1          | 1.56        | 0.639627 |
| agech 2          | 2.16        | 0.463469 |
| agech 3          | 2.03        | 0.492336 |
| agech 4          | 2.07        | 0.483392 |
| 1.sexch          | 1.00        | 0.998835 |
| windex5 2        | 1.42        | 0.706638 |
| windex5 3        | 1.57        | 0.637468 |
| windex5 4        | 2.52        | 0.397459 |
| delivery_a ~ e 2 | 5.68        | 0.176173 |
| delivery_a ~ e 3 | 7.72        | 0.129605 |
| delivery_a ~ e 4 | 4.65        | 0.214921 |
| delivery_a ~ e 5 | 1.53        | 0.651811 |
| delivery_a ~ e 6 | 1.37        | 0.731035 |
| delivery_a ~ e 9 | 9.71        | 0.102945 |
| 2.urban_fa ~ r   | 1.20        | 0.832255 |
| edlevelmom 20    | 1.52        | 0.659492 |
| edlevelmom 40    | 1.99        | 0.502378 |
| marrcurr 12      | 1.11        | 0.903016 |
| marrcurr 20      | 1.71        | 0.584942 |
| 2.sexhhead       | 1.60        | 0.624231 |
| numch 1          | 1.40        | 0.714792 |
| numch 2          | 1.32        | 0.758479 |
| numch 4          | 1.10        | 0.910840 |
| 1.mobphone ~ h   | 1.48        | 0.677956 |
| <b>Mean VIF</b>  | <b>2.36</b> |          |

**Table G3:** Null Model Results

**Integration Method:** mvaghermite

**Integration Points:** 7

**Wald chi<sup>2</sup> (0):** .

**Log Pseudolikelihood:** -5541.4459

**Prob > chi<sup>2</sup>:** .

(Standard errors adjusted for 774 clusters in imicscluster)

| Model Coefficients          |          |           |       |        |                      |
|-----------------------------|----------|-----------|-------|--------|----------------------|
| Variable                    | Odds     | Std. Err. | z     | P >  z | [95% Conf. Interval] |
| _cons                       | 3.577847 | 0.4173495 | 10.93 | 0.000  | [2.846628, 4.496897] |
| <b>imicscluster</b>         |          |           |       |        |                      |
| var(_cons)                  | 6.348495 | 0.6556167 |       |        | [5.185208, 7.772762] |
| <b>imicscluster&gt;hhno</b> |          |           |       |        |                      |
| var(_cons)                  | 3.664326 | 0.5217786 |       |        | [2.771967, 4.843957] |

*Note: Estimates are transformed only in the first equation to odds.*

**Table G4:** Intraclass Correlation Coefficients (ICC)

| Intraclass Correlation |           |           |                        |
|------------------------|-----------|-----------|------------------------|
| Level                  | ICC       | Std. Err. | [95% Conf. Interval]   |
| imicscluster           | 0.477234  | 0.0173665 | [0.443354, 0.5113247]  |
| hhno   imicscluster    | 0.7526915 | 0.0204292 | [0.7105214, 0.7905295] |

**Table G5: Descriptive Statistics-Variable Distributions (MICS Madagascar 2018, N= 12,025)**

| Variable                                           | No Birth Certificate | Has Birth Certificate | Total           |
|----------------------------------------------------|----------------------|-----------------------|-----------------|
| <b>Child's age in completed years</b>              |                      |                       |                 |
| Less than 1 year                                   | 1,334 (51.3%)        | 1,264 (48.7%)         | 2,598 (100.0%)  |
| 1 year                                             | 1,022 (40.9%)        | 1,477 (59.1%)         | 2,499 (100.0%)  |
| 2 years                                            | 893 (38.7%)          | 1,415 (61.3%)         | 2,308 (100.0%)  |
| 3 years                                            | 893 (38.0%)          | 1,457 (62.0%)         | 2,350 (100.0%)  |
| 4 years                                            | 835 (36.7%)          | 1,435 (63.3%)         | 2,270 (100.0%)  |
| <b>Total</b>                                       | 4,977 (41.4%)        | 7,048 (58.6%)         | 12,025 (100.0%) |
| <b>Sex of child</b>                                |                      |                       |                 |
| Female                                             | 2,442 (41.3%)        | 3,463 (58.7%)         | 5,905 (100.0%)  |
| Male                                               | 2,535 (41.4%)        | 3,585 (58.6%)         | 6,120 (100.0%)  |
| <b>Total</b>                                       | 4,977 (41.4%)        | 7,048 (58.6%)         | 12,025 (100.0%) |
| <b>Wealth index quintile</b>                       |                      |                       |                 |
| Poorest                                            | 2,378 (62.2%)        | 1,445 (37.8%)         | 3,823 (100.0%)  |
| Second                                             | 1,332 (44.8%)        | 1,642 (55.2%)         | 2,974 (100.0%)  |
| Middle                                             | 764 (33.3%)          | 1,530 (66.7%)         | 2,294 (100.0%)  |
| Fourth + Richest                                   | 503 (17.1%)          | 2,431 (82.9%)         | 2,934 (100.0%)  |
| <b>Total</b>                                       | 4,977 (41.4%)        | 7,048 (58.6%)         | 12,025 (100.0%) |
| <b>Delivery Assistance</b>                         |                      |                       |                 |
| Doctor                                             | 101 (28.2%)          | 257 (71.8%)           | 358 (100.0%)    |
| Nurse/Midwife                                      | 558 (26.6%)          | 1,537 (73.4%)         | 2,095 (100.0%)  |
| Traditional Birth Attendant                        | 1,866 (55.7%)        | 1,485 (44.3%)         | 3,351 (100.0%)  |
| Relative/Friend                                    | 759 (50.7%)          | 737 (49.3%)           | 1,496 (100.0%)  |
| Other                                              | 96 (49.0%)           | 100 (51.0%)           | 196 (100.0%)    |
| No one assisted                                    | 85 (65.4%)           | 45 (34.6%)            | 130 (100.0%)    |
| Missing                                            | 1,512 (34.4%)        | 2,887 (65.6%)         | 4,399 (100.0%)  |
| <b>Total</b>                                       | 4,977 (41.4%)        | 7,048 (58.6%)         | 12,025 (100.0%) |
| <b>Urban Status</b>                                |                      |                       |                 |
| Urban                                              | 736 (27.1%)          | 1,983 (72.9%)         | 2,719 (100.0%)  |
| Rural                                              | 4,241 (45.5%)        | 5,065 (54.5%)         | 9,306 (100.0%)  |
| <b>Total</b>                                       | 4,977 (41.4%)        | 7,048 (58.6%)         | 12,025 (100.0%) |
| <b>Mother's education level</b>                    |                      |                       |                 |
| Less than primary                                  | 2,033 (60.6%)        | 1,319 (39.4%)         | 3,352 (100.0%)  |
| Primary                                            | 2,413 (41.1%)        | 3,455 (58.9%)         | 5,868 (100.0%)  |
| Secondary or higher                                | 531 (18.9%)          | 2,274 (81.1%)         | 2,805 (100.0%)  |
| <b>Total</b>                                       | 4,977 (41.4%)        | 7,048 (58.6%)         | 12,025 (100.0%) |
| <b>Currently married or in a union</b>             |                      |                       |                 |
| Yes, currently married                             | 2,291 (34.4%)        | 4,372 (65.6%)         | 6,663 (100.0%)  |
| Yes, living with a partner                         | 1,613 (51.4%)        | 1,522 (48.6%)         | 3,135 (100.0%)  |
| No, not in a union                                 | 1,073 (48.1%)        | 1,154 (51.9%)         | 2,227 (100.0%)  |
| <b>Total</b>                                       | 4,977 (41.4%)        | 7,048 (58.6%)         | 12,025 (100.0%) |
| <b>Sex of household head</b>                       |                      |                       |                 |
| Male                                               | 4,143 (40.5%)        | 6,083 (59.5%)         | 10,226 (100.0%) |
| Female                                             | 834 (46.4%)          | 965 (53.6%)           | 1,799 (100.0%)  |
| <b>Total</b>                                       | 4,977 (41.4%)        | 7,048 (58.6%)         | 12,025 (100.0%) |
| <b>HH has mobile phone</b>                         |                      |                       |                 |
| No                                                 | 3,654 (49.6%)        | 3,708 (50.4%)         | 7,362 (100.0%)  |
| Yes                                                | 1,323 (28.3%)        | 3,340 (71.7%)         | 4,663 (100.0%)  |
| <b>Total</b>                                       | 4,977 (41.4%)        | 7,048 (58.6%)         | 12,025 (100.0%) |
| <b>Number of children under age 5 in household</b> |                      |                       |                 |
| 0                                                  | 1,906 (34.2%)        | 3,656 (65.8%)         | 5,562 (100.0%)  |
| 1                                                  | 2,197 (45.6%)        | 2,624 (54.4%)         | 4,821 (100.0%)  |
| 2                                                  | 676 (51.9%)          | 624 (48.1%)           | 1,300 (100.0%)  |
| 3+                                                 | 198 (57.9%)          | 144 (42.1%)           | 342 (100.0%)    |
| <b>Total</b>                                       | 4,977 (41.4%)        | 7,048 (58.6%)         | 12,025 (100.0%) |

**Table G6: Madagascar Model 2: BC Determinants Model within the Household**

| Mixed-effects logistic regression                       |               |                        |                                   |         |                    |
|---------------------------------------------------------|---------------|------------------------|-----------------------------------|---------|--------------------|
| Number of observations = 12,025                         |               |                        |                                   |         |                    |
| Grouping Information                                    |               |                        |                                   |         |                    |
| Group variable                                          | No. of groups | Minimum                | Average                           | Maximum |                    |
| imicscluster                                            | 774           | 1                      | 15.5                              | 44      |                    |
| hhno                                                    | 8,546         | 1                      | 1.4                               | 8       |                    |
| Model Information                                       |               |                        |                                   |         |                    |
| Integration method: mvaghermite                         |               | Integration points = 7 |                                   |         |                    |
| Wald chi <sup>2</sup> (24) = 370.59                     |               |                        | Log pseudolikelihood = -5044.5844 |         |                    |
| Prob > chi <sup>2</sup> = 0.0000                        |               |                        |                                   |         |                    |
| (Std. errors adjusted for 774 clusters in imicscluster) |               |                        |                                   |         |                    |
| Parameter Estimates                                     |               |                        |                                   |         |                    |
| Variable                                                | Odds Ratio    | Std. Err.              | z                                 | P >  z  | 95% Conf. Interval |
| Child's Age (Ref: Age 0)                                |               |                        |                                   |         |                    |
| 1                                                       | 3.6128        | 0.4784                 | 9.70                              | 0.000   | [2.7869, 4.6834]   |
| 2                                                       | 4.9451        | 0.5981                 | 9.45                              | 0.000   | [3.9275, 6.2248]   |
| 3                                                       | 4.4903        | 0.6576                 | 10.25                             | 0.000   | [3.3658, 5.9833]   |
| 4                                                       | 5.3604        | 0.8441                 | 10.66                             | 0.000   | [3.9369, 7.2987]   |
| Sex of Child (Ref: Female)                              |               |                        |                                   |         |                    |
| Male                                                    | 0.9968        | 0.0765                 | -0.04                             | 0.967   | [0.8576, 1.1596]   |
| Household Wealth Index (Ref: Third Quintile)            |               |                        |                                   |         |                    |
| Poorest Quintile                                        | 2.2188        | 0.0347                 | -9.59                             | 0.000   | [1.6584, 2.9795]   |
| Second Quintile                                         | 3.8479        | 0.6630                 | -4.99                             | 0.000   | [2.9252, 5.0638]   |
| Fourth + Richest Quintile                               | 2.4681        | 0.4849                 | 5.51                              | 0.000   | [1.7895, 3.4042]   |
| Delivery Assistance (Ref: Doctor/Health Worker)         |               |                        |                                   |         |                    |
| Nurse/Midwife                                           | 1.1681        | 0.3258                 | 0.59                              | 0.558   | [0.6624, 2.0595]   |
| Traditional Birth Attendant                             | 0.4349        | 0.1237                 | -2.96                             | 0.004   | [0.2432, 0.7803]   |
| Relative/Friend                                         | 0.5548        | 0.1866                 | -1.96                             | 0.050   | [0.3080, 0.9994]   |
| Other                                                   | 0.3417        | 0.1594                 | -2.30                             | 0.021   | [0.1369, 0.8524]   |
| No one assisted                                         | 0.2572        | 0.1454                 | -2.40                             | 0.016   | [0.0849, 0.7792]   |
| Missing                                                 | 0.7784        | 0.2283                 | -0.89                             | 0.376   | [0.4470, 1.3554]   |
| Urban/Rural Residence (Ref: Urban)                      |               |                        |                                   |         |                    |
| Rural                                                   | 0.3637        | 0.0785                 | -4.69                             | 0.000   | [0.2383, 0.5552]   |
| Education Level of Mother (Ref: Less than Primary)      |               |                        |                                   |         |                    |
| Primary                                                 | 1.9939        | 0.2344                 | 5.63                              | 0.000   | [1.5151, 2.3626]   |
| Secondary or Higher                                     | 4.6857        | 0.7238                 | 9.72                              | 0.000   | [3.3846, 6.4846]   |
| Currently Married (Ref: Married)                        |               |                        |                                   |         |                    |
| Yes, living with a partner/in a union                   | 0.5029        | 0.0632                 | -5.47                             | 0.000   | [0.3931, 0.6435]   |
| No, not in a union                                      | 0.5236        | 0.0742                 | -4.56                             | 0.000   | [0.3966, 0.6933]   |
| Sex of Head of Household (Ref: Male)                    |               |                        |                                   |         |                    |
| Female                                                  | 1.0245        | 0.1404                 | 0.17                              | 0.867   | [0.7713, 1.3607]   |
| Constant                                                |               |                        |                                   |         |                    |
| _cons                                                   | 3.1759        | 1.1740                 | 3.13                              | 0.002   | [1.5388, 6.5544]   |
| Random Effects (Variance Components)                    |               |                        |                                   |         |                    |
| imicscluster                                            |               |                        |                                   |         |                    |
| var(_cons)                                              | 4.0289        | 0.4537                 |                                   |         | [3.2310, 5.0239]   |
| imicscluster>hhno                                       |               |                        |                                   |         |                    |
| var(_cons)                                              | 3.9359        | 0.5917                 |                                   |         | [2.9315, 5.2845]   |

Table G7: Madagascar Model 3: Household Structure and Access Model

| Mixed-effects logistic regression                       |               |                        |                                   |         |                    |
|---------------------------------------------------------|---------------|------------------------|-----------------------------------|---------|--------------------|
| Number of observations = 12,025                         |               |                        |                                   |         |                    |
| Grouping Information                                    |               |                        |                                   |         |                    |
| Group variable                                          | No. of groups | Minimum                | Average                           | Maximum |                    |
| imicscluster                                            | 774           | 1                      | 15.5                              | 44      |                    |
| hhno                                                    | 8,546         | 1                      | 1.4                               | 8       |                    |
| Model Information                                       |               |                        |                                   |         |                    |
| Integration method: mvaghermite                         |               | Integration points = 7 |                                   |         |                    |
| Wald chi²(28) = 379.40                                  |               |                        | Log pseudolikelihood = -5033.4084 |         |                    |
| Prob > chi² = 0.0000                                    |               |                        |                                   |         |                    |
| (Std. errors adjusted for 774 clusters in imicscluster) |               |                        |                                   |         |                    |
| Parameter Estimates                                     |               |                        |                                   |         |                    |
| Variable                                                | Odds Ratio    | Std. Err.              | z                                 | P >  z  | 95% Conf. Interval |
| Child's Age (Ref: Age 0)                                |               |                        |                                   |         |                    |
| 1                                                       | 3.5481        | 0.4711                 | 9.54                              | 0.000   | [2.7351, 4.6028]   |
| 2                                                       | 4.3863        | 0.6486                 | 10.00                             | 0.000   | [3.2827, 5.8689]   |
| 3                                                       | 4.8011        | 0.7048                 | 10.69                             | 0.000   | [3.6086, 6.4018]   |
| 4                                                       | 5.8824        | 0.9297                 | 11.21                             | 0.000   | [4.3155, 8.0183]   |
| Sex of Child (Ref: Female)                              |               |                        |                                   |         |                    |
| Male                                                    | 0.9938        | 0.0765                 | -0.08                             | 0.936   | [0.8547, 1.1556]   |
| Household Wealth Index (Ref: Third Quintile)            |               |                        |                                   |         |                    |
| Poorest Quintile                                        | 0.2553        | 0.0419                 | -8.33                             | 0.000   | [0.1852, 0.3521]   |
| Second Quintile                                         | 0.5544        | 0.0756                 | -4.33                             | 0.000   | [0.4244, 0.7242]   |
| Fourth + Richest Quintile                               | 2.1986        | 0.3614                 | 4.79                              | 0.000   | [1.5931, 3.0344]   |
| Delivery Assistance (Ref: Doctor/Health Worker)         |               |                        |                                   |         |                    |
| Nurse/Midwife                                           | 1.1646        | 0.3343                 | 0.53                              | 0.595   | [0.6635, 2.0441]   |
| Traditional Birth Attendant                             | 0.4404        | 0.1273                 | -2.84                             | 0.005   | [0.2499, 0.7761]   |
| Relative/Friend                                         | 0.5854        | 0.1754                 | -1.79                             | 0.074   | [0.3254, 1.0522]   |
| Other                                                   | 0.3417        | 0.1594                 | -2.30                             | 0.021   | [0.1369, 0.8524]   |
| No one assisted                                         | 0.2857        | 0.1490                 | -2.37                             | 0.018   | [0.1082, 0.7553]   |
| Missing                                                 | 0.6737        | 0.1939                 | -1.38                             | 0.169   | [0.3836, 1.1830]   |
| Urban/Rural Res (Ref: Urban)                            |               |                        |                                   |         |                    |
| Rural                                                   | 0.3607        | 0.0778                 | -4.73                             | 0.000   | [0.2364, 0.5504]   |
| Education Level Mother (Ref: Less than Primary)         |               |                        |                                   |         |                    |
| Primary                                                 | 1.8386        | 0.2093                 | 5.35                              | 0.000   | [1.4780, 2.2983]   |
| Secondary or Higher                                     | 4.2095        | 0.6701                 | 9.23                              | 0.000   | [3.1388, 5.6473]   |
| Currently Married (Ref: Married)                        |               |                        |                                   |         |                    |
| Yes, living with a partner/in a union                   | 0.5008        | 0.0632                 | -5.49                             | 0.000   | [0.3931, 0.6410]   |
| No, not in a union                                      | 0.5326        | 0.0756                 | -4.44                             | 0.000   | [0.3966, 0.7134]   |
| Sex Head of Household (Ref: Male)                       |               |                        |                                   |         |                    |
| Female                                                  | 1.0026        | 0.1458                 | 0.02                              | 0.986   | [0.7539, 1.3334]   |
| Number of Children (Ref: 0)                             |               |                        |                                   |         |                    |
| 1                                                       | 0.7673        | 0.0823                 | -2.47                             | 0.013   | [0.6218, 0.9467]   |
| 2                                                       | 0.5769        | 0.0991                 | -3.20                             | 0.001   | [0.4119, 0.8079]   |
| 3+                                                      | 0.5408        | 0.1976                 | -1.68                             | 0.093   | [0.2642, 1.1069]   |
| Household Owns Mobile Phone (Ref: No)                   |               |                        |                                   |         |                    |
| Yes                                                     | 1.4245        | 0.1628                 | 3.10                              | 0.002   | [1.1386, 1.7821]   |
| _cons                                                   | 3.2016        | 1.2125                 | 3.07                              | 0.002   | [1.5240, 6.7255]   |
| Random effects (variance components)                    |               |                        |                                   |         |                    |
| imicscluster                                            |               |                        |                                   |         |                    |
| var(_cons)                                              | 4.0524        | 0.4568                 |                                   |         | [3.2491, 5.0542]   |
| imicscluster>hhno                                       |               |                        |                                   |         |                    |
| var(_cons)                                              | 3.9146        | 0.5908                 |                                   |         | [2.9123, 5.2620]   |

Table 13: Mixed-effects logistic regression results

**Table G8 Madagascar Model 4: Household Structure and Access Model with Interaction Terms**

| Mixed-effects logistic regression                       |               |                        |                                   |         |                    |
|---------------------------------------------------------|---------------|------------------------|-----------------------------------|---------|--------------------|
| Number of observations = 12,025                         |               |                        |                                   |         |                    |
| Grouping Information                                    |               |                        |                                   |         |                    |
| Group variable                                          | No. of groups | Minimum                | Average                           | Maximum |                    |
| imicscluster                                            | 774           | 1                      | 15.5                              | 44      |                    |
| hhno                                                    | 8,546         | 1                      | 1.4                               | 8       |                    |
| Model Information                                       |               |                        |                                   |         |                    |
| Integration method: mvaghermite                         |               | Integration points = 7 |                                   |         |                    |
| Wald chi <sup>2</sup> (32) = 385.02                     |               |                        | Log pseudolikelihood = -5031.6963 |         |                    |
| Prob > chi <sup>2</sup> = 0.0000                        |               |                        |                                   |         |                    |
| (Std. errors adjusted for 774 clusters in imicscluster) |               |                        |                                   |         |                    |
| Parameter Estimates                                     |               |                        |                                   |         |                    |
| Variable                                                | Odds Ratio    | Std. Err.              | z                                 | P >  z  | 95% Conf. Interval |
| Child's Age (Ref: Age 0)                                |               |                        |                                   |         |                    |
| 1                                                       | 3.5512        | 0.4703                 | 9.57                              | 0.000   | [2.7394, 4.6037]   |
| 2                                                       | 4.4072        | 0.6540                 | 9.99                              | 0.000   | [3.2949, 5.8950]   |
| 3                                                       | 4.8266        | 0.7097                 | 10.71                             | 0.000   | [3.6181, 6.4388]   |
| 4                                                       | 5.9236        | 0.9408                 | 11.20                             | 0.000   | [4.3390, 8.0867]   |
| Sex of Child (Ref: Female)                              |               |                        |                                   |         |                    |
| Male                                                    | 0.9958        | 0.0765                 | -0.05                             | 0.956   | [0.8565, 1.1577]   |
| Household Wealth Index (Ref: Third Quintile)            |               |                        |                                   |         |                    |
| Poorest Quintile                                        | 0.2224        | 0.0643                 | -5.20                             | 0.000   | [0.1262, 0.3920]   |
| Second Quintile                                         | 0.5393        | 0.1522                 | -2.19                             | 0.029   | [0.3102, 0.9376]   |
| Fourth + Richest Quintile                               | 2.1867        | 0.9470                 | 1.81                              | 0.071   | [0.9358, 5.1098]   |
| Delivery Assistance (Ref: Doctor/Health Worker)         |               |                        |                                   |         |                    |
| Nurse/Midwife                                           | 1.1604        | 0.3330                 | 0.52                              | 0.604   | [0.6612, 2.0365]   |
| Traditional Birth Attendant                             | 0.4381        | 0.1269                 | -2.85                             | 0.004   | [0.2483, 0.7729]   |
| Relative/Friend                                         | 0.5823        | 0.1750                 | -1.80                             | 0.072   | [0.3231, 1.0493]   |
| Other                                                   | 0.3478        | 0.1622                 | -2.27                             | 0.024   | [0.1395, 0.8674]   |
| No one assisted                                         | 0.2679        | 0.1497                 | -2.36                             | 0.018   | [0.0896, 0.8007]   |
| Missing                                                 | 0.6726        | 0.1936                 | -1.38                             | 0.168   | [0.3826, 1.1824]   |
| Urban/Rural Res (Ref: Urban)                            |               |                        |                                   |         |                    |
| Rural                                                   | 0.3583        | 0.0774                 | -4.75                             | 0.000   | [0.2347, 0.5471]   |
| Education Level Mother (Ref: Less than Primary)         |               |                        |                                   |         |                    |
| Primary                                                 | 1.6001        | 0.4346                 | 1.73                              | 0.084   | [0.9396, 2.7250]   |
| Secondary or higher                                     | 4.3236        | 1.3747                 | 4.60                              | 0.000   | [2.3184, 8.0629]   |
| Currently Married (Ref: Married)                        |               |                        |                                   |         |                    |
| Yes, living with a partner/in a union                   | 0.5040        | 0.0648                 | -5.33                             | 0.000   | [0.3917, 0.6485]   |
| No, not in a union                                      | 0.5824        | 0.0969                 | -3.25                             | 0.001   | [0.4205, 0.8069]   |
| Sex Head of Household (Ref: Male)                       |               |                        |                                   |         |                    |
| Female                                                  | 1.2933        | 0.3718                 | 0.89                              | 0.371   | [0.7362, 2.2720]   |
| Number of Children (Ref: 0)                             |               |                        |                                   |         |                    |
| 1                                                       | 0.7654        | 0.0822                 | -2.49                             | 0.013   | [0.6202, 0.9447]   |
| 2                                                       | 0.5687        | 0.0985                 | -3.26                             | 0.001   | [0.4051, 0.7985]   |
| 3+                                                      | 0.5333        | 0.1962                 | -1.71                             | 0.088   | [0.2593, 1.0969]   |
| Household Owns Mobile Phone (Ref: No)                   |               |                        |                                   |         |                    |
| Yes                                                     | 1.4222        | 0.1629                 | 3.08                              | 0.002   | [1.1362, 1.7801]   |
| Interaction: Wealth Index & Education Level Mother      |               |                        |                                   |         |                    |
| Poorest # Primary                                       | 1.3022        | 0.4114                 | 0.84                              | 0.403   | [0.7011, 2.4187]   |
| Poorest # Secondary or higher                           | 0.9566        | 0.4380                 | -0.10                             | 0.923   | [0.3899, 2.3467]   |
| Second # Primary                                        | 1.0353        | 0.3421                 | 0.10                              | 0.916   | [0.5417, 1.9785]   |
| Second # Secondary or higher                            | 1.0450        | 0.4386                 | 0.10                              | 0.917   | [0.4590, 2.3790]   |
| Fourth + Richest # Primary                              | 1.1190        | 0.5308                 | 0.24                              | 0.813   | [0.4416, 2.8354]   |
| Fourth + Richest # Secondary or higher                  | 0.8556        | 0.4202                 | -0.32                             | 0.751   | [0.3268, 2.2402]   |
| Interaction: Married & Sex Head of Household            |               |                        |                                   |         |                    |
| Yes, living with a partner/in a union # Female          | 0.8246        | 0.3730                 | -0.43                             | 0.670   | [0.3398, 2.0010]   |
| No, not in a union # Female                             | 0.6718        | 0.2417                 | -1.11                             | 0.269   | [0.3319, 1.3598]   |
| Constant                                                |               |                        |                                   |         |                    |
| _cons                                                   | 3.4699        | 1.4730                 | 2.93                              | 0.003   | [1.5100, 7.9737]   |
| Random effects (variance components)                    |               |                        |                                   |         |                    |
| imicscluster                                            |               |                        |                                   |         |                    |
| var(_cons)                                              | 4.0487        | 0.4561                 |                                   |         | [3.2466, 5.0489]   |
| imicscluster>hhno                                       |               |                        |                                   |         |                    |
| var(_cons)                                              | 3.9147        | 0.5903                 |                                   |         | [2.9131, 5.2608]   |

Table 14: Mixed-effects logistic regression results

## 7 Appendix H: MICS Lao People's Democratic Republic 2017

**\*Table H1:** Model Comparison Statistics

| Model      | Log Pseudo- likelihood | AIC      | BIC      | ICC (Imicscluster) | ICC (hhno) | Wald Chi <sup>2</sup> | DoF |
|------------|------------------------|----------|----------|--------------------|------------|-----------------------|-----|
| Null Model | -5621.266              | 25321.12 | 25560.34 | 0.4471472          | 0.8059345  | -                     | -   |
| Model 2    | -5121.6301             | 25200.84 | 25440.06 | 0.3723             | 0.6277     | 145.76                | 21  |
| Model 3    | -5118.4372             | 25085.78 | 25324.99 | 0.3744             | 0.6256     | 158.32                | 28  |
| Model 4    | -5113.9257             | 24965.62 | 25204.84 | 0.3744             | 0.6256     | 167.89                | 39  |

**\*Table H2:** Lao VIF

| Variable         | VIF         | 1/VIF    |
|------------------|-------------|----------|
| agech 1          | 1.59        | 0.629893 |
| agech 2          | 2.26        | 0.442647 |
| agech 3          | 2.32        | 0.431504 |
| agech 4          | 2.24        | 0.445653 |
| 1.sexch          | 1.00        | 0.997641 |
| windex5 2        | 1.59        | 0.628519 |
| windex5 3        | 1.73        | 0.579509 |
| windex5 4        | 2.65        | 0.377433 |
| delivery_a ~ e 2 | 2.00        | 0.498905 |
| delivery_a ~ e 3 | 1.20        | 0.832765 |
| delivery_a ~ e 4 | 2.11        | 0.473466 |
| delivery_a ~ e 5 | 1.16        | 0.858648 |
| delivery_a ~ e 6 | 1.27        | 0.787553 |
| delivery_a ~ e 9 | 3.88        | 0.257951 |
| 2.urban_fa ~ r   | 1.39        | 0.717110 |
| edlevelmom 20    | 1.80        | 0.555829 |
| edlevelmom 30    | 1.86        | 0.538320 |
| edlevelmom 40    | 2.13        | 0.468933 |
| marrcurr 12      | 1.01        | 0.991579 |
| marrcurr 20      | 1.05        | 0.952798 |
| 2.sexhhead       | 1.06        | 0.943064 |
| numch 2          | 1.35        | 0.743150 |
| numch 3          | 1.26        | 0.796426 |
| numch 4          | 1.05        | 0.955308 |
| numch 5          | 1.02        | 0.984444 |
| numch 6          | 1.01        | 0.989918 |
| numch 7          | 1.01        | 0.991177 |
| 1.mobphone~ h    | 1.23        | 0.815996 |
| <b>Mean VIF</b>  | <b>1.61</b> |          |

**Table H3:** for Null Model-ICC

### Null Model Results

Integration Method: mvaghermite

Integration Points: 7

Wald chi<sup>2</sup> (0): .

Log Pseudolikelihood: -5621.266

Prob > chi<sup>2</sup>: .

(Standard errors adjusted for 1,157 clusters in imicscluster)

| Model Coefficients          |          |           |      |        |                      |
|-----------------------------|----------|-----------|------|--------|----------------------|
| Variable                    | Odds     | Std. Err. | z    | P >  z | [95% Conf. Interval] |
| _cons                       | 2.171734 | 0.2249863 | 7.49 | 0.000  | [1.772655, 2.660658] |
| <b>imicscluster</b>         |          |           |      |        |                      |
| var(_cons)                  | 7.580202 | 0.8322296 |      |        | [6.11262, 9.400135]  |
| <b>imicscluster&gt;hhno</b> |          |           |      |        |                      |
| var(_cons)                  | 6.082293 | 0.7775322 |      |        | [4.734277, 7.814137] |

Note: Estimates are transformed only in the first equation to odds.

**Table H4:** Intraclass Correlation Coefficients (ICC)

| Intraclass Correlation |           |           |                        |
|------------------------|-----------|-----------|------------------------|
| Level                  | ICC       | Std. Err. | [95% Conf. Interval]   |
| imicscluster           | 0.4471472 | 0.0179181 | [0.4123482, 0.4824719] |
| hhno > imicscluster    | 0.8059345 | 0.0172448 | [0.7698928, 0.8375224] |

**Table H5: Descriptive Statistics-Variable Distributions (MICS Laos 2017, N=10,843)**

| Variable                                           | No Birth Certificate | Has Birth Certificate | Total                  |
|----------------------------------------------------|----------------------|-----------------------|------------------------|
| <b>Child's age in completed years</b>              |                      |                       |                        |
| Less than 1 year                                   | 1,060 (48.5%)        | 1,127 (51.5%)         | 2,187 (100.0%)         |
| 1 year                                             | 930 (44.6%)          | 1,155 (55.4%)         | 2,085 (100.0%)         |
| 2 years                                            | 979 (44.5%)          | 1,222 (55.5%)         | 2,201 (100.0%)         |
| 3 years                                            | 1,088 (47.8%)        | 1,190 (52.2%)         | 2,278 (100.0%)         |
| 4 years                                            | 1,010 (48.2%)        | 1,082 (51.8%)         | 2,092 (100.0%)         |
| <b>Total</b>                                       | <b>5,067 (46.8%)</b> | <b>5,776 (53.2%)</b>  | <b>10,843 (100.0%)</b> |
| <b>Sex of child</b>                                |                      |                       |                        |
| Female                                             | 2,496 (46.9%)        | 2,819 (53.1%)         | 5,315 (100.0%)         |
| Male                                               | 2,571 (46.5%)        | 2,957 (53.5%)         | 5,528 (100.0%)         |
| <b>Total</b>                                       | <b>5,067 (46.8%)</b> | <b>5,776 (53.2%)</b>  | <b>10,843 (100.0%)</b> |
| <b>Wealth index quintile</b>                       |                      |                       |                        |
| Poorest                                            | 2,207 (68.5%)        | 1,013 (31.5%)         | 3,220 (100.0%)         |
| Second                                             | 1,372 (52.7%)        | 1,231 (47.3%)         | 2,603 (100.0%)         |
| Middle                                             | 854 (43.1%)          | 1,124 (56.9%)         | 1,978 (100.0%)         |
| Fourth + Fifth                                     | 634 (20.9%)          | 2,408 (79.1%)         | 3,042 (100.0%)         |
| <b>Total</b>                                       | <b>5,067 (46.8%)</b> | <b>5,776 (53.2%)</b>  | <b>10,843 (100.0%)</b> |
| <b>Delivery Assistance</b>                         |                      |                       |                        |
| Doctor                                             | 393 (28.2%)          | 999 (71.8%)           | 1,392 (100.0%)         |
| Nurse/Midwife                                      | 620 (30.5%)          | 1,409 (69.5%)         | 2,029 (100.0%)         |
| Traditional Birth Attendant                        | 230 (79.0%)          | 61 (21.0%)            | 291 (100.0%)           |
| Relative/Friend                                    | 1,308 (73.4%)        | 475 (26.6%)           | 1,783 (100.0%)         |
| Other                                              | 164 (73.2%)          | 60 (26.8%)            | 224 (100.0%)           |
| No one assisted                                    | 256 (64.6%)          | 140 (35.4%)           | 396 (100.0%)           |
| NIU (not in Universe)                              | 2,096 (44.3%)        | 2,632 (55.7%)         | 4,728 (100.0%)         |
| <b>Total</b>                                       | <b>5,067 (46.8%)</b> | <b>5,776 (53.2%)</b>  | <b>10,843 (100.0%)</b> |
| <b>Urban Status</b>                                |                      |                       |                        |
| Urban                                              | 672 (24.1%)          | 2,124 (75.9%)         | 2,796 (100.0%)         |
| Rural                                              | 4,395 (54.5%)        | 3,652 (45.5%)         | 8,047 (100.0%)         |
| <b>Total</b>                                       | <b>5,067 (46.8%)</b> | <b>5,776 (53.2%)</b>  | <b>10,843 (100.0%)</b> |
| <b>Mother's education level</b>                    |                      |                       |                        |
| Less than primary                                  | 1,705 (67.5%)        | 819 (32.5%)           | 2,524 (100.0%)         |
| Primary                                            | 2,193 (51.0%)        | 2,111 (49.0%)         | 4,304 (100.0%)         |
| Lower secondary                                    | 888 (38.3%)          | 1,432 (61.7%)         | 2,320 (100.0%)         |
| Secondary or higher                                | 281 (16.6%)          | 1,414 (83.4%)         | 1,695 (100.0%)         |
| <b>Total</b>                                       | <b>5,067 (46.8%)</b> | <b>5,776 (53.2%)</b>  | <b>10,843 (100.0%)</b> |
| <b>Currently married or in a union</b>             |                      |                       |                        |
| Yes, currently married                             | 4,815 (46.3%)        | 5,572 (53.7%)         | 10,387 (100.0%)        |
| Yes, living with a partner                         | 124 (69.7%)          | 54 (30.3%)            | 178 (100.0%)           |
| No, not in a union                                 | 128 (46.0%)          | 150 (54.0%)           | 278 (100.0%)           |
| <b>Total</b>                                       | <b>5,067 (46.8%)</b> | <b>5,776 (53.2%)</b>  | <b>10,843 (100.0%)</b> |
| <b>Sex of household head</b>                       |                      |                       |                        |
| Male                                               | 4,707 (47.6%)        | 5,191 (52.4%)         | 9,898 (100.0%)         |
| Female                                             | 360 (38.1%)          | 585 (61.9%)           | 945 (100.0%)           |
| <b>Total</b>                                       | <b>5,067 (46.8%)</b> | <b>5,776 (53.2%)</b>  | <b>10,843 (100.0%)</b> |
| <b>HH has mobile phone</b>                         |                      |                       |                        |
| No                                                 | 881 (67.7%)          | 420 (32.3%)           | 1,301 (100.0%)         |
| Yes                                                | 4,186 (43.9%)        | 5,356 (56.1%)         | 9,542 (100.0%)         |
| <b>Total</b>                                       | <b>5,067 (46.8%)</b> | <b>5,776 (53.2%)</b>  | <b>10,843 (100.0%)</b> |
| <b>Number of children under age 5 in household</b> |                      |                       |                        |
| 1 child                                            | 2,441 (42.2%)        | 3,355 (57.8%)         | 5,796 (100.0%)         |
| 2 children                                         | 1,967 (50.4%)        | 1,937 (49.6%)         | 3,904 (100.0%)         |
| 3+ children                                        | 659 (60.8%)          | 424 (39.2%)           | 1,083 (100.0%)         |
| <b>Total</b>                                       | <b>5,067 (46.8%)</b> | <b>5,776 (53.2%)</b>  | <b>10,843 (100.0%)</b> |

**Table H6: Lao Model 2: Birth Certificate Determinants Model within the Household**

| Mixed-effects logistic regression                       |               |                  |                                   |         |                      |
|---------------------------------------------------------|---------------|------------------|-----------------------------------|---------|----------------------|
| Number of obs = 10,843                                  |               |                  |                                   |         |                      |
| Grouping information                                    |               |                  |                                   |         |                      |
| Group variable                                          | No. of groups | Minimum          | Average                           | Maximum |                      |
| imicscluster                                            | 1,157         | 1                | 9.4                               | 33      |                      |
| hhno                                                    | 8,149         | 1                | 1.3                               | 7       |                      |
| Integration method: mvaghermite                         |               |                  |                                   |         |                      |
| Integration pts. = 7                                    |               |                  |                                   |         |                      |
| Wald chi²(21) = 378.67                                  |               |                  | Log pseudolikelihood = -5121.6301 |         |                      |
| Prob > chi² = 0.0000                                    |               |                  |                                   |         |                      |
| (Std. err. adjusted for 1,157 clusters in imicscluster) |               |                  |                                   |         |                      |
| Parameter Estimates                                     |               |                  |                                   |         |                      |
| Variable                                                | Odds ratio    | Robust std. err. | z                                 | P >  z  | [95% conf. interval] |
| Child's Age (Ref: Age 0)                                |               |                  |                                   |         |                      |
| 1                                                       | 1.3454        | 0.1816           | 2.20                              | 0.028   | [1.0326, 1.7530]     |
| 2                                                       | 1.7282        | 0.2636           | 3.54                              | 0.000   | [1.2739, 2.3228]     |
| 3                                                       | 1.5666        | 0.2483           | 2.83                              | 0.005   | [1.1483, 2.1374]     |
| 4                                                       | 1.4124        | 0.2301           | 2.12                              | 0.034   | [1.0263, 1.9438]     |
| Sex of Child (Ref: Female)                              |               |                  |                                   |         |                      |
| Male                                                    | 1.0685        | 0.0942           | 0.66                              | 0.508   | [0.8911, 1.2622]     |
| Household Wealth Index (Ref: Third Quintile)            |               |                  |                                   |         |                      |
| Poorest                                                 | 0.3520        | 0.0633           | -5.81                             | 0.000   | [0.2475, 0.5007]     |
| Second                                                  | 0.7132        | 0.1082           | -2.23                             | 0.026   | [0.5298, 0.9601]     |
| Fourth + Fifth                                          | 3.5283        | 0.5851           | 7.57                              | 0.000   | [2.5416, 4.8760]     |
| Delivery Assistance (Ref: Doctor)                       |               |                  |                                   |         |                      |
| Nurse/Midwife                                           | 0.7509        | 0.1477           | -1.46                             | 0.145   | [0.5108, 1.1041]     |
| Traditional Birth Attendant                             | 0.0495        | 0.0213           | -7.00                             | 0.000   | [0.0213, 0.1149]     |
| Relative/Friend                                         | 0.1023        | 0.0240           | -9.72                             | 0.000   | [0.0646, 0.1621]     |
| Other                                                   | 0.1014        | 0.0444           | -5.22                             | 0.000   | [0.0430, 0.2393]     |
| No one assisted                                         | 0.1644        | 0.0544           | -5.45                             | 0.000   | [0.0859, 0.3146]     |
| NIU (not in Universe)                                   | 0.3497        | 0.0650           | -5.56                             | 0.000   | [0.2430, 0.5033]     |
| Urban/Rural Residence (Ref: Urban)                      |               |                  |                                   |         |                      |
| Rural                                                   | 0.2859        | 0.0526           | -6.00                             | 0.000   | [0.1993, 0.4101]     |
| Mother's Education Level (Ref: None)                    |               |                  |                                   |         |                      |
| Primary                                                 | 2.2867        | 0.3193           | 5.92                              | 0.000   | [1.7392, 3.0066]     |
| Lower secondary                                         | 2.8216        | 0.4944           | 5.92                              | 0.000   | [2.0014, 3.9779]     |
| Secondary or higher                                     | 9.0954        | 2.1136           | 9.50                              | 0.000   | [5.7679, 14.3425]    |
| Marital Status (Ref: Never Married)                     |               |                  |                                   |         |                      |
| Yes, living with a partner/in a union                   | 0.2098        | 0.0811           | -4.04                             | 0.000   | [0.0984, 0.4475]     |
| No, not in a union                                      | 0.9851        | 0.2791           | -0.05                             | 0.958   | [0.5654, 1.7165]     |
| Sex of Household Head (Ref: Male)                       |               |                  |                                   |         |                      |
| Female                                                  | 1.0670        | 0.2004           | 0.35                              | 0.730   | [0.7304, 1.5518]     |
| _con                                                    | 3.3445        | 0.8880           | 4.55                              | 0.000   | [1.9877, 5.6277]     |
| imicscluster                                            |               |                  |                                   |         |                      |
| var(_cons)                                              | 3.3776        | 0.4890           |                                   |         | [2.6639, 4.2824]     |
| imicscluster>hhno                                       |               |                  |                                   |         |                      |
| var(_cons)                                              | 5.6782        | 0.7393           |                                   |         | [4.3915, 7.3212]     |

Table H7: Lao Model 3: Household Structure and Access Model

| Mixed-effects logistic regression                         |            |           |                                   |        |                    |
|-----------------------------------------------------------|------------|-----------|-----------------------------------|--------|--------------------|
| Integration method: mvaghermite, Integration points = 7   |            |           |                                   |        |                    |
| Wald chi <sup>2</sup> (28) = 607.90                       |            |           | Log pseudolikelihood = -5118.4372 |        |                    |
| Prob > chi <sup>2</sup> = 0.0000                          |            |           |                                   |        |                    |
| (Std. errors adjusted for 1,157 clusters in imicscluster) |            |           |                                   |        |                    |
| Parameter Estimates                                       |            |           |                                   |        |                    |
| Variable                                                  | Odds Ratio | Std. Err. | z                                 | P >  z | 95% Conf. Interval |
| Child's Age (Ref: Age 0)                                  |            |           |                                   |        |                    |
| 1                                                         | 1.3343     | 0.1805    | 2.13                              | 0.033  | [1.0236, 1.7394]   |
| 2                                                         | 1.7803     | 0.2738    | 3.75                              | 0.000  | [1.3169, 2.4066]   |
| 3                                                         | 1.6182     | 0.2592    | 3.01                              | 0.003  | [1.1823, 2.2149]   |
| 4                                                         | 1.4678     | 0.2423    | 2.32                              | 0.020  | [1.0620, 2.0285]   |
| Sex of Child (Ref: Female)                                |            |           |                                   |        |                    |
| Male                                                      | 1.0604     | 0.0942    | 0.66                              | 0.509  | [0.8910, 1.2628]   |
| Household Wealth Index (Ref: Third Quintile)              |            |           |                                   |        |                    |
| Poorest                                                   | 0.3546     | 0.0656    | -5.60                             | 0.000  | [0.2468, 0.5096]   |
| Second                                                    | 0.7118     | 0.1182    | -2.24                             | 0.025  | [0.5284, 0.9589]   |
| Fourth + Fifth                                            | 3.5040     | 0.5837    | 7.53                              | 0.000  | [2.5280, 4.8659]   |
| Delivery Assistance (Ref: Doctor)                         |            |           |                                   |        |                    |
| Nurse/Midwife                                             | 0.7526     | 0.1481    | -1.44                             | 0.149  | [0.5118, 1.1067]   |
| Traditional Birth Attendant                               | 0.0497     | 0.0214    | -6.99                             | 0.000  | [0.0212, 0.1154]   |
| Relative/Friend                                           | 0.1063     | 0.0251    | -9.58                             | 0.000  | [0.0640, 0.1766]   |
| Other                                                     | 0.1034     | 0.0452    | -5.19                             | 0.000  | [0.0493, 0.2435]   |
| No one assisted                                           | 0.1675     | 0.0526    | -5.43                             | 0.000  | [0.0973, 0.2886]   |
| NIU (not in Universe)                                     | 0.3252     | 0.0628    | -5.82                             | 0.000  | [0.2228, 0.4747]   |
| Urban/Rural Res (Ref: Urban)                              |            |           |                                   |        |                    |
| Rural                                                     | 0.2842     | 0.0524    | -6.83                             | 0.000  | [0.1980, 0.4078]   |
| Education Level Mother (Ref: Less than Primary)           |            |           |                                   |        |                    |
| Primary                                                   | 2.2616     | 0.3164    | 5.83                              | 0.000  | [1.7193, 2.9751]   |
| Lower Secondary                                           | 2.7932     | 0.4906    | 5.85                              | 0.000  | [1.9796, 3.9410]   |
| Secondary or Higher                                       | 8.9131     | 2.0775    | 9.39                              | 0.000  | [5.6445, 14.0745]  |
| Marital Status (Ref: Never Married)                       |            |           |                                   |        |                    |
| Yes, living with a partner/in a union                     | 0.2096     | 0.0810    | -4.04                             | 0.000  | [0.0982, 0.4471]   |
| No, not in a union                                        | 0.9750     | 0.2763    | -0.09                             | 0.929  | [0.5595, 1.6993]   |
| Sex of Household Head (Ref: Male)                         |            |           |                                   |        |                    |
| Female                                                    | 1.0679     | 0.2004    | 0.35                              | 0.726  | [0.7392, 1.5427]   |
| _cons                                                     | 3.5754     | 1.1202    | 4.07                              | 0.000  | [1.9348, 6.6071]   |
| Number of Children (Ref: 1)                               |            |           |                                   |        |                    |
| 2                                                         | 0.8996     | 0.1074    | -0.89                             | 0.376  | [0.7120, 1.1368]   |
| 3+                                                        | 0.6477     | 0.1541    | -1.83                             | 0.068  | [0.4063, 1.0325]   |
| Mobile Phone Ownership (Ref: No)                          |            |           |                                   |        |                    |
| Yes                                                       | 1.0146     | 0.1742    | 0.08                              | 0.932  | [0.7248, 1.4204]   |
| _cons                                                     | 3.5754     | 1.1202    | 4.07                              | 0.000  | [1.9348, 6.6071]   |
| Random effects (variance components)                      |            |           |                                   |        |                    |
| imicscluster                                              |            |           |                                   |        |                    |
| var(_cons)                                                | 3.3792     | 0.4095    |                                   |        | [2.6648, 4.2852]   |
| imicscluster>hhno                                         |            |           |                                   |        |                    |
| var(_cons)                                                | 5.6524     | 0.7387    |                                   |        | [4.3751, 7.3026]   |

**Table H8: Lao Model 4: Household Structure and Access Model with Interaction Terms**

| Mixed-effects logistic regression                         |               |                        |                                   |         |                    |
|-----------------------------------------------------------|---------------|------------------------|-----------------------------------|---------|--------------------|
| Number of observations = 10,843                           |               |                        |                                   |         |                    |
| Grouping Information                                      |               |                        |                                   |         |                    |
| Group variable                                            | No. of groups | Minimum                | Average                           | Maximum |                    |
| imicscluster                                              | 1,157         | 1                      | 9.4                               | 33      |                    |
| hhno                                                      | 8,149         | 1                      | 1.3                               | 7       |                    |
| Model Information                                         |               |                        |                                   |         |                    |
| Integration method: mvaghermite                           |               | Integration points = 7 |                                   |         |                    |
| Wald chi <sup>2</sup> (39) = 620.28                       |               |                        | Log pseudolikelihood = -5113.9257 |         |                    |
| Prob > chi <sup>2</sup> = 0.0000                          |               |                        |                                   |         |                    |
| (Std. errors adjusted for 1,157 clusters in imicscluster) |               |                        |                                   |         |                    |
| Parameter Estimates                                       |               |                        |                                   |         |                    |
| Variable                                                  | Odds Ratio    | Std. Err.              | z                                 | P >  z  | 95% Conf. Interval |
| Child's Age (Ref: Age 0)                                  |               |                        |                                   |         |                    |
| 1                                                         | 1.3170        | 0.1772                 | 2.05                              | 0.041   | [1.0118, 1.7143]   |
| 2                                                         | 1.7645        | 0.2711                 | 3.70                              | 0.000   | [1.3058, 2.3845]   |
| 3                                                         | 1.6139        | 0.2578                 | 3.00                              | 0.003   | [1.1802, 2.2071]   |
| 4                                                         | 1.4523        | 0.2395                 | 2.26                              | 0.024   | [1.0512, 2.0063]   |
| Sex of Child (Ref: Female)                                |               |                        |                                   |         |                    |
| Male                                                      | 1.0643        | 0.0945                 | 0.70                              | 0.483   | [0.8943, 1.2666]   |
| Household Wealth Index (Ref: Third Quintile)              |               |                        |                                   |         |                    |
| Poorest                                                   | 0.2477        | 0.0958                 | -3.61                             | 0.000   | [0.1161, 0.5286]   |
| Second                                                    | 0.5944        | 0.2196                 | -1.41                             | 0.159   | [0.2881, 1.2260]   |
| Fourth + Fifth                                            | 2.0110        | 1.1871                 | 1.18                              | 0.237   | [0.6324, 6.3954]   |
| Delivery Assistance (Ref: Doctor/Health Worker)           |               |                        |                                   |         |                    |
| Nurse/Midwife                                             | 0.7480        | 0.1470                 | -1.48                             | 0.139   | [0.5089, 1.0994]   |
| Traditional Birth Attendant                               | 0.0495        | 0.0212                 | -7.01                             | 0.000   | [0.0214, 0.1146]   |
| Relative/Friend                                           | 0.1061        | 0.0248                 | -9.59                             | 0.000   | [0.0671, 0.1677]   |
| Other                                                     | 0.1029        | 0.0450                 | -5.20                             | 0.000   | [0.0437, 0.2425]   |
| No one assisted                                           | 0.1698        | 0.0557                 | -5.41                             | 0.000   | [0.0893, 0.3230]   |
| NIU (not in Universe)                                     | 0.3233        | 0.0622                 | -5.87                             | 0.000   | [0.2218, 0.4714]   |
| Urban/Rural Res (Ref: Urban)                              |               |                        |                                   |         |                    |
| Rural                                                     | 0.2894        | 0.0535                 | -6.70                             | 0.000   | [0.2014, 0.4158]   |
| Education Level Mother (Ref: Less than Primary)           |               |                        |                                   |         |                    |
| Primary                                                   | 1.5645        | 0.5604                 | 1.25                              | 0.212   | [0.7753, 3.1570]   |
| Lower secondary                                           | 2.4848        | 0.9646                 | 2.34                              | 0.019   | [1.1610, 5.3179]   |
| Secondary or higher                                       | 5.0141        | 2.3854                 | 3.39                              | 0.001   | [1.9735, 12.7393]  |
| Currently Married (Ref: Married)                          |               |                        |                                   |         |                    |
| Yes, living with a partner/in a union                     | 0.1738        | 0.0747                 | -4.07                             | 0.000   | [0.0748, 0.4037]   |
| No, not in a union                                        | 1.0072        | 0.3634                 | 0.02                              | 0.984   | [0.4966, 2.0430]   |
| Sex Head of Household (Ref: Male)                         |               |                        |                                   |         |                    |
| Female                                                    | 1.0513        | 0.2104                 | 0.25                              | 0.803   | [0.7101, 1.5564]   |
| Number of Children (Ref: 1)                               |               |                        |                                   |         |                    |
| 2                                                         | 0.8921        | 0.1071                 | -0.95                             | 0.341   | [0.7051, 1.1287]   |
| 3+                                                        | 0.6388        | 0.1519                 | -1.88                             | 0.059   | [0.4008, 1.0180]   |
| Household Owns Mobile Phone (Ref: No)                     |               |                        |                                   |         |                    |
| Yes                                                       | 1.0208        | 0.1752                 | 0.12                              | 0.905   | [0.7292, 1.4291]   |
| Interaction: Wealth Index & Education Level Mother        |               |                        |                                   |         |                    |
| Poorest # Primary                                         | 1.8065        | 0.7698                 | 1.39                              | 0.165   | [0.7836, 4.1644]   |
| Poorest # Lower secondary                                 | 1.0305        | 0.5463                 | 0.06                              | 0.955   | [0.3646, 2.9127]   |
| Poorest # Secondary or higher                             | 1.3536        | 1.1016                 | 0.37                              | 0.710   | [0.2747, 6.6712]   |
| Second # Primary                                          | 1.2431        | 0.5331                 | 0.51                              | 0.612   | [0.5364, 2.8812]   |
| Second # Lower secondary                                  | 1.1364        | 0.5347                 | 0.27                              | 0.786   | [0.4518, 2.8581]   |
| Second # Secondary or higher                              | 1.1425        | 0.7749                 | 0.20                              | 0.844   | [0.3024, 4.3171]   |
| Fourth + Fifth # Primary                                  | 1.9145        | 1.2315                 | 1.01                              | 0.313   | [0.5427, 6.7544]   |
| Fourth + Fifth # Lower secondary                          | 1.3333        | 0.8574                 | 0.45                              | 0.655   | [0.3780, 4.7023]   |
| Fourth + Fifth # Secondary or higher                      | 2.7795        | 2.0068                 | 1.42                              | 0.157   | [0.6751, 11.4428]  |
| Interaction: Married & Sex Head of Household              |               |                        |                                   |         |                    |
| Yes, living with a partner/in a union # Female            | 3.7988        | 3.6213                 | 1.40                              | 0.161   | [0.5865, 24.6077]  |
| No, not in a union # Female                               | 0.9101        | 0.5490                 | -0.16                             | 0.876   | [0.2790, 2.9688]   |
| Constant                                                  |               |                        |                                   |         |                    |
| _cons                                                     | 4.6764        | 1.9649                 | 3.67                              | 0.000   | [2.0524, 10.6551]  |

## 8 Appendix I. MICS Sudan 2014

**\*\*Table I1: Model Fit Statistics \*\*Table I2: Sudan VIF**

| Model      | AIC      | BIC      | Log Pseudo-likelihood | Wald Chi <sup>2</sup> | DoF | ICC (Imicscluster) | ICC (hhno — Imicscluster) |
|------------|----------|----------|-----------------------|-----------------------|-----|--------------------|---------------------------|
| Null Model | 13665.36 | 13687.92 | -6917.235             | —                     | —   | 0.4505613          | 0.8000904                 |
| Model 2    | 12071.41 | 12229.39 | -6014.7045            | 324.57                | 18  | 0.1663             | 0.6038                    |
| Model 3    | 12046.43 | 12242.03 | -5997.214             | 343.97                | 23  | 0.1645             | 0.6035                    |
| Model 4    | 12056.50 | 12304.76 | -5995.251             | 350.89                | 30  | 0.1642             | 0.6039                    |

| Variable         | VIF         | 1/VIF    |
|------------------|-------------|----------|
| agech 1          | 1.53        | 0.653548 |
| agech 2          | 1.89        | 0.530106 |
| agech 3          | 1.80        | 0.556050 |
| agech 4          | 1.76        | 0.569091 |
| 1.sexch          | 1.00        | 0.998840 |
| windex5 2        | 1.67        | 0.597709 |
| windex5 3        | 1.91        | 0.523830 |
| windex5 4        | 2.81        | 0.356103 |
| delivery_a ~ e 2 | 5.96        | 0.167827 |
| delivery_a ~ e 3 | 3.74        | 0.267437 |
| delivery_a ~ e 5 | 2.11        | 0.473270 |
| delivery_a ~ e 6 | 1.22        | 0.816934 |
| delivery_a ~ e 9 | 6.03        | 0.165736 |
| 2.urban_fa ~ r   | 1.30        | 0.768685 |
| edlevelmom 20    | 1.33        | 0.750710 |
| edlevelmom 40    | 1.73        | 0.576519 |
| marrcurr 20      | 1.12        | 0.892419 |
| 2.sexhhead       | 1.11        | 0.903385 |
| numch 2          | 1.56        | 0.639549 |
| numch 3          | 1.51        | 0.661411 |
| numch 4          | 1.07        | 0.932730 |
| numch 5          | 1.03        | 0.967712 |
| 1. mobphone ~ h  | 1.21        | 0.828623 |
| <b>Mean VIF</b>  | <b>2.02</b> |          |

**Table I3: Null Model-ICC**

### Null Model Results

**Integration Method:** mvaghermite

**Integration Points:** 7

**Wald chi<sup>2</sup> (0):** .

**Log Pseudolikelihood:** -6917.235

**Prob > chi<sup>2</sup>:** .

(Standard errors adjusted for 720 clusters in imicscluster)

| Model Coefficients          |          |           |      |        |                       |
|-----------------------------|----------|-----------|------|--------|-----------------------|
| Variable                    | Odds     | Std. Err. | z    | P >  z | [95% Conf. Interval]  |
| _cons                       | 1.143856 | 0.1264918 | 1.22 | 0.224  | [0.9209631, 1.420693] |
| <b>imicscluster</b>         |          |           |      |        |                       |
| var(_cons)                  | 7.414788 | 0.7519272 |      |        | [6.078258, 9.045203]  |
| <b>imicscluster&gt;hhno</b> |          |           |      |        |                       |
| var(_cons)                  | 5.752124 | 0.6874705 |      |        | [4.550888, 7.270435]  |

*Note: Estimates are transformed only in the first equation to odds.*

**Table I4: Intraclass Correlation Coefficients (ICC)**

| Intraclass Correlation |           |           |                        |
|------------------------|-----------|-----------|------------------------|
| Level                  | ICC       | Std. Err. | [95% Conf. Interval]   |
| imicscluster           | 0.4505613 | 0.0165484 | [0.4183815, 0.48316]   |
| hhno   imicscluster    | 0.8000904 | 0.0163675 | [0.7660775, 0.8302536] |

**Table I5: Descriptive Statistics-Variable Distributions (MICS Sudan 2014, N=13,672)**

| Variable                                           | No Birth Certificate | Has Birth Certificate | Total                  |
|----------------------------------------------------|----------------------|-----------------------|------------------------|
| <b>Child's age in completed years</b>              |                      |                       |                        |
| Less than 1 year                                   | 1,916 (64.9%)        | 1,036 (35.1%)         | 2,952 (100.0%)         |
| 1 year                                             | 1,429 (54.9%)        | 1,175 (45.1%)         | 2,604 (100.0%)         |
| 2 years                                            | 1,212 (47.4%)        | 1,349 (52.6%)         | 2,561 (100.0%)         |
| 3 years                                            | 1,448 (46.8%)        | 1,646 (53.2%)         | 3,094 (100.0%)         |
| 4 years                                            | 1,151 (46.8%)        | 1,310 (53.2%)         | 2,461 (100.0%)         |
| <b>Total</b>                                       | <b>7,156 (52.3%)</b> | <b>6,516 (47.7%)</b>  | <b>13,672 (100.0%)</b> |
| <b>Sex of child</b>                                |                      |                       |                        |
| Female                                             | 3,628 (54.3%)        | 3,063 (45.7%)         | 6,691 (100.0%)         |
| Male                                               | 3,528 (50.5%)        | 3,453 (49.5%)         | 6,981 (100.0%)         |
| <b>Total</b>                                       | <b>7,156 (52.3%)</b> | <b>6,516 (47.7%)</b>  | <b>13,672 (100.0%)</b> |
| <b>Wealth index quintile</b>                       |                      |                       |                        |
| Poorest                                            | 2,445 (78.9%)        | 655 (21.1%)           | 3,100 (100.0%)         |
| Second                                             | 2,511 (69.4%)        | 1,104 (30.6%)         | 3,615 (100.0%)         |
| Middle                                             | 1,463 (48.4%)        | 1,558 (51.6%)         | 3,021 (100.0%)         |
| Fourth                                             | 737 (18.7%)          | 3,199 (81.3%)         | 3,936 (100.0%)         |
| <b>Total</b>                                       | <b>7,156 (52.3%)</b> | <b>6,516 (47.7%)</b>  | <b>13,672 (100.0%)</b> |
| <b>Delivery Assistance</b>                         |                      |                       |                        |
| Doctor                                             | 216 (33.7%)          | 427 (66.3%)           | 643 (100.0%)           |
| Nurse/Midwife                                      | 3,010 (48.7%)        | 3,178 (51.3%)         | 6,188 (100.0%)         |
| Traditional Birth Attendant                        | 1,526 (81.6%)        | 342 (18.4%)           | 1,868 (100.0%)         |
| Other                                              | 445 (60.3%)          | 292 (39.7%)           | 737 (100.0%)           |
| No one assisted                                    | 83 (65.9%)           | 43 (34.1%)            | 126 (100.0%)           |
| NIU (not in Universe)                              | 1,876 (45.6%)        | 2,234 (54.4%)         | 4,110 (100.0%)         |
| <b>Total</b>                                       | <b>7,156 (52.3%)</b> | <b>6,516 (47.7%)</b>  | <b>13,672 (100.0%)</b> |
| <b>Urban Status</b>                                |                      |                       |                        |
| Urban                                              | 981 (26.4%)          | 2,732 (73.6%)         | 3,713 (100.0%)         |
| Rural                                              | 6,175 (62.0%)        | 3,784 (38.0%)         | 9,959 (100.0%)         |
| <b>Total</b>                                       | <b>7,156 (52.3%)</b> | <b>6,516 (47.7%)</b>  | <b>13,672 (100.0%)</b> |
| <b>Mother's education level</b>                    |                      |                       |                        |
| Less than primary                                  | 4,379 (69.4%)        | 1,928 (30.6%)         | 6,307 (100.0%)         |
| Primary                                            | 2,214 (48.3%)        | 2,370 (51.7%)         | 4,584 (100.0%)         |
| Secondary or higher                                | 563 (20.3%)          | 2,218 (79.7%)         | 2,781 (100.0%)         |
| <b>Total</b>                                       | <b>7,156 (52.3%)</b> | <b>6,516 (47.7%)</b>  | <b>13,672 (100.0%)</b> |
| <b>Currently married or in a union</b>             |                      |                       |                        |
| Yes, currently married                             | 6,885 (51.9%)        | 6,331 (48.1%)         | 13,216 (100.0%)        |
| No, not in a union                                 | 271 (59.5%)          | 185 (40.5%)           | 456 (100.0%)           |
| <b>Total</b>                                       | <b>7,156 (52.3%)</b> | <b>6,516 (47.7%)</b>  | <b>13,672 (100.0%)</b> |
| <b>Sex of household head</b>                       |                      |                       |                        |
| Male                                               | 6,468 (51.7%)        | 6,047 (48.3%)         | 12,515 (100.0%)        |
| Female                                             | 688 (59.5%)          | 469 (40.5%)           | 1,157 (100.0%)         |
| <b>Total</b>                                       | <b>7,156 (52.3%)</b> | <b>6,516 (47.7%)</b>  | <b>13,672 (100.0%)</b> |
| <b>HH has mobile phone</b>                         |                      |                       |                        |
| No                                                 | 2,647 (71.7%)        | 1,043 (28.3%)         | 3,690 (100.0%)         |
| Yes                                                | 4,509 (45.2%)        | 5,473 (54.8%)         | 9,982 (100.0%)         |
| <b>Total</b>                                       | <b>7,156 (52.3%)</b> | <b>6,516 (47.7%)</b>  | <b>13,672 (100.0%)</b> |
| <b>Number of children under age 5 in household</b> |                      |                       |                        |
| 1 child                                            | 2,012 (48.6%)        | 2,124 (51.4%)         | 4,136 (100.0%)         |
| 2 children                                         | 3,890 (54.0%)        | 3,311 (46.0%)         | 7,201 (100.0%)         |
| 3+ children                                        | 1,254 (53.7%)        | 1,081 (46.3%)         | 2,335 (100.0%)         |
| <b>Total</b>                                       | <b>7,156 (52.3%)</b> | <b>6,516 (47.7%)</b>  | <b>13,672 (100.0%)</b> |

**Table I6: Sudan Model 2: Birth Certificate Determinants Model within the Household**

| Mixed-effects logistic regression                       |               |                        |                                   |         |                    |
|---------------------------------------------------------|---------------|------------------------|-----------------------------------|---------|--------------------|
| Number of observations = 13,672                         |               |                        |                                   |         |                    |
| Grouping Information                                    |               |                        |                                   |         |                    |
| Group variable                                          | No. of groups | Minimum                | Average                           | Maximum |                    |
| imicscluster                                            | 720           | 2                      | 19.0                              | 39      |                    |
| hhno                                                    | 8,535         | 1                      | 1.6                               | 7       |                    |
| Model Information                                       |               |                        |                                   |         |                    |
| Integration method: mvaghermite                         |               | Integration points = 7 |                                   |         |                    |
| Wald chi <sup>2</sup> (18) = 324.57                     |               |                        | Log pseudolikelihood = -6014.7045 |         |                    |
| Prob > chi <sup>2</sup> = 0.0000                        |               |                        |                                   |         |                    |
| (Std. errors adjusted for 720 clusters in imicscluster) |               |                        |                                   |         |                    |
| Parameter Estimates                                     |               |                        |                                   |         |                    |
| Variable                                                | Odds Ratio    | Std. Err.              | z                                 | P >  z  | 95% Conf. Interval |
| Age of Child (Ref: 0)                                   |               |                        |                                   |         |                    |
| 1                                                       | 3.2057        | 0.5533                 | 6.75                              | 0.000   | [2.2857, 4.4962]   |
| 2                                                       | 8.3590        | 1.6358                 | 10.85                             | 0.000   | [5.6962, 12.2667]  |
| 3                                                       | 16.2450       | 4.1954                 | 10.79                             | 0.000   | [9.7924, 26.9494]  |
| 4                                                       | 12.7685       | 2.8199                 | 11.53                             | 0.000   | [8.2824, 19.6845]  |
| Sex of Child (Ref: Female)                              |               |                        |                                   |         |                    |
| Male                                                    | 1.3626        | 0.1344                 | 3.14                              | 0.002   | [1.1231, 1.6532]   |
| Household Wealth Index (Ref: Third Quintile)            |               |                        |                                   |         |                    |
| Poorest                                                 | 0.1200        | 0.0287                 | -8.88                             | 0.000   | [0.0752, 0.1917]   |
| Second                                                  | 0.2664        | 0.0484                 | -7.28                             | 0.000   | [0.1866, 0.3803]   |
| Fourth                                                  | 9.0481        | 1.8890                 | 10.55                             | 0.000   | [6.0097, 13.6227]  |
| Delivery Assistance (Ref: Doctor)                       |               |                        |                                   |         |                    |
| Nurse/Midwife                                           | 0.6242        | 0.1715                 | -1.72                             | 0.086   | [0.3643, 1.0695]   |
| Traditional Birth Attendant                             | 0.2537        | 0.0865                 | -4.02                             | 0.000   | [0.1301, 0.4948]   |
| Other                                                   | 0.4855        | 0.1807                 | -1.94                             | 0.052   | [0.2341, 1.0069]   |
| No one assisted                                         | 0.5369        | 0.3713                 | -0.90                             | 0.369   | [0.1384, 2.0827]   |
| NIU (Not in Universe)                                   | 0.6214        | 0.1816                 | -1.63                             | 0.104   | [0.3504, 1.1020]   |
| Urban/Rural Res (Ref: Urban)                            |               |                        |                                   |         |                    |
| Rural                                                   | 0.2084        | 0.0418                 | -7.81                             | 0.000   | [0.1406, 0.3089]   |
| Education Level Mother (Ref: Less than Primary)         |               |                        |                                   |         |                    |
| Primary                                                 | 2.5802        | 0.4018                 | 6.09                              | 0.000   | [1.9016, 3.5010]   |
| Secondary or Higher                                     | 8.9139        | 1.8274                 | 10.67                             | 0.000   | [5.9645, 13.3220]  |
| Marital Status (Ref: Married)                           |               |                        |                                   |         |                    |
| No, not in a union                                      | 0.4723        | 0.1388                 | -2.55                             | 0.011   | [0.2655, 0.8401]   |
| Sex Head of Household (Ref: Male)                       |               |                        |                                   |         |                    |
| Female                                                  | 0.8233        | 0.1616                 | -0.99                             | 0.322   | [0.5604, 1.2097]   |
| _cons                                                   | 0.4746        | 0.1569                 | -2.25                             | 0.024   | [0.2482, 0.9074]   |
| Random effects (variance components)                    |               |                        |                                   |         |                    |
| imicscluster                                            |               |                        |                                   |         |                    |
| var(_cons)                                              | 2.3797        | 0.3581                 |                                   |         | [1.7719, 3.1961]   |
| imicscluster>hhno                                       |               |                        |                                   |         |                    |
| var(_cons)                                              | 8.6409        | 1.3170                 |                                   |         | [6.4096, 11.6491]  |

Table I7: Sudan Model 3: Household Structure and Access Model

| Mixed-effects logistic regression                       |               |                        |                                   |         |                    |
|---------------------------------------------------------|---------------|------------------------|-----------------------------------|---------|--------------------|
| Number of observations = 13,672                         |               |                        |                                   |         |                    |
| Grouping Information                                    |               |                        |                                   |         |                    |
| Group variable                                          | No. of groups | Minimum                | Average                           | Maximum |                    |
| imicscluster                                            | 720           | 2                      | 19.0                              | 39      |                    |
| hhno                                                    | 8,535         | 1                      | 1.6                               | 7       |                    |
| Model Information                                       |               |                        |                                   |         |                    |
| Integration method: mvaghermite                         |               | Integration points = 7 |                                   |         |                    |
| Wald chi <sup>2</sup> (23) = 343.97                     |               |                        | Log pseudolikelihood = -5997.2137 |         |                    |
| Prob > chi <sup>2</sup> = 0.0000                        |               |                        |                                   |         |                    |
| (Std. errors adjusted for 720 clusters in imicscluster) |               |                        |                                   |         |                    |
| Parameter Estimates                                     |               |                        |                                   |         |                    |
| Variable                                                | Odds Ratio    | Std. Err.              | z                                 | P >  z  | 95% Conf. Interval |
| Age of Child (Ref: 0)                                   |               |                        |                                   |         |                    |
| 1                                                       | 3.1607        | 0.5459                 | 6.66                              | 0.000   | [2.2531, 4.4340]   |
| 2                                                       | 8.7212        | 1.7182                 | 10.99                             | 0.000   | [5.9275, 12.8314]  |
| 3                                                       | 16.5589       | 4.2652                 | 10.90                             | 0.000   | [9.9949, 27.4336]  |
| 4                                                       | 13.3769       | 2.9954                 | 11.58                             | 0.000   | [8.6248, 20.7473]  |
| Sex of Child (Ref: Female)                              |               |                        |                                   |         |                    |
| Male                                                    | 1.3686        | 0.1350                 | 3.18                              | 0.001   | [1.1280, 1.6606]   |
| Household Wealth Index (Ref: Third Quintile)            |               |                        |                                   |         |                    |
| Poorest                                                 | 0.1498        | 0.0352                 | -8.07                             | 0.000   | [0.0945, 0.2375]   |
| Second                                                  | 0.2932        | 0.0527                 | -6.82                             | 0.000   | [0.2061, 0.4171]   |
| Fourth                                                  | 8.7182        | 1.8011                 | 10.48                             | 0.000   | [5.8153, 13.0702]  |
| Delivery Assistance (Ref: Doctor)                       |               |                        |                                   |         |                    |
| Nurse/Midwife                                           | 0.6175        | 0.1710                 | -1.74                             | 0.082   | [0.3588, 1.0627]   |
| Traditional Birth Attendant                             | 0.2619        | 0.0895                 | -3.92                             | 0.000   | [0.1340, 0.5118]   |
| Other                                                   | 0.4674        | 0.1750                 | -2.03                             | 0.042   | [0.2243, 0.9738]   |
| No one assisted                                         | 0.5468        | 0.3804                 | -0.87                             | 0.386   | [0.1399, 2.1378]   |
| NIU (Not in Universe)                                   | 0.5327        | 0.1621                 | -2.07                             | 0.039   | [0.2934, 0.9672]   |
| Urban/Rural Res (Ref: Urban)                            |               |                        |                                   |         |                    |
| Rural                                                   | 0.2061        | 0.0413                 | -7.89                             | 0.000   | [0.1392, 0.3052]   |
| Education Level Mother (Ref: Less than Primary)         |               |                        |                                   |         |                    |
| Primary                                                 | 2.4602        | 0.3743                 | 5.92                              | 0.000   | [1.8258, 3.3150]   |
| Secondary or Higher                                     | 8.0274        | 1.6275                 | 10.27                             | 0.000   | [5.3952, 11.9440]  |
| Marital Status (Ref: Married)                           |               |                        |                                   |         |                    |
| No, not in a union                                      | 0.4715        | 0.1391                 | -2.55                             | 0.011   | [0.2645, 0.8406]   |
| Sex Head of Household (Ref: Male)                       |               |                        |                                   |         |                    |
| Female                                                  | 0.8689        | 0.1707                 | -0.72                             | 0.474   | [0.5912, 1.2770]   |
| Number of Children (Ref: 1)                             |               |                        |                                   |         |                    |
| 2                                                       | 0.7776        | 0.0996                 | -1.96                             | 0.050   | [0.6050, 0.9995]   |
| 3+                                                      | 0.6236        | 0.1208                 | -2.44                             | 0.015   | [0.4267, 0.9116]   |
| Household Owns Mobile Phone (Ref: No)                   |               |                        |                                   |         |                    |
| Yes                                                     | 1.9750        | 0.2802                 | 4.80                              | 0.000   | [1.4955, 2.6082]   |
| _cons                                                   | 0.3494        | 0.1239                 | -2.97                             | 0.003   | [0.1744, 0.7001]   |
| Random effects (variance components)                    |               |                        |                                   |         |                    |
| imicscluster                                            |               |                        |                                   |         |                    |
| var(_cons)                                              | 2.3346        | 0.3503                 |                                   |         | [1.7398, 3.1328]   |
| imicscluster>hhno                                       |               |                        |                                   |         |                    |
| var(_cons)                                              | 8.5669        | 1.2908                 |                                   |         | [6.3763, 11.5099]  |

**Table I8: Sudan Model 4: Household Structure and Access Model with Interaction Terms**

| Mixed-effects logistic regression                       |               |                        |                                   |         |                    |
|---------------------------------------------------------|---------------|------------------------|-----------------------------------|---------|--------------------|
| Number of observations = 13,672                         |               |                        |                                   |         |                    |
| Grouping Information                                    |               |                        |                                   |         |                    |
| Group variable                                          | No. of groups | Minimum                | Average                           | Maximum |                    |
| imicscluster                                            | 720           | 2                      | 19.0                              | 39      |                    |
| hhno                                                    | 8,535         | 1                      | 1.6                               | 7       |                    |
| Model Information                                       |               |                        |                                   |         |                    |
| Integration method: mvaghermite                         |               | Integration points = 7 |                                   |         |                    |
| Wald chi <sup>2</sup> (30) = 350.89                     |               |                        | Log pseudolikelihood = -5995.2508 |         |                    |
| Prob > chi <sup>2</sup> = 0.0000                        |               |                        |                                   |         |                    |
| (Std. errors adjusted for 720 clusters in imicscluster) |               |                        |                                   |         |                    |
| Parameter Estimates                                     |               |                        |                                   |         |                    |
| Variable                                                | Odds Ratio    | Std. Err.              | z                                 | P >  z  | 95% Conf. Interval |
| Age of Child (Ref: 0)                                   |               |                        |                                   |         |                    |
| 1                                                       | 3.1427        | 0.5418                 | 6.64                              | 0.000   | [2.2416, 4.4060]   |
| 2                                                       | 8.7075        | 1.7139                 | 11.00                             | 0.000   | [5.9203, 12.8067]  |
| 3                                                       | 16.5703       | 4.2672                 | 10.90                             | 0.000   | [10.0030, 27.4494] |
| 4                                                       | 13.3341       | 2.9854                 | 11.57                             | 0.000   | [8.5978, 20.6797]  |
| Sex of Child (Ref: Female)                              |               |                        |                                   |         |                    |
| Male                                                    | 1.3695        | 0.1353                 | 3.18                              | 0.001   | [1.1284, 1.6622]   |
| Household Wealth Index (Ref: Third Quintile)            |               |                        |                                   |         |                    |
| Poorest                                                 | 0.1406        | 0.0392                 | -7.04                             | 0.000   | [0.0814, 0.2427]   |
| Second                                                  | 0.2468        | 0.0566                 | -6.11                             | 0.000   | [0.1575, 0.3867]   |
| Fourth                                                  | 8.9841        | 3.1060                 | 6.35                              | 0.000   | [4.5624, 17.6911]  |
| Delivery Assistance (Ref: Doctor)                       |               |                        |                                   |         |                    |
| Nurse/Midwife                                           | 0.6116        | 0.1694                 | -1.78                             | 0.076   | [0.3554, 1.0524]   |
| Traditional Birth Attendant                             | 0.2577        | 0.0883                 | -3.96                             | 0.000   | [0.1317, 0.5045]   |
| Other                                                   | 0.4617        | 0.1732                 | -2.06                             | 0.039   | [0.2214, 0.9631]   |
| No one assisted                                         | 0.5267        | 0.3687                 | -0.92                             | 0.360   | [0.1336, 2.0772]   |
| NIU (Not in Universe)                                   | 0.5271        | 0.1607                 | -2.10                             | 0.036   | [0.2900, 0.9580]   |
| Urban/Rural Res (Ref: Urban)                            |               |                        |                                   |         |                    |
| Rural                                                   | 0.2066        | 0.0416                 | -7.84                             | 0.000   | [0.1393, 0.3064]   |
| Education Level Mother (Ref: Less than Primary)         |               |                        |                                   |         |                    |
| Primary                                                 | 2.1445        | 0.5280                 | 3.10                              | 0.002   | [1.3236, 3.4745]   |
| Secondary or Higher                                     | 7.1069        | 2.3724                 | 5.87                              | 0.000   | [3.6943, 13.6717]  |
| Marital Status (Ref: Married)                           |               |                        |                                   |         |                    |
| No, not in a union                                      | 0.4327        | 0.1692                 | -2.14                             | 0.032   | [0.2011, 0.9310]   |
| Sex Head of Household (Ref: Male)                       |               |                        |                                   |         |                    |
| Female                                                  | 0.8468        | 0.1775                 | -0.79                             | 0.427   | [0.5615, 1.2769]   |
| Number of Children (Ref: 1)                             |               |                        |                                   |         |                    |
| 2                                                       | 0.7785        | 0.0999                 | -1.95                             | 0.051   | [0.6053, 1.0011]   |
| 3+                                                      | 0.6210        | 0.1204                 | -2.46                             | 0.014   | [0.4247, 0.9081]   |
| Household Owns Mobile Phone (Ref: No)                   |               |                        |                                   |         |                    |
| Yes                                                     | 1.9924        | 0.2829                 | 4.85                              | 0.000   | [1.5084, 2.6317]   |
| Interaction: windex5 # edlevelmom                       |               |                        |                                   |         |                    |
| Poorest#Primary                                         | 1.2337        | 0.4398                 | 0.59                              | 0.556   | [0.6135, 2.4810]   |
| Poorest#Secondary or higher                             | 0.5956        | 0.3689                 | -0.84                             | 0.403   | [0.1769, 2.0050]   |
| Second#Primary                                          | 1.4065        | 0.4455                 | 1.08                              | 0.282   | [0.7560, 2.6167]   |
| Second#Secondary or higher                              | 1.6082        | 0.7719                 | 0.99                              | 0.322   | [0.6277, 4.1202]   |
| Fourth#Primary                                          | 0.9605        | 0.3699                 | -0.10                             | 0.917   | [0.4515, 2.0432]   |
| Fourth#Secondary or higher                              | 1.0440        | 0.4491                 | 0.10                              | 0.920   | [0.4493, 2.4258]   |
| Interaction: marrcurr # sexhhead                        |               |                        |                                   |         |                    |
| No, not in a union#Female                               | 1.2343        | 0.7548                 | 0.34                              | 0.731   | [0.3723, 4.0919]   |
| Constant                                                |               |                        |                                   |         |                    |
| _cons                                                   | 0.3793        | 0.1411                 | -2.61                             | 0.009   | [0.1829, 0.7866]   |
| Random effects (variance components)                    |               |                        |                                   |         |                    |
| imicscluster                                            |               |                        |                                   |         |                    |
| var(_cons)                                              | 2.3311        | 0.3502                 |                                   |         | [1.7365, 3.1293]   |
| imicscluster>hhno                                       |               |                        |                                   |         |                    |
| var(_cons)                                              | 8.5734        | 1.2938                 |                                   |         | [6.3782, 11.5241]  |

## 9 Appendix J: Part Two Country Analysis

### 9.1 Null Model: Multilevel Logistic Regression (Household, Cluster, Country)

$$\log\left(\frac{P(Y_{ijk} = 1)}{1 - P(Y_{ijk} = 1)}\right) = \beta_0 + u_k + v_{jk} + w_{ijk} + \epsilon_{ijk}.$$

**Where:**

- $Y_{ijk}$  is the binary outcome variable (birth certificate possession).
- $i$  represents the child level,  $j$  represents the household level, and  $k$  represents the cluster level.
- $\beta_0$  is the intercept, representing the average log-odds of birth certificate possession across the sample.
- **Random Effects:**
  - $u_k \sim N(0, \sigma_u^2)$  is the country-level random intercept (variation across countries).
  - $v_{jk} \sim N(0, \sigma_v^2)$  is the cluster-level random intercept (variation across clusters: `imicscluster_nested`).
  - $w_{ijk} \sim N(0, \sigma_w^2)$  is the household-level random intercept (variation across households: `hhno`).
  - $\epsilon_{ijk}$  is the residual error term at the child level.
- **Weighting:**
  - In line with the MICS survey design, household weights were first de-normalized and then re-normalized based on the national population sizes of children under five, following the approach outlined by Ebbers and Smits (2022). These adjusted weights were then applied at the household level as probability weights (`[pw=weighthh]`), and cluster-robust standard errors were specified using `vce(cluster imicsclusternested)` to account for the complex sampling structure across countries.

### Intraclass Correlation Coefficient (ICC)

The ICC quantifies the proportion of total variance in the outcome that is attributable to between-group differences at each level of the multilevel structure. For a three-level logistic model (country, cluster, household), the ICC is calculated as:

$$\text{ICC}_{\text{total}} = \frac{\sigma_{\text{country}}^2 + \sigma_{\text{cluster}}^2 + \sigma_{\text{household}}^2}{\sigma_{\text{country}}^2 + \sigma_{\text{cluster}}^2 + \sigma_{\text{household}}^2 + \frac{\pi^2}{3}}$$

**Where:**

- $\sigma_{\text{country}}^2$  is the variance of the country-level random intercept ( $u_k$ ),
- $\sigma_{\text{cluster}}^2$  is the variance of the cluster-level random intercept ( $v_{jk}$ ),
- $\sigma_{\text{household}}^2$  is the variance of the household-level random intercept ( $w_{ijk}$ ),
- $\frac{\pi^2}{3} \approx 3.29$  is the fixed variance of the logistic distribution at the child level (residual error term).

## 9.2 Determinants of Birth Certificate Ownership: Multilevel Logistic Regression Model (Household, Cluster, Country)

$$\begin{aligned} \log\left(\frac{P(Y_{ijk} = 1)}{1 - P(Y_{ijk} = 1)}\right) = & \beta_0 + \beta_1 \text{Age}_{ijk} + \beta_2 \text{Sex}_{ijk} + \beta_3 \text{Wealth}_{ijk} \\ & + \beta_4 \text{DeliveryAssistance}_{ijk} + \beta_5 \text{Urban}_{ijk} + \beta_6 \text{MotherEd}_{ijk} \\ & + \beta_7 \text{CRVS}_{ijk} + \beta_8 \text{SPIndex}_{ijk} + \beta_9 \text{CPIA}_{ijk} \\ & + \beta_{10} \text{SPIDim3.1}_{ijk} + \beta_{11} \text{HealthExpenditure}_{ijk} \\ & + u_k + v_{jk} + w_{ijk} + \epsilon_{ijk}. \end{aligned}$$

**Where:**

- $Y_{ijk}$  is the binary outcome variable (birth certificate possession).
- $i$  represents the child level,  $j$  represents the household level, and  $k$  represents the cluster level.
- $\beta_0$  is the intercept.
- $\beta_1, \beta_2, \dots, \beta_{11}$  are the fixed-effect coefficients for predictors:
  - $\text{Age}_{ijk}$ : Child's age (categorical: `i.agech`)
  - $\text{Sex}_{ijk}$ : Child's sex (categorical: `i.sexch`)
  - $\text{Wealth}_{ijk}$ : Wealth index (categorical: `i.windex5`)
  - $\text{DeliveryAssistance}_{ijk}$ : Birth delivery assistance (categorical: `i.delivery_assistance`)
  - $\text{Urban}_{ijk}$ : Urban–rural factor (categorical: `i.urban_factor`)
  - $\text{MotherEd}_{ijk}$ : Mother's education level (categorical: `i.edlevelmom`)
  - $\text{CRVS}_{ijk}$ : Civil registration and vital statistics score (categorical: `i.crvs_cat`)
  - $\text{SPI}_{ijk}$ : Statistical Performance Indicator (scaled, categorical: `i.SPI_Quartile`)
  - $\text{CPIA}_{ijk}$ : CPIA gender equality rating (categorical: `i.CPIA_cat`)
  - $\text{SPI Dim 3.1}_{ijk}$ : SPI 3.1 Dimension (categorical: `spidim31index`)
  - $\text{HealthExpenditure}_{ijk}$ : Health expenditure per capita category (categorical: `i.healthexpcapita_cat`)
- **Random Effects:**
  - $u_k \sim N(0, \sigma_u^2)$  is the cluster-level random intercept (variation across clusters: `imicscluster`).
  - $v_{jk} \sim N(0, \sigma_v^2)$  is the household-level random intercept (variation across households: `hhno`).
  - $w_{ijk} \sim N(0, \sigma_w^2)$  is the country-level random intercept (variation across countries).
  - $\epsilon_{ijk}$  is the residual error term.
- **Weighting:**
  - In line with the MICS survey design, household weights were first de-normalized and then re-normalized based on the national population sizes of children under five, following the approach outlined by Ebberts and Smits (2022). These adjusted weights were then applied at the household level as probability weights (`[pw=weighthh]`), and cluster-robust standard errors were specified using `vce(cluster imicsclusternested)` to account for the complex sampling structure across countries.

**Table J1: Descriptive Statistics – Variable Distributions (Pooled MICS Sample, N = 320,769)**

| Variable                                        | No Birth Certificate | Has Birth Certificate | Total            |
|-------------------------------------------------|----------------------|-----------------------|------------------|
| <b>Child's age in completed years</b>           |                      |                       |                  |
| Less than 1 year                                | 39,095 (23.9%)       | 26,506 (16.9%)        | 65,601 (20.5%)   |
| 1 year                                          | 32,027 (19.6%)       | 30,913 (19.7%)        | 62,940 (19.6%)   |
| 2 years                                         | 31,300 (19.1%)       | 31,955 (20.3%)        | 63,255 (19.7%)   |
| 3 years                                         | 31,646 (19.3%)       | 34,534 (21.9%)        | 66,180 (20.7%)   |
| 4 years                                         | 29,461 (18.0%)       | 33,332 (21.2%)        | 62,793 (19.6%)   |
| <b>Total</b>                                    | 163,529 (50.9%)      | 157,240 (49.1%)       | 320,769 (100.0%) |
| <b>Sex of child</b>                             |                      |                       |                  |
| Female                                          | 81,193 (49.8%)       | 76,330 (48.5%)        | 157,523 (49.1%)  |
| Male                                            | 82,336 (50.5%)       | 80,910 (51.5%)        | 163,246 (50.9%)  |
| <b>Total</b>                                    | 163,529 (50.9%)      | 157,240 (49.1%)       | 320,769 (100.0%) |
| <b>Wealth index quintile</b>                    |                      |                       |                  |
| Poorest                                         | 53,624 (32.8%)       | 28,979 (18.4%)        | 82,603 (25.8%)   |
| Second                                          | 42,292 (25.9%)       | 30,685 (19.5%)        | 72,977 (22.8%)   |
| Middle                                          | 32,316 (19.8%)       | 32,860 (20.9%)        | 65,176 (20.3%)   |
| Fourth                                          | 22,254 (13.6%)       | 33,411 (21.3%)        | 55,665 (17.3%)   |
| Richest                                         | 13,043 (8.1%)        | 31,305 (19.9%)        | 44,348 (13.8%)   |
| <b>Total</b>                                    | 163,529 (50.9%)      | 157,240 (49.1%)       | 320,769 (100.0%) |
| <b>Delivery Assistance</b>                      |                      |                       |                  |
| Doctor                                          | 7,873 (4.81%)        | 11,125 (7.07%)        | 18,998 (5.92%)   |
| Nurse/Midwife                                   | 48,043 (29.36%)      | 54,730 (34.84%)       | 102,773 (32.04%) |
| Traditional Birth Attendant                     | 21,335 (13.04%)      | 10,022 (6.37%)        | 31,357 (9.78%)   |
| Relative/Friend                                 | 22,664 (13.86%)      | 11,229 (7.14%)        | 33,893 (10.57%)  |
| Other                                           | 2,308 (1.41%)        | 1,416 (0.90%)         | 3,724 (1.16%)    |
| No one assisted                                 | 7,736 (4.73%)        | 7,253 (4.61%)         | 14,989 (4.67%)   |
| NIU (not in Universe)                           | 53,570 (32.77%)      | 61,465 (39.04%)       | 115,035 (35.86%) |
| <b>Total</b>                                    | 163,529 (100.0%)     | 157,240 (100.0%)      | 320,769 (100.0%) |
| <b>Urban Status</b>                             |                      |                       |                  |
| Urban                                           | 29,505 (17.6%)       | 56,984 (36.2%)        | 86,489 (27.0%)   |
| Rural                                           | 134,024 (82.4%)      | 100,256 (63.8%)       | 234,280 (73.0%)  |
| <b>Total</b>                                    | 163,529 (50.9%)      | 157,240 (49.1%)       | 320,769 (100.0%) |
| <b>Mother's education level</b>                 |                      |                       |                  |
| Less than Primary                               | 79,762 (48.8%)       | 53,801 (34.2%)        | 133,563 (41.7%)  |
| Primary                                         | 55,348 (33.9%)       | 51,017 (32.4%)        | 106,365 (33.2%)  |
| Secondary                                       | 28,380 (17.3%)       | 52,386 (33.3%)        | 80,766 (25.2%)   |
| Unknown                                         | 39 (0.0%)            | 36 (0.0%)             | 75 (0.0%)        |
| <b>Total</b>                                    | 163,529 (50.9%)      | 157,240 (49.1%)       | 320,769 (100.0%) |
| <b>CRVS (WDI) Category</b>                      |                      |                       |                  |
| No CRVS                                         | 149,480 (91.4%)      | 137,885 (87.7%)       | 287,365 (89.7%)  |
| Partial C                                       | 13,765 (8.4%)        | 9,032 (5.7%)          | 22,797 (7.1%)    |
| Full CRVS                                       | 284 (0.2%)           | 10,323 (6.6%)         | 10,607 (3.3%)    |
| <b>Total</b>                                    | 163,529 (50.9%)      | 157,240 (49.1%)       | 320,769 (100.0%) |
| <b>SPI Overall Score Quantile</b>               |                      |                       |                  |
| 1st Quantile                                    | 50,651 (31.0%)       | 28,737 (18.3%)        | 79,388 (24.8%)   |
| 2nd Quantile                                    | 42,125 (25.7%)       | 57,663 (36.6%)        | 99,788 (31.1%)   |
| 3rd Quantile                                    | 44,101 (27.0%)       | 30,306 (19.3%)        | 74,407 (23.2%)   |
| 4th Quantile                                    | 26,652 (16.3%)       | 40,534 (25.8%)        | 67,186 (21.0%)   |
| <b>Total</b>                                    | 163,529 (50.9%)      | 157,240 (49.1%)       | 320,769 (100.0%) |
| <b>CPIA Combined Score</b>                      |                      |                       |                  |
| Low (1-2)                                       | 110,501 (67.5%)      | 100,475 (64.0%)       | 210,976 (65.8%)  |
| Medium (3-4)                                    | 37,225 (22.7%)       | 24,731 (15.7%)        | 61,956 (19.3%)   |
| High (5-6)                                      | 15,803 (9.7%)        | 32,034 (20.4%)        | 47,837 (14.9%)   |
| <b>Total</b>                                    | 163,529 (50.9%)      | 157,240 (49.1%)       | 320,769 (100.0%) |
| <b>SPI Dimension 3.1 Social Statistic Score</b> |                      |                       |                  |
| Low ( $\leq 0.61$ )                             | 12,600 (7.7%)        | 16,228 (10.3%)        | 28,828 (9.0%)    |
| Low-Medium ( $0.61 - \leq 0.70$ )               | 49,708 (30.4%)       | 46,626 (29.7%)        | 96,334 (30.1%)   |
| Medium-High ( $0.70 - \leq 0.73$ )              | 77,014 (47.1%)       | 68,642 (43.6%)        | 145,656 (45.5%)  |
| High ( $> 0.73$ )                               | 24,207 (14.8%)       | 25,744 (16.4%)        | 49,951 (15.6%)   |
| <b>Total</b>                                    | 163,529 (50.9%)      | 157,240 (49.1%)       | 320,769 (100.0%) |
| <b>Health Expenditure Category</b>              |                      |                       |                  |
| (<29.7)                                         | 43,755 (26.8%)       | 33,933 (21.6%)        | 77,688 (24.2%)   |
| (29.7-43.49)                                    | 36,852 (22.5%)       | 25,227 (16.0%)        | 62,079 (19.4%)   |
| (43.4-54.8)                                     | 28,901 (17.7%)       | 29,290 (18.6%)        | 58,191 (18.2%)   |
| (54.8-83.8)                                     | 32,582 (19.9%)       | 33,193 (21.1%)        | 65,775 (20.5%)   |
| (>83.8)                                         | 21,439 (13.1%)       | 35,597 (22.6%)        | 57,036 (17.8%)   |
| <b>Total</b>                                    | 163,529 (50.9%)      | 157,240 (49.1%)       | 320,769 (100.0%) |

**\*\*Table J2:** Variance Inflation Factor (VIF) Analysis

| Variable                                                  | VIF         | 1/VIF    |
|-----------------------------------------------------------|-------------|----------|
| <b>Age of Child (Ref: 0)</b>                              |             |          |
| 1 Year                                                    | 1.57        | 0.636311 |
| 2 Years                                                   | 2.01        | 0.497378 |
| 3 Years                                                   | 1.90        | 0.526032 |
| 4 Years                                                   | 1.88        | 0.530896 |
| <b>Sex of Child (Ref: Female)</b>                         |             |          |
| Male                                                      | 1.00        | 0.999607 |
| <b>Household Wealth Index (Ref: Third Quintile)</b>       |             |          |
| Poorest                                                   | 1.75        | 0.571882 |
| Second                                                    | 1.66        | 0.603026 |
| Fourth                                                    | 1.67        | 0.598941 |
| Richest                                                   | 1.92        | 0.520366 |
| <b>Delivery Assistance (Ref: Doctor)</b>                  |             |          |
| Nurse/Midwife                                             | 4.42        | 0.226160 |
| Traditional Birth Attendant                               | 2.46        | 0.406801 |
| Relative/Friend                                           | 2.54        | 0.393230 |
| Other                                                     | 1.20        | 0.831117 |
| No one assisted                                           | 1.78        | 0.562792 |
| NIU (Not in Universe)                                     | 5.11        | 0.195538 |
| <b>Urban/Rural Residence (Ref: Urban)</b>                 |             |          |
| Rural                                                     | 1.55        | 0.646120 |
| <b>Education Level of Mother (Ref: Less than Primary)</b> |             |          |
| Primary + Lower Secondary                                 | 1.48        | 0.676217 |
| Secondary or Higher                                       | 1.94        | 0.514727 |
| Unknown                                                   | 1.00        | 0.998505 |
| <b>CRVS Category (Ref: Full CRVS (1))</b>                 |             |          |
| No CRVS (0)                                               | 7.93        | 0.126125 |
| Partial CRVS (0.5)                                        | 9.31        | 0.088423 |
| <b>SPI Quartile (Ref: 2nd Quartile)</b>                   |             |          |
| 1st Quartile                                              | 2.69        | 0.372260 |
| 3rd Quartile                                              | 5.72        | 0.174873 |
| 4th Quartile                                              | 3.54        | 0.282559 |
| <b>CPIA Combined (Ref: Low: 1 – 2)</b>                    |             |          |
| Medium: 3 – 4                                             | 3.31        | 0.301743 |
| High: 5 – 6                                               | 5.07        | 0.197104 |
| <b>SPI Dimension 3 Index Group (Ref: Low)</b>             |             |          |
| Low-Medium                                                | 8.72        | 0.114698 |
| Medium-High                                               | 6.10        | 0.163857 |
| High                                                      | 6.43        | 0.155567 |
| <b>Health Expenditure Category (Ref: (&lt;29.7))</b>      |             |          |
| (29.7-43.49)                                              | 5.53        | 0.180882 |
| (43.4-54.8)                                               | 6.29        | 0.156533 |
| (54.8-83.8)                                               | 8.81        | 0.113539 |
| (<83.8)                                                   | 5.55        | 0.180049 |
| <b>Mean VIF</b>                                           | <b>3.82</b> |          |

**Table J3: Null Model-ICC****Null Model Results****Integration Method:** mvaghermite**Integration Points:** 7**Wald chi<sup>2</sup> (0):** .**Log Pseudolikelihood:** -192,856.450**Prob > chi<sup>2</sup>:** .

(Standard errors adjusted for 21,017 clusters in imicscluster)

| Model Coefficients               |        |           |       |           |                      |
|----------------------------------|--------|-----------|-------|-----------|----------------------|
| Variable                         | Coef   | Std. Err. | z     | $P >  z $ | [95% Conf. Interval] |
| _cons                            | -0.840 | 0.215     | -3.91 | <0.001    | [0.284, 0.657]       |
| <b>country</b>                   |        |           |       |           |                      |
| var(_cons)                       | 6.830  | 0.320     |       |           | [6.21, 7.45]         |
| <b>country &gt; imicscluster</b> |        |           |       |           |                      |
| var(_cons)                       | 6.290  | 0.687     |       |           | [5.00, 7.80]         |
| <b>imicscluster &gt; hhno</b>    |        |           |       |           |                      |
| var(_cons)                       | 7.840  | 0.7519272 |       |           | [6.37, 9.42]         |

*Note: Estimates are transformed only in the first equation to odds.***Table J4: Intraclass Correlation Coefficients (ICC)**

| Intraclass Correlation |       |           |                      |
|------------------------|-------|-----------|----------------------|
| Level                  | ICC   | Std. Err. | [95% Conf. Interval] |
| country                | 0.317 | 0.0165484 | [0.309, 0.317]       |
| imicscluster   country | 0.304 | 0.0163675 | [0.284, 0.292]       |
| hhno   imicscluster    | 0.379 | 0.0165484 | [0.347, 0.411]       |

**Note:** Confidence intervals in this table are expressed on the odds ratio scale for interpretability.

**\*\*Table J5: Multilevel Logistic Regression (27 LMIC)**

| Mixed-effects logistic regression                                    |               |                        |                                   |         |                          |
|----------------------------------------------------------------------|---------------|------------------------|-----------------------------------|---------|--------------------------|
| Number of observations = 320,769                                     |               |                        |                                   |         |                          |
| Grouping Information                                                 |               |                        |                                   |         |                          |
| Group variable                                                       | No. of groups | Minimum                | Average                           | Maximum |                          |
| imicscluster                                                         | 21,017        | 1                      | 15.2                              | 101     |                          |
| hhno                                                                 | 204,635       | 1                      | 1.6                               | 19      |                          |
| Model Information                                                    |               |                        |                                   |         |                          |
| Integration method: mvaghermite                                      |               | Integration points = 7 |                                   |         |                          |
| Wald chi <sup>2</sup> (25) = 7047.77                                 |               |                        | Log pseudolikelihood = -184656.97 |         |                          |
| Prob > chi <sup>2</sup> = 0.0000                                     |               |                        |                                   |         |                          |
| Parameter Estimates                                                  |               |                        |                                   |         |                          |
| Variable                                                             | Coefficient   | Std. Err.              | z                                 | P >  z  | 95% Conf. Interval       |
| Age of Child (Ref: 0)                                                |               |                        |                                   |         |                          |
| 1                                                                    | 0.4207513     | 0.0643815              | 6.54                              | 0.000   | [0.2945659, 0.5469366]   |
| 2                                                                    | 0.4317255     | 0.1156425              | 3.73                              | 0.000   | [0.2050704, 0.6583805]   |
| 3                                                                    | 0.5361299     | 0.1385014              | 3.87                              | 0.000   | [0.2646723, 0.8075876]   |
| 4                                                                    | 0.5788245     | 0.1627281              | 3.56                              | 0.000   | [0.2598833, 0.8977657]   |
| Sex of Child (Ref: Female)                                           |               |                        |                                   |         |                          |
| Male                                                                 | 0.0489797     | 0.0098029              | 5.00                              | 0.000   | [0.0297663, 0.0681931]   |
| Household Wealth Index (Ref: Third Quintile)                         |               |                        |                                   |         |                          |
| Poorest                                                              | -0.6200181    | 0.108446               | -5.72                             | 0.000   | [-0.8325683, -0.4074678] |
| Second                                                               | -0.2653899    | 0.0453461              | -5.85                             | 0.000   | [-0.3542666, -0.1765131] |
| Fourth                                                               | 0.2572562     | 0.056665               | 4.54                              | 0.000   | [0.1461948, 0.3683177]   |
| Richest                                                              | 0.5688118     | 0.1304311              | 4.36                              | 0.000   | [0.3131715, 0.824452]    |
| Delivery Assistance (Ref: Doctor)                                    |               |                        |                                   |         |                          |
| Nurse/Midwife                                                        | -0.132849     | 0.137609               | -0.97                             | 0.334   | [-0.4025577, 0.1368596]  |
| Traditional Birth Attendant                                          | -0.5854032    | 0.1820061              | -3.22                             | 0.001   | [-0.9421286, -0.2286778] |
| Relative/Friend                                                      | -0.5879195    | 0.1813458              | -3.24                             | 0.001   | [-0.9433507, -0.2324882] |
| Other                                                                | -0.5748845    | 0.1976736              | -2.91                             | 0.004   | [-0.9623176, -0.1874514] |
| No one assisted                                                      | -0.2702068    | 0.1749187              | -1.54                             | 0.122   | [-0.6130411, 0.0726275]  |
| NIU (Not in Universe)                                                | -0.1460723    | 0.1337128              | -1.09                             | 0.275   | [-0.4081445, 0.1159999]  |
| Urban/Rural Res (Ref: Urban)                                         |               |                        |                                   |         |                          |
| Rural                                                                | -0.348153     | 0.0917883              | -3.79                             | 0.000   | [-0.5280547, -0.1682513] |
| Education Level Mother (Ref: Less than Primary)                      |               |                        |                                   |         |                          |
| Primary + Lower Secondary                                            | 0.1708573     | 0.1044089              | 1.64                              | 0.102   | [-0.0337804, 0.375495]   |
| Secondary or Higher                                                  | 0.3867255     | 0.1227491              | 3.15                              | 0.002   | [0.1461416, 0.6273094]   |
| Unknown                                                              | 0.7676647     | 0.3077986              | 2.49                              | 0.013   | [0.1643906, 1.370939]    |
| CRVS Category (Ref: Full CRVS)                                       |               |                        |                                   |         |                          |
| No CRVS                                                              | -3.589946     | 0.7143041              | -5.03                             | 0.000   | [-4.989957, -2.189936]   |
| Partial CRVS                                                         | -4.375345     | 0.8959703              | -4.88                             | 0.000   | [-6.131415, -2.619276]   |
| SPI Quartile (Ref: 2nd Quartile)                                     |               |                        |                                   |         |                          |
| 1                                                                    | -1.236483     | 0.4887599              | -2.53                             | 0.011   | [-2.194435, -0.2785312]  |
| 3                                                                    | -0.0290239    | 0.4359359              | -0.07                             | 0.947   | [-0.8834426, 0.8253948]  |
| 4                                                                    | 0.2672131     | 0.4632981              | 0.58                              | 0.564   | [-0.6408345, 1.175261]   |
| CPIA Combined (Ref: Low (1-2))                                       |               |                        |                                   |         |                          |
| Medium (3-4)                                                         | -0.5074687    | 0.4688459              | -1.08                             | 0.279   | [-1.42639, 0.4114524]    |
| High (5-6)                                                           | 0.0365145     | 0.4332168              | 0.08                              | 0.933   | [-0.8125749, 0.8856039]  |
| SPI Dimension 3 Index Group (Ref: Low (≤ 0.61))                      |               |                        |                                   |         |                          |
| Low-Medium (0.61 ≤ 0.70)                                             | -3.713355     | 2.001209               | -1.86                             | 0.064   | [-7.635654, 0.2089429]   |
| Medium-High (0.70 ≤ 0.73)                                            | -3.846467     | 0.1094523              | -35.14                            | 0.000   | [-4.060989, -3.631944]   |
| High (> 0.73)                                                        | -1.422988     | 0.1399993              | -10.16                            | 0.000   | [-1.697381, -1.148594]   |
| Current health expenditure per capita current US dollar (Ref: <29.7) |               |                        |                                   |         |                          |
| (29.7-43.49)                                                         | -0.8786124    | 0.4473619              | -1.96                             | 0.050   | [-1.755426, -0.0017992]  |
| (43.4-54.8)                                                          | -0.6336875    | 0.1333024              | -4.75                             | 0.000   | [-0.8949555, -0.3724196] |
| (54.8-83.8)                                                          | -2.631435     | 0.1565495              | -16.81                            | 0.000   | [-2.938267, -2.324604]   |
| (>83.8)                                                              | -0.7887993    | 0.1227825              | -6.42                             | 0.000   | [-1.029449, -0.5481499]  |
| Constant                                                             |               |                        |                                   |         |                          |
| _cons                                                                | 6.584863      | 1.88298                | 3.50                              | 0.000   | [2.89429, 10.27544]      |
| Random effects (variance components)                                 |               |                        |                                   |         |                          |
| country                                                              |               |                        |                                   |         |                          |
| var(_cons)                                                           | 5.545963      | 0.1408539              |                                   |         | [3.565284, 9.871004]     |
| country>imicscluster                                                 |               |                        |                                   |         |                          |
| var(_cons)                                                           | 5.092209      | 0.1205703              |                                   |         | [4.861295, 5.334092]     |
| imicscluster>hhno                                                    |               |                        |                                   |         |                          |
| var(_cons)                                                           | 7.05895       | 0.1867908              |                                   |         | [6.702179, 7.434714]     |