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The Impact of Maternal Education on Child Nutrition in Guatemala

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ABSTRACT

Deutsche Version

Kindliche Mangelernährung stellt nach wie vor eine der größten Herausforderungen für die öffentliche Gesundheit in Ländern mit niedrigem und mittlerem Einkommen dar und hat langfristige Auswirkungen auf die Gesundheit, die Humankapitalentwicklung und das sozioökonomische Wohlergehen (Adair et al., 2013; Victora et al., 2008, 2010, 2015; Vollmer et al., 2014). Guatemala stellt in diesem Zusammenhang einen besonders relevanten Fall dar, da das Land die höchste Prävalenz von Wachstumsverzögerungen (Stunting) bei Kindern in Lateinamerika aufweist und gleichzeitig einen Ernährungswandel erlebt, der durch das gleichzeitige Auftreten von Unter- und Überernährung gekennzeichnet ist (FAO et al., 2025).

Diese Masterarbeit untersucht den Zusammenhang zwischen der Bildung von Müttern und den Ernährungsergebnissen ihrer Kinder in Guatemala anhand von Daten der Guatemala Demographic and Health Survey (DHS) 2014–2015. Die Analyse konzentriert sich auf Kinder unter fünf Jahren und betrachtet verschiedene Formen der Mangelernährung, darunter Wachstumsverzögerung (Stunting), Untergewicht, Auszehrung (Wasting) sowie Übergewicht und Adipositas. Besonderes Augenmerk wird auf ethnische und geografische Ungleichheiten sowie auf die direkten und indirekten Wirkungsmechanismen gelegt, durch die die Bildung der Mutter die Ernährungssituation von Kindern beeinflusst.

Deskriptive Analysen und ordinal-logistische Regressionsmodelle unter Berücksichtigung des Stichprobendesigns zeigen, dass ein höheres Bildungsniveau der Mutter im Allgemeinen mit besseren Ernährungsergebnissen von Kindern verbunden ist, insbesondere mit geringeren Formen der Unterernährung. Stunting erwies sich als das schwerwiegendste und am weitesten verbreitete Ernährungsproblem und betraf einen erheblichen Anteil der guatemaltekischen Kinder. Gleichzeitig traten Übergewicht und Adipositas häufiger bei Kindern von besser gebildeten Müttern auf, wobei diese Zusammenhänge in den vollständig adjustierten Modellen statistisch nicht signifikant waren. Der Abschluss der Sekundarschulbildung war durchgängig mit den größten Verbesserungen der Ernährungsergebnisse verbunden, was auf das Vorhandensein einer wichtigen Bildungsschwelle hindeutet. Dennoch bestehen erhebliche Ungleichheiten fort. Kinder der indigenen Maya-Bevölkerung, Kinder in ländlichen Gebieten sowie Kinder in historisch benachteiligten Regionen weisen weiterhin schlechtere Ernährungsergebnisse auf als ihre Vergleichsgruppen, selbst bei ähnlichem Bildungsniveau der Mutter. Die Ergebnisse deuten zudem darauf hin, dass die Bildung der Mutter sowohl direkt als auch indirekt über den Haushaltswohlstand, den Ernährungszustand der Mutter, Familienmerkmale und weitere sozioökonomische Faktoren wirkt.

Insgesamt unterstreichen die Ergebnisse die zentrale Bedeutung der Bildung von Müttern für die Verbesserung der kindlichen Ernährung, zeigen jedoch zugleich, dass bildungspolitische Maßnahmen besonders wirksam sind, wenn sie durch umfassendere sozioökonomische Interventionen ergänzt werden. Die Verringerung der kindlichen Mangelernährung in Guatemala erfordert daher integrierte Strategien, die bestehende sozioökonomische, ethnische und territoriale Ungleichheiten abbauen und gleichzeitig Investitionen in die Bildung von Frauen – insbesondere auf Sekundarschulniveau – fördern. Darüber hinaus ist die Bekämpfung chronischer Formen der Unterernährung, insbesondere von Stunting, nicht nur für die unmittelbare Gesundheit und Entwicklung von Kindern von entscheidender Bedeutung, sondern auch zur Verringerung des Risikos von Übergewicht, Adipositas und anderen ernährungsbedingten nichtübertragbaren Krankheiten im späteren Lebensverlauf.

ABSTRACT

English version

Child malnutrition remains a major public health challenge in low- and middle-income countries, with long-term consequences for health, human capital development, and socioeconomic well-being (Adair et al., 2013; Victora et al., 2008, 2010, 2015; Vollmer et al., 2014). Guatemala represents a particularly relevant case, as it exhibits the highest prevalence of child stunting in Latin America while simultaneously experiencing a nutritional transition characterized by the coexistence of undernutrition and overnutrition (FAO et al., 2025).

This thesis investigates the relationship between maternal education and child nutritional outcomes in Guatemala using data from the 2014–2015 Guatemala Demographic and Health Survey (DHS). The analysis focuses on children under five years of age and examines multiple dimensions of malnutrition, including stunting, underweight, wasting, and overweight/obesity. Particular attention is given to ethnic and geographical disparities, as well as to the direct and indirect pathways through which maternal education influences child nutrition.

Descriptive analyses and survey-weighted ordinal logistic regression models indicate that higher levels of maternal education are generally associated with improved child nutritional outcomes, particularly lower levels of undernutrition. Stunting emerged as the most severe and widespread nutritional problem, affecting a substantial proportion of Guatemalan children. At the same time, patterns of overweight and obesity appeared more frequently among children of more educated mothers, although these associations were not statistically significant in the fully adjusted models. Secondary education was consistently associated with the largest improvements in nutritional outcomes, suggesting the existence of an important educational threshold. However, significant inequalities persist. Indigenous Maya children, children living in rural areas, and those residing in historically disadvantaged regions continue to experience worse nutritional outcomes than their counterparts, even at similar levels of maternal education. The findings further suggest that maternal education operates both directly and indirectly through household wealth, maternal nutritional status, family characteristics, and other socioeconomic factors.

Overall, the results highlight the central role of maternal education in improving child nutrition while emphasizing that educational policies are likely to be most effective when combined with broader socioeconomic interventions. Reducing child malnutrition in Guatemala therefore requires integrated strategies addressing persistent socioeconomic, ethnic, and territorial inequalities alongside investments in female education, particularly at the secondary level. Furthermore, tackling chronic forms of undernutrition, especially stunting, is crucial not only for improving children's immediate health and developmental outcomes but also for reducing the risk of overweight, obesity, and other nutrition-related non-communicable diseases later in life.

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1. INTRODUCTION

The first 1,000 days of life, from conception through pregnancy to a child's second birthday, represent a critical window for human development (Victora et al., 2010). This period builds the biological and cognitive foundations that influence health throughout life. Growth impairment during these early stages is strongly associated with increased risks of morbidity and mortality in childhood and may produce lasting consequences, including impaired cognitive development, reduced adult stature, and a higher likelihood of metabolic and cardiovascular diseases later in life (Adair et al., 2013; Prado & Dewey, 2014; Reinhardt & Fanzo, 2014; Victora et al., 2008, 2015). These adverse health effects also translate into long-term socioeconomic disadvantages, influencing educational attainment, lifetime earnings, and overall productivity (Black et al., 2008, 2013; Simelane & Worth, 2020; Victora et al., 2008)

Malnutrition manifests in multiple forms, including undernutrition and overnutrition. Undernutrition includes stunting, wasting, underweight, and deficiencies in essential micronutrients such as vitamins and minerals. At the same time, malnutrition also encompasses overnutrition, which appears as overweight and obesity (WHO, 2024). Increasingly, evidence points to a complex interaction between these conditions, showing that early undernutrition may raise the risk of overweight and chronic diseases later in life (Shrimpton & Rokx, 2012).

A large body of literature emphasizes the pivotal role of maternal education in shaping child health outcomes (Baker et al., 2011; Caldwell et al., 2005; Herd, 2010; Mirowsky & Ross, 2003), including nutritional status (Frost et al., 2005; Gewa, 2010). Education enhances mothers' knowledge of appropriate nutrition, disease prevention, and early symptom recognition, fostering healthier behaviours and more effective health management practices. Beyond these direct effects, maternal education also influences child well-being indirectly by improving household economic conditions, strengthening women's empowerment and decision-making capacity, and increasing awareness of fertility choices (Chowdhury & Haque, 2025; Duflo, 2001; Fuchs et al., 2010; Marphatia et al., 2020). Although economic resources are important determinants of child health, their effects are often mediated and amplified by educational attainment (Vollmer et al., 2014).

Within this framework, Guatemala presents a particularly critical case. Located in Central America and bordering Mexico, Honduras, Belize and El Salvador, the country exhibits the highest prevalence of stunting among children under five in the Latin America and Caribbean region (FAO et al., 2025). Despite modest improvements in recent years, nutritional conditions remain alarming: 44% of children suffer from stunting, 3.7% are overweight, and nearly half of the population experiences moderate or severe food insecurity (FAO et al., 2025).

These patterns are rooted in longstanding structural challenges, including a history of political instability and violence, widespread poverty, deep ethnic inequalities, climate-related disasters, geographic barriers limiting access to healthcare services, inadequate sanitation and hygienic conditions, and persistently low levels of educational attainment (Kreft et al., 2015; Mansukoski et al., 2020; Mazariegos et al., 2019; Monroy-Valle et al., 2025). Inequalities are particularly pronounced between regions, urban and rural areas, men and women, and Indigenous and non-Indigenous populations, especially in terms of income, access to schooling, and quality of education. Such disparities contribute to unequal nutritional outcomes among children, reinforcing intergenerational cycles of poor health and limited human capital development.

Against this background, this master's thesis investigates the relationship between maternal education and child nutritional outcomes in Guatemala. Particular attention is given to the extent to which this relationship varies across different social and geographical contexts, reflecting the persistent inequalities that characterize the country. The study examines multiple forms of child malnutrition and their severity levels while accounting for both individual- and household-level characteristics. The findings contribute to the broader literature on socio-demographic determinants of health and provide evidence to support the design of more effective and targeted nutrition policies in Guatemala.

The analysis is guided by the following hypotheses:

H1. Higher levels of maternal education are associated with better child nutritional outcomes. Children of more educated mothers are expected to exhibit lower levels of undernutrition, particularly stunting and underweight, and higher probabilities of achieving normal nutritional status compared to children of mothers with lower educational attainment.

H2. The protective effect of maternal education on child nutritional outcomes is expected to differ across ethnic groups. In particular, Indigenous Maya children are expected to experience worse nutritional outcomes than Ladino children at comparable levels of maternal education, reflecting persistent structural and socioeconomic disadvantages.

H3. The relationship between maternal education and child nutritional outcomes is expected to vary according to geographical context. Children living in rural areas and in historically disadvantaged regions are expected to face higher levels of malnutrition than their urban counterparts, even when maternal education levels are similar.

H4. Maternal education influences child nutritional outcomes both directly and indirectly through a range of mediating mechanisms. Household wealth, maternal nutritional status, family characteristics, and maternal employment are expected to partially mediate the relationship between maternal education and child nutrition, reducing the magnitude of the direct education effect once these factors are taken into account.

This thesis is structured as follows. First, a theoretical and empirical overview examines the role of maternal education in shaping child health and nutritional outcomes, as well as its broader implications for women's socioeconomic status and household well-being. This is followed by a contextual overview of Guatemala, focusing on the country's demographic, socioeconomic, and nutritional profile. The next chapter reviews the concept of malnutrition, discussing its definitions, measurement, determinants, and consequences, with particular attention to child malnutrition and the double burden of malnutrition. Subsequently, the data, methodology, and analytical framework are presented. Finally, empirical analyses based on the 2014–2015 Guatemala Demographic and Health Survey (DHS) are conducted to examine the relationship between maternal educational attainment and child nutritional outcomes, exploring both direct and indirect pathways as well as ethnic and geographical disparities.

2. THE IMPORTANCE OF EDUCATION

The United Nations, through the Universal Declaration of Human Rights (UN, 1948), proclaims education as a fundamental human right. In line with this principle, United Nations' 2030 Agenda for Sustainable Development identifies education as a central priority: Goal 4 of the Sustainable Development Goals defines the commitment to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all". Specifically, it aims to achieve, by 2030, free and universal primary education for all children, regardless of gender, as well as free and compulsory primary and secondary education. It further promotes equal access to technical, vocational, and higher education, based on merit.

These commitments highlight the growing recognition, at the institutional and global governance levels, of education as a cornerstone of social development, equality, and sustainable progress.

Beyond its intrinsic value as a fundamental human right, education has played a crucial role in broader demographic transformations. A growing body of research identifies educational expansion as one of the key forces underlying the First Demographic Transition, characterized by sustained declines in mortality and fertility rates (Baker et al., 2011; Caldwell, 1979). By improving cognitive skills, access to information, and decision-making capacities, education has contributed to changes in reproductive behaviour, family formation patterns, and child survival outcomes (Caldwell, 1979; Coale & Watkins, 1986). Consequently, educational attainment is increasingly viewed as a fundamental determinant of demographic change and population well-being (Baker et al., 2011; Mirowsky & Ross, 2003).

2.1 THE EFFECTS OF WOMEN'S EDUCATION

Mothers are often regarded as the primary health caregivers of their children and, in many contexts, the most influential ones. They observe and monitor their children's health, identify symptoms of illness, decide when and how to seek care, provide treatment, and manage follow-up in case of complications (Caldwell, 1979; Fuchs et al., 2010). In numerous developing countries, mothers frequently act as the sole providers of such care. Beyond direct medical decisions, their everyday choices concerning nutrition, hygiene, sanitation, and exposure to environmental risks play a crucial role in shaping children's overall health outcomes (Fuchs et al., 2010).

Even though many studies emphasize the importance of economic resources in explaining childhood survival and health (Cleland & Van Ginneken, 1988), this perspective is not universally accepted. Some argue that focusing mainly on income may overestimate the role of material resources and underestimate the independent effects of education on health-related knowledge, behaviors, and social opportunities (Caldwell, 1979; Lutz & Kebede, 2018).

In his seminal work on maternal education and child mortality in Nigeria, John C. Caldwell (1979) identified several pathways through which education can influence child health. His research marked a turning point in demographic and development studies, initiating a substantial body of literature that has since documented the independent and potentially causal relationship between maternal schooling and child survival. Caldwell's argument challenged a widely held assumption in development thinking during the 1980s: the belief that reductions in infant mortality would occur automatically as a by-product of economic growth. He contended that rising national income alone is insufficient to substantially reduce mortality and malnutrition. Instead, improvements in education, health services, and social behaviors are necessary components of sustained progress in child health outcomes.

A useful way to demonstrate the central role of parental—particularly maternal—education in shaping child health is to examine the more proximate mechanisms through which education affects health and survival. Research shows that controlling for factors such as household income and material resources, family size and structure, reproductive behaviors (e.g., age at first birth and birth intervals), spousal communication, women's status, health knowledge, and the use of health services reduces the magnitude of the association between maternal education and child health, but does not eliminate it entirely (Heaton et al., 2005). This suggests that education exerts an independent effect beyond socioeconomic background. In fact, in developing countries, increasing attention has been given to maternal education as a stronger predictor of child survival than household wealth alone (Fuchs et al., 2010).

Additional evidence of the importance of education comes from the work of Lutz and Kebede (2018), who compared the relationship between life expectancy and GDP per capita with that between life expectancy and educational attainment. Their findings suggest that education is a more consistent and stable predictor of health outcomes than income. While the association between GDP and health varies across countries and over time, the relationship between education and both life expectancy and child survival remain remarkably stable. These results support the view that education influences health not only indirectly through higher income, but also through its direct effects on knowledge, behaviors, and decision-making.

The extent of economic confounding varies across contexts, yet consistent findings across studies indicate that maternal education exerts an independent influence on child health beyond household wealth alone (Bicego & Boerma, 1993; Fuchs et al., 2010; Heaton et al., 2005; Lutz & Kebede, 2018).

Below, a review of the main effects that female education has on women and children.

2.1.1 Economic aspects

A central mechanism linking education to child health operates through economic resources. Higher levels of education increase income by improving access to better-paying jobs and enhancing the productivity of self-employment. Greater income, in turn, facilitates access to health-promoting resources, including higher-quality nutrition, improved housing conditions, sanitation, and preventive or curative medical care (Fuchs et al., 2010). For both parents—though particularly for women—these economic benefits may derive from their own labor market participation and income-generating activities, as well as through marriage to a partner with equal or higher educational attainment.

A foundational contribution to understanding the economic value of education comes from Theodore W. Schultz, who conceptualized education as an investment in human capital. In contrast to earlier views that treated schooling primarily as a social or consumption good, Schultz (1961) argued that expenditures on education enhance individuals' productive capacities in ways analogous to investments in physical capital. By improving skills, knowledge, and information-processing abilities, education raises individual earnings and contributes to aggregate economic growth. This human capital framework was further developed by Gary Becker (1964), who emphasized that the returns to education extend beyond wages to include greater adaptability to technological change, improved decision-making, and higher overall efficiency. In development contexts, this perspective provided a strong theoretical justification for investing in schooling as a strategy for long-term economic and social progress.

Empirical evidence supports these theoretical claims. Shafiq and collegues (2019) show that, across nine low- and middle-income countries, individuals with higher education degrees are significantly more likely to participate in the labor force, secure employment, and earn substantial wage premiums compared to those with lower levels of schooling. Similarly, Duflo (2001) provides causal evidence from a developing-country setting that increased schooling leads to higher adult wages, demonstrating that education generates tangible economic returns in low- and middle-income contexts.

2.1.2 Knowledge and health knowledge

Education has been shown to increase cognitive human capital—even after controlling for childhood IQ (Herd, 2010)—which helps explain why the academic and cognitive benefits of schooling are associated with positive health outcomes. A common assumption is that maternal education improves child health primarily by directly providing health knowledge (Baker et al., 2010). However, Baker and collegues (2011) emphasize that acquiring even basic literacy and numeracy skills requires substantial abstract cognitive effort. This process likely reshapes how individuals think, reason, and approach problem-solving, thereby influencing health-related decision-making. Similarly, Mirowsky and Ross (2003) argue that education builds both cognitive and psychological human capital, which influence health indirectly—through pathways such as occupational attainment—and directly, by promoting healthier behaviors and more effective health management. Schooling can therefore improve women's health and that of their children by enhancing reasoning skills, strengthening confidence in modern medicine, and fostering a commitment to its appropriate use (Caldwell et al., 2005).

Empirical evidence supports this broader interpretation. Heaton and colleagues (2005) analyzing data from 42 countries, examined two specific health knowledge indicators: knowledge of oral rehydration therapy for diarrhea and knowledge of the timing of conception. Although both indicators were initially strongly associated with lower infant mortality and reduced stunting, these relationships largely disappeared after controlling for maternal education and household economic resources. This suggests that formal education matters not merely because it directly imparts health knowledge, but because it equips women with the skills necessary to acquire, understand, and apply health information from multiple sources and so enhances the capacity to effectively use available information for child health.

However, an alternative perspective suggests that much health knowledge is acquired from other sources, such as mass media (television, radio, newspapers) or social networks (family members, friends, and community ties) (Fuchs et al., 2010). From this viewpoint, formal schooling may not simply transmit specific health information but rather enhance the cognitive skills needed to access, interpret, and apply information obtained elsewhere.

2.1.3 Empowerment of women and fertility decisions

In his comparative work on mortality decline, Caldwell (1986) sought to explain why some populations experienced more substantial reductions in mortality than others. He identified "female autonomy"—closely linked to women's education—as one of the most important determinants, alongside the availability of effective local health services. Caldwell argued that when women possess greater autonomy within the household and community, they are better positioned to make decisions that directly affect child survival and family health. Women's empowerment is a multidimensional concept encompassing psychological, social, economic, legal, and political dimensions (Pratley, 2016).

Empirical evidence indicates that empowerment across these dimensions is significantly associated with improved maternal and child health outcomes. These include higher utilization of antenatal care, increased likelihood of skilled birth attendance, greater contraceptive use, improved child survival, higher rates of full immunization, better nutritional status, and reduced exposure to violence (Pratley, 2016).

Education and empowerment must also be considered in relation to fertility outcomes, as it indirectly shapes child health through demographic behavior. Longer schooling for women is associated with delayed marriage and later childbearing (Marphatia et al., 2020). Moreover, increased investment in children's education raises the perceived and actual costs of childrearing, encouraging families to have fewer children and to allocate greater resources and care to each child (Becker & Tomes, 1976). Evidence suggests that more empowered women tend to prefer fewer children and to delay childbearing (Chowdhury & Haque, 2025) but also to shape attitudes by promoting modern values over traditional norms and hierarchical authority structures (Castro Martin & Juarez, 1995). Supporting this perspective, Becker and collegues (2006), studying western Guatemala, found that women with higher levels of education were more likely to participate actively in household decision-making, particularly regarding preventive health behaviors for themselves and their children.

Taken together, the literature suggests that maternal education may influence child nutritional outcomes through multiple pathways. These include improved economic resources, greater health knowledge and cognitive skills, enhanced female empowerment and decision-making autonomy, and changes in fertility behaviour and family size. Consequently, the relationship between maternal education and child nutrition is expected to operate through both direct and indirect mechanisms.

2.2 THE STATE OF EDUCATION IN GUATEMALA

In Guatemala, the education system is administered by the Ministerio de Educación (MINEDUC) and is divided into four main levels. Primary and lower secondary education are compulsory for a total of 10 years[1] (CIEN, 2019). Education is recognized as a fundamental right in the country, and it is established that it must be free and compulsory at certain levels.

[1] Primary and lower secondary education are compulsory for a total of 10 years from ages 6 to 15, up to Grade 6. Pre-primary education is attended from ages 4 to 6; primary school runs from ages 7 to 12 (Grades 1–6); secondary school covers ages 13 to 17, including lower secondary (Grades 7–9) and upper secondary (Grades 10–11); and tertiary education typically ranges from ages 18 to 22 (CIEN, 2019).

However, the fulfillment of these provisions is not always effective, and significant disparities are observed in access, quality, and attainment across different regions and ethnic groups (Meade, 2012; Orozco & Valdivia, 2017; Porter et al., 2019)

Educational disparities in Guatemala are deeply influenced by geographic location, ethnicity, and socioeconomic status. Students in rural areas generally face lower rates of school completion, higher levels of dropout, and weaker educational infrastructure, such as insufficient sanitation facilities, overcrowded classrooms, and limited access to learning materials. They often lack of sufficient learning resources and adequately trained teachers. Educational outcomes are also shaped by the country's ethnic and linguistic diversity (Porter et al., 2019; Treviño et al., 2015).

A key challenge affecting both the quality and availability of education is that Guatemala invests significantly less in education than the regional average for Central America and the Caribbean—about 3% of GDP compared to roughly 5% across the region (Porter et al., 2019). In addition, widespread corruption and limited government effectiveness—according to several indicators developed by the World Bank's Governance Matters project—suggest that allocated education funds are not used as efficiently as they could be (World Bank Group, n.d.). At the same time, broader contextual factors—including economic and labor market conditions, violence, and migration—strongly influence both the functioning of the education system and students' educational outcomes (Porter et al., 2019).

2.2.1 Historical legacy: the civil war and educational development

As underlined in Chamarbagwala and Morán work (2011), Guatemala was affected by a protracted civil war from 1960 to 1996, a period marked by widespread human rights abuses that primarily affected the Maya population. The conflict led to the destruction of community property, infrastructure, schools, educational facilities, bridges, and electrical towers. University and secondary school teachers and students were killed, and family capital—especially among Mayan families in the western and northwestern regions of Guatemala—was severely damaged. The tense situation also led many families to keep their children at home to protect them from potential violence at school or on their way to school.

The most intense phase of the conflict (1979–1984) disproportionately affected the departments of Quiché, Huehuetenango, Chimaltenango, Alta and Baja Verapaz, the south coast, and the capital. The violence had a particularly severe impact on Indigenous communities: among fully identified victims, 83% were Maya and 17% were Ladino. The impact of the civil war on educational outcomes particularly affected girls—especially older girls—with a decline in completion rates of over 12% , although males were also affected to a lesser extent. Indigenous

Mayan males and females completed 1.09 and 1.17 fewer years of schooling, respectively, during the final period of the conflict (1985–1996) compared to non-Indigenous populations. Increasing military spending during the war limited investment in health and education during this period (Chamarbagwala & Morán, 2011).

The post-war period recorded rapid improvements in access to primary education in rural areas, so much so that primary net enrollment rose from 72% to almost 94%, and primary completion increased by 24% (Meade, 2012).

Efforts have been made to improve educational opportunities in rural areas. MINEDUC developed policies to expand access to education in marginalized communities and sought alternatives to facilitate rural expansion and compensate for limited government investment in these areas (Gershberg et al., 2009; Meade, 2012).

2.2.2 Educational attainment and quality

Despite substantial progress in recent decades, Guatemala continues to lag behind other Central American countries in terms of educational attainment. By 2017, the average years of schooling reached 5.7 years (5.5 for females and 5.9 for males), yet this remains the lowest level in Central America and below that of countries with comparable GDP per capita, such as Morocco, Bolivia, and Guyana. These gaps are particularly pronounced among women, especially those living in rural and Indigenous communities (Porter et al., 2019). Literacy data illustrate this pattern: in 2011, non-Indigenous men aged 15 and over had a literacy rate of 88%, compared to 81% among non-Indigenous women. The disparity was even greater among the Indigenous population, where literacy rates were 74% for men and only 51% for women (Orozco & Valdivia, 2017).

Educational attainment has nevertheless improved over time. Primary school completion increased from 35% to 58% between 2000 and 2017 (Porter et al., 2019). However, Guatemala still records the lowest completion rates in Central America. School dropout remains a major challenge, particularly during the transition from primary to secondary education. In 2013, one-quarter of students completing primary school did not continue to lower secondary education, and only 42% remained enrolled through tenth grade (Adelman et al., 2018).

Beyond access and attainment, concerns about educational quality remain significant. Research from Hanushek and collegues (2015) suggests that improvements in learning outcomes contribute more to long-term development than increases in years of schooling alone. Guatemala performs poorly on national and international assessments, with secondary-level test scores in reading, mathematics, and science among the lowest in the region. Less than half of students completing primary school meet national standards in mathematics and science, while only one-quarter of secondary school graduates achieve reading proficiency.

Educational outcomes also vary considerably across regions and population groups. Half of the Guatemalan population is Indigenous (UNHCR, 2018), and many children begin school speaking an Indigenous language rather than Spanish (Fortin Morales et al., 2016). Students in the capital consistently outperform those in rural departments such as Huehuetenango, where achievement rates can be up to 50 percentage points lower than the national average. Indigenous students and students living in rural areas generally obtain lower test scores than their Ladino and urban counterparts (Meade, 2012; Orozco & Valdivia, 2017). Similar inequalities are observed by income level, as children from poorer households are less likely to remain in school and more likely to struggle academically (Szekely &Adelman, 2016).

Additional challenges relate to the quality of teaching and broader socioeconomic conditions. Teachers' educational attainment remains below the regional average, with nearly 80% of third-grade teachers and 60% of sixth-grade teachers having completed only secondary education (Treviño et al., 2015). Child labour also remains widespread and negatively affects educational performance: 8.9% of Guatemalan third-grade students work while attending school, a proportion above the regional average (Treviño et al., 2015).

Overall, educational opportunities in Guatemala remain strongly shaped by ethnicity, gender, place of residence, and socioeconomic status. These inequalities have important implications not only for economic development but also for broader demographic and health outcomes. In particular, maternal educational attainment influences health knowledge, economic opportunities, and childcare practices, while educational disadvantages often overlap with poverty, Indigenous status, and rural residence. Consequently, disparities in education may contribute to persistent inequalities in child nutritional outcomes across Guatemala.

3. THE BURDEN OF CHILD MALNUTRITION

Tackling malnutrition is one of the main global public health priorities and is widely recognised as a crucial factor in achieving the SDGs. In particular, it is closely linked to the "Zero Hunger" goal (SDG 2), which aims to "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture" (UN, n.d.).

Malnutrition is defined by the World Health Organization as "deficiencies, excesses, or imbalances in a person's intake of energy and/or nutrients" (WHO, 2024). It encompasses both undernutrition and overnutrition.

Undernutrition includes conditions such as stunting, wasting, underweight, and micronutrient deficiencies. Stunting occurs when a child has low height for their age, indicating a failure in linear growth. It is the result of chronic or recurrent undernutrition and can lead to severe and irreversible physical and cognitive impairments. Wasting refers to low weight for a child's height and indicates recent and severe weight loss or a failure to gain weight, often associated with acute undernutrition. Underweight, instead, describes a child who has low weight for their age. Micronutrient deficiencies arise from an inadequate intake of essential vitamins and minerals required for proper growth, development, and physiological functioning (WHO, 2024). The most common micronutrient deficienceis are iron, vitamin A and iodine but also vitamin C and B1, niacin and thiamin (WFP & CDC, 2005).

Overnutrition, on the other hand, includes overweight and obesity and refers to a child who is excessively heavy for their height. It is also associated with diet-related non-communicable diseases later in life, such as diabetes, cardiovascular diseases, stroke, and certain types of cancer (WHO, 2024).

Children can experience multiple forms of malnutrition simultaneously, a condition that significantly increases the risk of morbidity and mortality and may also have intergenerational consequences across the life course (UNICEF et al., 2025)

Adequate nutrition, particularly during the first 1,000 days, from conception to a child's second birthday, is critical for optimal cognitive, social, and educational development. It can have long-lasting and often irreversible effects on health, productivity, and overall human potential (Adair et al., 2013; Victora et al., 2008, 2010, 2015; Vollmer et al., 2014).

To provide an overview of the issue, in 2024 stunting affected 150.2 million children under the age of five, representing approximately 23.2% of children worldwide. In the same year, 6.6% of children under five were wasted and 5.5% were overweight (UNICEF et al., 2025). Although these figures are alarming, some progress has been made toward achieving the ambitious SDGs aimed at eliminating all forms of child malnutrition, including reductions in stunting. According to the analysis conducted by UNICEF, WHO and World Bank Group (UNICEF et al., 2025) the prevalence of stunting declined by approximately 10 percentage points between 2000 and 2024, although a U-shaped trend has been observed following the COVID-19 pandemic. Similarly, the prevalence of wasting among children under five slightly decreased from 8% to 6% over the same period. On the other hand, the prevalence of overweight children has shown a slight increase.

Despite these improvements, progress remains insufficient to meet the 2030 targets.

3.1 THE STATE OF MALNUTRITION IN GUATEMALA

According to FAO (FAO et al., 2025), in 2024, 44% of Guatemalan children under five years of age suffered from chronic malnutrition. This represents the highest prevalence in Central and South America and exceeds average levels observed in most world regions. Food insecurity also remains widespread, affecting almost half of the population, while 3.7% of children under five were classified as overweight. Reflecting these persistent challenges, Guatemala has been classified as one of the countries experiencing a protracted food crisis since 2016 (FSIN & GNAFC, 2025).

Despite the alarming prevalence levels, Guatemala has recorded some improvements over time (FAO et al., 2025). Between 2004–2006 and 2024, the prevalence of undernourishment in the total population declined from 19.2% to 11.8%. Nevertheless, trends in child stunting remain highly concerning. In 2012, 47.7% of children under five suffered from chronic undernutrition. Over the following twelve years, this proportion declined only slightly, reaching 44.6% in 2024.

Some improvements have been observed also in childhood overnutrition (FAO et al., 2025). The prevalence of overweight among children under five declined from 4.4% in 2012 to 3.7% in 2024. In this regard, Guatemala performs relatively better than other Central American countries; for example, Panama recorded an overweight prevalence of 10.9% among children under five in 2024. However, an opposite trend is observed among adults. The prevalence of obesity among individuals aged 18 years and older increased from 20% in 2012 to 26.8% in 2022, indicating a worrying shift away from the SDGs and highlighting the growing burden of non-communicable diseases.

Together, these trends illustrate the emergence of a double burden of malnutrition, whereby persistent child undernutrition coexists with rising levels of adult overweight and obesity.

Significant progress has been achieved in exclusive breastfeeding. Exclusive breastfeeding during the first six months of life, as recommended by UNICEF and WHO (2018), is essential for optimal cognitive and physical development. In Guatemala, the proportion of infants aged 0–5 months who were exclusively breastfed increased from 49.6% in 2012 to 58.5% in 2023. The prevalence of low birth weight has remained largely unchanged, stabilizing at approximately 14% between 2012 and 2020.

While some nutritional indicators have improved over time, food insecurity remains a major challenge (FAO et al., 2025). Between 2014–2016 and 2022–2024, the share of the population experiencing moderate or severe food insecurity increased from 42.7% to 48.8%, the highest level in Central America and above that of all South American countries. Severe food insecurity followed a similar trend, rising from 16.1% to 21.3% over the same period. Although a slight improvement was observed after the peak recorded in 2023, driven by better income opportunities, average agricultural production, and increased remittance inflows, food insecurity remains critically high (FSIN & GNAFC, 2025). In 2024, acute food insecurity was largely driven by rising inflation—particularly higher prices of imported goods—as well as extreme weather events and crop losses.

Guatemala is characterized by profound inequalities related to income, ethnicity, geographic isolation, infrastructure development, and access to basic services. In 2023, the country recorded a Gini coefficient of 45.2, reflecting a highly unequal distribution of income and wealth and placing Guatemala among the most unequal countries in Latin America (*World Bank Open Data, Gini Index - Guatemala*, n.d.).

Furthermore, the country is home to 21 Maya ethnic groups, which together represent approximately 51% of the total population, and recognizes 26 Indigenous languages, including Q'eqchi', Kaqchikel, Mam, Tz'utujil, Achi, and Poqomam. Indigenous populations are primarily concentrated in the western highlands, particularly in the departments of Alta Verapaz, Sololá, Totonicapán, Huehuetenango and Quiché (MSPAS et al., 2015; UNHCR, 2018). These areas experience some of the highest levels of poverty and child malnutrition in the country, alongside departments such as Huehuetenango, San Marcos, Quetzaltenango, and Baja Verapaz (Pons, 2012). As a result, ethnic identity, geographical location, and socioeconomic disadvantage often overlap, reinforcing persistent inequalities in health, education, and nutritional outcomes.

In addition to persistent socioeconomic and ethnic disparities, Guatemala is highly vulnerable to climate-related shocks that affect both livelihoods and food production. The country ranks among those most affected by extreme weather events globally and forms part of the Central American Dry Corridor, a region encompassing much of central and eastern Guatemala (Kreft et al., 2015). This area is characterized by recurrent droughts, high temperatures, and low precipitation, conditions that are becoming increasingly severe due to climate change (CEPAL et al., 2018; Sain et al., 2017). In 2024, delayed and below-average rainfall, combined with unusually high temperatures associated with the El Niño phenomenon, negatively affected agricultural production (FSIN & GNAFC, 2025). These conditions resulted in delayed planting, reduced cultivated areas, and lower crop yields, particularly among smallholder farmers, thereby increasing food insecurity and nutritional vulnerability among already disadvantaged populations.

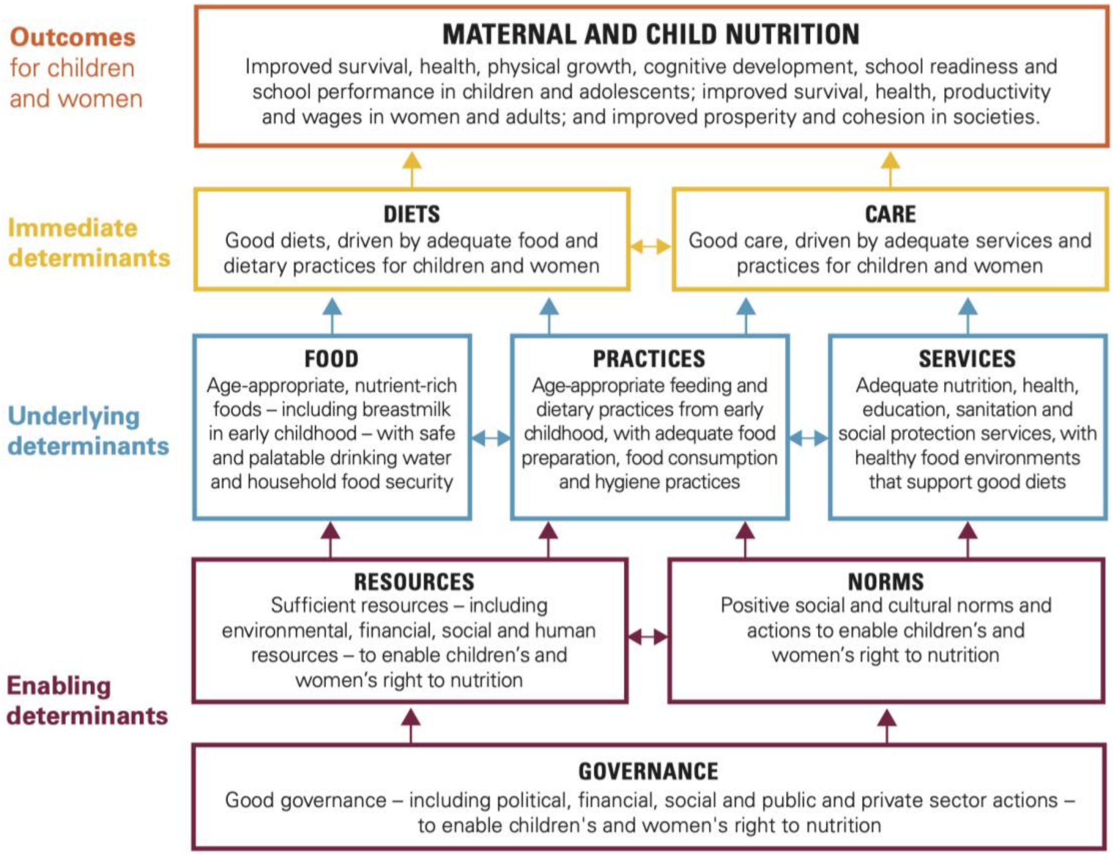
These conditions are particularly relevant for understanding child nutritional outcomes in Guatemala, as socioeconomic disadvantage, ethnic inequalities, and geographical isolation often coincide with lower levels of maternal education. Consequently, Guatemala provides a particularly relevant setting in which to examine how maternal educational attainment shapes child nutrition.

3.2 UNICEF THEORETICAL FRAMEWORK

UNICEF (1990) developed a conceptual framework to explain the determinants of maternal and child nutrition, highlighting the complex and multidimensional nature of malnutrition (see Figure 1). Both undernutrition and overnutrition rarely result from a single cause; rather, they emerge from the interaction of social, economic, environmental, and political factors operating at multiple levels (Bhutta et al., 2017).

A key strength of this conceptual framework lies in its flexibility, as it can be adapted to different geographical contexts and tailored to diverse intervention priorities and policy objectives (Black et al., 2013; Levitt et al., 2009).The framework distinguishes between immediate, underlying, and basic causes of malnutrition. The following sections describe each of these components and their role in shaping maternal and child nutritional outcomes (UNICEF, 2021).

Figure 1: UNICEF Conceptual Framework on the Determinants of Maternal and Child Nutrition, 2020. A framework for the prevention of malnutrition in all its forms.



Source: (UNICEF, 2021)

3.2.1 Immidiate causes

The immediate causes of malnutrition are twofold: inadequate dietary intake and the presence of disease.

Inadequate food intake refers not only to the quantity of food consumed by a child but also to the quality of the diet. Adequate intake of all essential nutrients is fundamental for the biological processes that support child growth, nervous system development, and musculoskeletal maturation (Reinhardt & Fanzo, 2014). Diet quality is largely determined by dietary diversity and the micronutrient content of foods. Deficiencies in essential micronutrients are often not immediately visible – a condition commonly referred to as *"hidden hunger"* – and can have severe consequences for brain development, including impairments in cognitive, motor, and socio-emotional abilities (Prado & Dewey, 2014)

Disease represents the second immediate cause of malnutrition. Common childhood infectious and diarrhoeal diseases, reduce nutrient absorption and increase nutrient losses. Evidences demonstrates that children suffering from recurrent infections face a significantly higher risk of becoming malnourished (Brown, 2003; Checkley et al., 2008).

Importantly, inadequate dietary intake and disease interact in a self-reinforcing *vicious cycle*. Children with insufficient diets often have weakened immune systems, which increases their susceptibility to infections (Bhutta et al., 2017; Ijaiya et al., 2005; Sankar et al., 2015). In turn, infectious diseases exacerbate malnutrition by reducing appetite, impairing nutrient absorption, and inducing metabolic and behavioural changes that increase nutritional requirements while simultaneously limiting intake (Brown, 2003). This malnutrition–infection cycle allows each condition to intensify the other, leading to longer and more frequent illnesses and, in severe cases, to life-threatening outcomes.

3.2.2 Underlying causes

The immediate causes of malnutrition are, in turn, underpinned by a set of underlying determinants operating at the household and community levels. These include household food security, adequate maternal and child care practices, and access to health services and a healthy environment. Together, these factors shape the ability of individuals and households to obtain, utilise, and benefit from adequate nutrition.

3.2.2.1 Household food security

Food security constitutes a central underlying determinant of malnutrition. The World Food Summit have defines food security as a condition that *"exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life"* (World Food Summit, 1996). Food insecurity can result from shocks occurring at the household or community level and may arise as isolated events, recur cyclically, or persist over time (Reinhardt & Fanzo, 2014). This definition is grounded in four interrelated dimensions: access, availability, utilisation, and stability (FAO et al., 2024).

Food access refers to the ability of households to regularly acquire sufficient and appropriate food for a nutritious diet. This dimension encompasses both economic access—such as purchasing power—and physical access, including the ability to reach markets safely, affordably, and without social or structural barriers. Access to food is not limited to market purchases but also includes own food production through crops, livestock, fishing, hunting, and gathering, as well as barter exchange, social transfers, gifts, and cash assistance.

Food availability concerns the supply side of the food system and includes domestic food production, food stocks, and net trade. It accounts for locally produced foods, imported goods, and food aid. Availability can be constrained by factors such as high import costs, climate shocks, or inadequate infrastructure.

Food utilisation refers to the way households use the food they access and the body's ability to absorb and metabolise the nutrients it contains. This dimension includes food storage, processing, and preparation practices; the type of cooking fuel available; hygiene conditions, including water quality; and feeding practices, particularly for children, pregnant women, older adults, and individuals who are ill. Intra-household food distribution and the allocation of food among household members are also critical components of utilisation.

Food stability represents the temporal dimension of food security and reflects the consistency of access, availability, and utilisation over time. It involves reducing vulnerability to shocks and seasonal fluctuations that may disrupt food security in the short or long term.

Limited access to sufficient and nutritious food has been shown to increase the risk of undernutrition, particularly stunting and underweight (Moradi et al., 2018), while also heightening children's vulnerability to infections and poor health conditions (Hackett et al., 2009)

3.2.2.2 Care practices

The second underlying determinant of child malnutrition is care, defined as the provision at the household and community levels of *"time, attention, and support to meet the physical, mental, and social needs of the growing child and other household members"* (FAO & WHO, 1992). Caregivers—most often women—play a central role in delivering adequate care through activities such as caring for pregnant women, supporting appropriate breastfeeding practices, providing psychosocial stimulation, preparing and storing food safely, maintaining hygiene, and caring for children during illness (Engle et al., 1997).

Evidence underscores the importance of care practices for child nutritional outcomes. A study from Bangladesh demonstrated a strong association between exclusive breastfeeding during the first six months of life and a reduction in the prevalence of stunting among children aged 24 to 59 months (Arifeen et al., 2009).

3.2.2.3 Health services and a healthy environment

The third underlying determinant of malnutrition is access to health services and a healthy environment. Poor water, sanitation, and hygiene (WASH) conditions not only directly affect child health but also influence food production, food preparation, and overall hygiene practices.

Inadequate access to safe water can indirectly worsen nutritional outcomes by increasing women's workload, thereby reducing the time available for child care (UNICEF, 1990).

Lin et al. (2013) found that inadequate WASH conditions were associated with higher rates of infection and an increased risk of stunting compared to healthier household environments. Similarly, Taguri et al. (2009) reported a higher risk of stunting among children living in households with poor housing conditions, unsafe water supplies, inadequate sanitation, and insufficient garbage collection.

3.2.3 Basic causes

Within the UNICEF conceptual framework, basic causes represent the enabling determinants that shape the broader environments in which individuals and households operate. These determinants encompass the social, economic, political, and institutional drivers that influence nutrition outcomes. They relate both to the quantity and quality of available resources—such as human, economic, and financial capital—and to the ways in which these resources are controlled, distributed, and organised within societies. Basic causes also include a country's or community's potential resources, ranging from technology and environmental assets to infrastructure, human capital and cultural norms. In fact, extreme climate events as well as conflicts or political instability, gender disparities, economic slowdowns and downturns are observed to be all drivers of food instability (FAO et al., 2024; UNICEF, 2021).

Overweight conditions are also linked to those basic causes. Early work by Swinburn and collegues (1999) conceptualized obesogenic environments as being shaped by physical, economic, political, and sociocultural factors. These include the availability of foods and opportunities for physical activity, their relative affordability, the regulatory and policy context that influences food production and marketing, and prevailing social norms and beliefs that shape dietary behaviors and lifestyle choices. Later research further expanded this framework, emphasizing how environmental contexts interact with individual behaviors by influencing access to healthy foods, transportation systems, urban design, and exposure to food marketing (Glanz et al., 2005). Together, these factors create environments that can either promote healthy behaviors or encourage excessive energy intake and sedentary lifestyles, thereby increasing the risk of obesity.

The UNICEF Theoretical Framework provides a comprehensive perspective for understanding the complex determinants of maternal and child malnutrition (UNICEF, 2021). By distinguishing between immediate, underlying, and basic causes, it highlights how nutritional outcomes result from the interaction of biological, household, and structural factors rather than isolated conditions.

Building on this conceptual foundation, the next section reviews empirical studies that examine how these determinants translate into measurable nutritional outcomes across different settings.

3.3 DETERMINANTS OF CHILD NUTRITIONAL OUTCOMES

Building on the UNICEF conceptual framework, numerous studies have investigated the determinants of child nutritional outcomes in low- and middle-income countries. Evidence suggests that child malnutrition is influenced by a wide range of factors operating at different levels, from individual and household characteristics to broader socioeconomic and environmental conditions.

3.3.1 Birth order

Birth-related characteristics have been identified as important determinants of child nutritional outcomes. Several studies report that children of higher birth order face a greater risk of malnutrition, as household resources, parental attention, and caregiving capacity may become increasingly diluted as family size grows (Jana et al., 2023). However, evidence regarding birth order is not entirely consistent. For example, Chowdhury and collegues (2018), found that first-born children were more likely to have a low birth size than children of higher birth orders. Child age also plays an important role. Older children are generally more likely to experience stunting than younger children (Babatunde et al., 2011), partly because growth faltering often begins during the transition from exclusive breastfeeding to complementary feeding. High maternal parity may further increase these risks by placing additional demands on household resources and maternal caregiving capacity.

3.3.2 Parental education

Parental education plays a crucial role in shaping child nutritional outcomes. Children born to parents with little or no education exhibit significantly higher rates of malnutrition than those whose parents have attained higher levels of education (Arriaza et al., 2022; Chowdhury et al., 2018). Maternal education, in particular, is critical due to its association with greater awareness of nutritional requirements and improved healthcare-seeking behavior for both children and mothers (Babatunde et al., 2011; Gewa, 2010; van Ansem et al., 2014). Maternal education has been associated with lower risks of child stunting in Nigeria (Babatunde et al., 2011) and with reduced prevalence of low birth weight and infant mortality in countries such as India and Brazil (Vilanova et al., 2019).

In Guatemala, 67% of children born to mothers with no formal education suffer from chronic malnutrition, compared with only 19% of children whose mothers have higher education. Among women with higher education, 98% deliver in health facilities, compared with only 39% of women with no formal education (MSPAS et al., 2015).

At the individual level, Arriaza and colleagues (2022), show that Guatemalan women with the highest levels of education are, on average, 3.76 cm taller than women with no formal education, suggesting substantial differences in nutritional and health conditions throughout the life course.

In Guatemala, scholars have documented a positive relationship between education and hygiene beliefs and practices (Goldman et al., 2001) as well as a higher likelihood of seeking formal medical care among more educated women (Glei et al., 2003). In particular, more educated women and Ladinas are more likely to seek biomedical care during pregnancy compared to less educated and indigenous women (Glei et al., 2003). These findings are particularly relevant given the importance of hygiene and caregiving practices in shaping child nutritional outcomes.

3.3.3 Economic factors

Poverty is both a cause and a consequence of poor human development and adverse health outcomes (Di Cesare et al., 2013), and it is widely recognized as one of the most important determinants of child malnutrition and health outcomes (Di Cesare et al., 2013; Grantham-McGregor et al., 2007; Siddiqui et al., 2020). By limiting access to sufficient, safe, and nutritious food, economic deprivation increases the risk of both undernutrition and overnutrition. It may also compromise diet quality, leading to “hidden hunger”, whereby individuals consume adequate calories but insufficient essential nutrients (Siddiqui et al., 2020). Economic status therefore plays a crucial role in shaping both food preferences and access (Tanumihardjo et al., 2007).

Evidence from a wide range of low- and middle-income countries consistently shows that children from poorer households face higher risks of stunting, wasting, underweight, and adverse health outcomes (Black et al., 2013; M. Chowdhury et al., 2018; Jana et al., 2023; Vorster, 2010). Higher socioeconomic status has been associated with increased caloric intake among Nigerian children (Babatunde et al., 2011), while in Guatemala household economic conditions are strongly associated with child stunting and wasting conditions (Martorell & Young, 2012).

Economic conditions are also relevant for understanding the growing prevalence of overweight and obesity. For example, low-income neighbourhoods in Mexico City face higher prices for fresh fruits and vegetables, reducing access to healthier dietary options (Bridle-Fitzpatrick, 2015). However, in Guatemala, overweight and obesity in 2015 were more prevalent among high-income, non-Indigenous, and highly educated individuals, particularly women (Mazariegos et al., 2019). This pattern is consistent with the earlier stages of the obesity transition, during which excess body weight tends to be concentrated among more advantaged socioeconomic groups (Jaacks et al., 2019) (see *Panel 1*).

Although economic resources play a fundamental role in shaping nutritional outcomes, evidence suggests that economic growth alone is insufficient to substantially reduce child malnutrition (Vollmer et al., 2014). Improvements in child nutrition depend on how economic gains translate into better living conditions, including access to healthcare, sanitation, clean water, adequate housing, and other essential services (Fay et al., 2005). This highlights the importance of considering broader social and environmental determinants alongside household wealth when examining child nutritional outcomes.

3.3.4 Ethnicity

Ethnicity is an important determinant of child nutritional outcomes, as ethnic inequalities often overlap with socioeconomic disadvantage, lower educational attainment, and reduced access to healthcare services (MSPAS et al., 2015; UNHCR, 2018). Indigenous populations generally experience poorer health outcomes than non-Indigenous populations, including higher rates of infectious diseases, disability, and mortality populations (Gracey & King, 2009).

In Guatemala, the Maya population represents approximately half of the total population and is primarily concentrated in the western highlands, particularly in the departments of Alta Verapaz, Sololá, Totonicapán, Huehuetenango and Quiché (MSPAS et al., 2015; UNHCR, 2018). These regions also record some of the highest levels of poverty and child malnutrition in the country (MSPAS et al., 2015). As a result, Maya children face a disproportionately high risk of chronic malnutrition, largely due to structural factors such as food insecurity, limited access to healthcare, poverty, and the long-term consequences of political and social marginalization (Mansukoski et al., 2020; Mazariegos et al., 2019; Monroy-Valle et al., 2025).

Educational disadvantages further contribute to these inequalities. Indigenous children are more likely to leave school early than their non-Indigenous counterparts (Canelas & Gisselquist, 2018) reducing future opportunities and access to resources that promote health and well-being. Barriers to healthcare also remain significant. Indigenous women are more likely to rely on traditional midwives for pregnancy care and have reported higher levels of discrimination within the public health system, factors that may discourage the use of formal healthcare services and negatively affect maternal and child health outcomes (Glei & Goldman, 2000; Cerón et al., 2016).

3.3.5 Geographic factors

Geographic location is an important determinant of child nutritional outcomes. Undernutrition is generally more prevalent in rural areas, where poverty, limited access to healthcare, inadequate sanitation, and food insecurity remain widespread (Adel et al., 2008; Chowdhury et al., 2018). In contrast, urban environments have traditionally been associated with higher risks of overweight and obesity due to sedentary lifestyles and greater availability of energy-dense and ultra-processed foods (Glanz et al., 2005).

However, the distinction between rural and urban areas is becoming less clear. In many middle-income countries, rural populations are experiencing declining levels of physical activity due to agricultural mechanization, improved transportation, and the expansion of less physically demanding occupations (Ng & Popkin, 2012). Consequently, BMI levels have increased in rural areas, reflecting broader processes of nutrition transition (Jaacks et al., 2019; B. Popkin, 2002). At the same time, the shift from subsistence farming to cash-oriented agriculture has often reduced dietary diversity and increased households' vulnerability to food insecurity (Dewey, 1989).

Evidence from Guatemala illustrates these dynamics. Malnutrition disproportionately affects rural and Indigenous populations, with chronic malnutrition affecting 53% of children in rural areas and 58% of Indigenous children. Access to healthcare services also varies substantially across regions. For example, only around 70% of women in the Nororiente, Suroriente, Noroccidente, and Norte regions received postnatal care, compared with 91% in the metropolitan area of Guatemala City (MSPAS et al., 2015). Similarly, households located closer to the capital tend to report greater awareness of hygiene and contamination issues and are more likely to practice preventive health behaviours (Goldman et al., 2001). Recent evidence from Chichicastenango, in the department of Quiché, further highlights the challenges faced by rural communities. More than half of children were found to be stunted, while most households experienced food insecurity and lacked adequate water, sanitation, and hygiene (WASH) services (Monroy-Valle et al., 2025).

Food environments represent an additional mechanism linking geography and nutritional outcomes. Brown and collegues (2016) describe a situation similar to the concept of "food deserts", whereby rural households engaged in agricultural production nevertheless face limited access to diverse and nutritious foods. In many Indigenous communities, diets rely heavily on cereals, tubers, and inexpensive processed foods, while the consumption of dairy products, animal-source foods, and vitamin A–rich foods remains low. Limited market access, small landholdings, and the expansion of non-traditional agricultural exports further constrain dietary diversity. As a result, many households rely on corner stores, which predominantly sell ultra-processed foods that are cheaper and more readily available than healthier alternatives, while offering only limited access to fresh and nutrient-rich foods.

3.3.6 BMI and stature of mothers

Women's nutritional status before, during, and after pregnancy is a crucial factor to consider when examining the determinants of child malnutrition. Maternal body mass index (BMI), which measures weight relative to height, reflects women's nutritional status and is a key determinant of newborn health and nutritional outcomes (Black et al., 2008). Low maternal BMI, in particular, has been strongly associated with low birth weight (Black et al., 2013). Evidence from Gebreegziabher & Sidibe (2024) shows that low maternal BMI and short maternal stature are significantly associated with child undernutrition, whereas children born to mothers with normal or higher BMI face a lower risk of undernutrition.

Maternal stature is also an important determinant of intrauterine growth restriction and low birth weight, as it reflects the social and environmental shocks experienced during a woman's early life and is commonly used to assess intergenerational linkages in health (Black et al., 2013; Martorell & Young, 2012; Özaltin et al., 2010). These conditions are subsequently linked to higher child mortality and morbidity, including underweight and stunting (Özaltin et al., 2010; Black et al., 2008), and women of short stature are at increased risk of delivery complications (Black et al., 2013).

Guatemalan women have an average height of 148 cm, the lowest in Latin America and the Caribbean (Arriaza et al., 2022). This contributes to the high prevalence of child stunting and to the coexistence of stunted children and overweight mothers, a phenomenon commonly referred to as the Double Burden of Malnutrition (DBM – see below). As underlined in Arriaza and collegues (2022), female height in Guatemala is strongly associated with household wealth and educational attainment. Women in the highest wealth quintile are, on average, 4.91 cm taller than those in the lowest quintile. An indigenous woman in the highest wealth quintile is 2.89 cm taller than one in the lowest quintile, while non-indigenous women exhibit an even larger difference of 4.72 cm. Education also plays a key role: women with the highest educational attainment are, on average, 3.76 cm taller than those with the lowest education levels. Geographic disparities are evident, with women living in western regions being shorter than those in metropolitan areas. Over a 50-year period, indigenous women experienced an average height increase of 0.027 cm per year, compared to 0.017 cm per year among non-indigenous women. Despite this faster growth, indigenous women started from—and continue to have—a lower average height.

3.3.7 Dietary patterns

Dietary patterns constitute an important determinant of child nutritional outcomes, as they directly influence energy intake and the consumption of essential nutrients (UNICEF, 2021). However, dietary choices are shaped not only by cultural traditions but also by economic resources, food availability, and access to markets (Jensen et al., 2016; Mayén et al., 2016). Consequently, populations facing poverty and food insecurity often experience limited dietary diversity, increasing their risk of malnutrition.

In Guatemala, dietary patterns vary considerably across socioeconomic and ethnic groups. Among Indigenous Maya communities, diets are often centred on maize-based foods, reflecting both the cultural importance of maize and its affordability relative to other food sources (Hoss-Cruz et al., 2024; Luna-González & Sørensen, 2018; Monroy-Valle et al., 2025). While traditional Mayan cuisine can be nutritionally diverse and include fruits, vegetables, seeds, and animal-source foods, economic constraints frequently limit access to these products (Vera Pineda et al., 2026). As a result, many households rely heavily on staple foods such as maize and beans, while the consumption of meat, dairy products, and other nutrient-rich foods remains comparatively low.

Food purchasing decisions are strongly influenced by prices and household resources. Research conducted in Guatemala shows that foods such as meat, dairy products, and bread are often perceived as expensive, whereas locally available plant-based foods are more affordable (Jensen et al., 2016). Consequently, wealthier households tend to consume more diverse and nutrient-rich diets (but often rich in sodium and fat), while poorer households are more likely to rely on less varied diets dominated by staple foods (Mayén et al., 2016).

Recent evidence from the department of Quiché further highlights the nutritional limitations associated with grain-based dietary patterns. Children living in food-insecure households were more likely to consume diets centred on cereals and maize-based foods, which were associated with lower energy intake and deficiencies in several essential nutrients. Dietary patterns incorporating dairy products and poultry generally showed more favourable nutritional profiles (Monroy-Valle et al., 2025).

Dietary patterns are also shaped by cultural norms and household practices. UNICEF and MAGENTA (2023) highlight that food consumption behaviours are strongly influenced by family and community norms. For example, the regular consumption of coffee among young children and the use of snack foods as rewards are often perceived as normal practices within families. Similarly, research conducted among Indigenous Q’eqchi' households shows that food choices are influenced not only by economic constraints but also by cultural traditions, health beliefs, seasonality, and social customs (Jensen et al., 2016). The same study found that larger body size is frequently associated with good health, illustrating how cultural perceptions may shape attitudes towards nutrition and well-being.

3.3.8 Water, sanitation and hygiene (WASH)

Household characteristics play an important role in shaping child nutritional outcomes, particularly through access to safe water, adequate sanitation, and hygienic living conditions. Poor water, sanitation, and hygiene (WASH) environments increase children's exposure to pathogens and infectious diseases, which negatively affect nutritional status (Cristiano, 2022; Patlán-Hernández et al., 2022; Stobaugh et al., 2020). These illnesses reduce appetite, impair nutrient absorption, and increase nutrient losses, generating a vicious cycle in which poor health and malnutrition reinforce one another.

Empirical evidence suggests that improvements in WASH infrastructure can substantially reduce child undernutrition. While acute malnutrition is not always consistently associated with WASH conditions (Patlán-Hernández et al., 2022; Stobaugh et al., 2020), chronic malnutrition appears to be more strongly linked to prolonged exposure to poor environmental health conditions (Martorell & Young, 2012; Monteiro et al., 2010; Taguri et al., 2009).

Research conducted in several regions of western Guatemala and San Marcos underlines that access to WASH services remains a critical challenge in Guatemala, particularly in rural and Indigenous communities located in the western highlands (Voth-Gaeddert & Oerther, 2019). They have found that inadequate sanitation infrastructure, limited access to safe drinking water, and poor hygiene practices substantially increase children's exposure to pathogens. As a result, children experience more frequent infections and gastrointestinal illnesses, which compromise nutrient absorption and weaken immune responses. These challenges are particularly pronounced in remote, arid and mountainous areas, where poverty and limited infrastructure often force households to rely on unsafe water sources and inadequate sanitation facilities.

Panel 1: The nutritional transition

The nutrition transition refers to long-term shifts in dietary patterns and physical activity that influence population health and nutritional status. According to Popkin (2002), five broad stages can be identified.

The first stage corresponds to hunter-gatherer societies, characterized by diets rich in fiber and complex carbohydrates, high levels of physical activity, and virtually no obesity.

The second stage, known as the famine stage, is marked by limited dietary diversity and recurrent food shortages, often resulting in nutritional stress and reduced physical growth.

The third stage, associated with receding famine, involves improvements in food availability and dietary diversity, including greater consumption of fruits, vegetables, and animal-source foods. As living standards improve, physical activity gradually declines and sedentary behaviours become more common.

The fourth stage is characterized by the widespread adoption of the so-called Western diet, which is high in saturated fats, sugar, cholesterol, and ultra-processed foods, while being relatively low in fiber and other protective nutrients. Combined with increasingly sedentary lifestyles, these changes contribute to rising levels of overweight, obesity, and nutrition-related non-communicable diseases, thereby reflecting the later stages of the epidemiological transition (Omran, 1971).

A fifth stage has emerged in some countries and is marked by growing awareness of diet-related health risks and efforts to adopt healthier lifestyles through improved diets and increased physical activity.

The rapid increase in overweight and obesity observed during the fourth stage has led researchers to identify a more specific process known as the obesity transition. Jaacks and colleagues (2019) describe four stages of this transition. In the first stage, obesity is more prevalent among women, adults, and individuals with higher socioeconomic status, a pattern commonly observed in many low-income countries. During the second stage, obesity prevalence increases rapidly among adults and begins to rise among children, while gender and socioeconomic differences narrow. This pattern is characteristic of many countries in Latin America and the Middle East. In the third stage, obesity becomes increasingly concentrated among lower socioeconomic groups, while prevalence among higher-status women and children tends to stabilize. Most European countries are currently considered to be in this stage. A fourth stage, characterized by sustained declines in obesity prevalence, has been proposed; however, it remains largely hypothetical because only a limited number of countries have shown clear evidence of this pattern.

In addition, Monteiro and colleagues (2004) highlight how patterns of obesity in developing countries are changing alongside economic development. Obesity is no longer confined to higher socioeconomic groups; rather, as national income rises, the burden progressively shifts toward populations with lower socioeconomic status. Notably, this transition appears to affect women earlier than men, indicating a gendered dimension in the socioeconomic redistribution of obesity.

Today, many developing countries are experiencing a rapid transition toward Western dietary patterns driven by globalization, urbanization, and rising incomes (Azzam, 2021; Cordain et al., 2005). Unlike high-income countries, where these changes occurred gradually over nearly two centuries, many low- and middle-income countries have undergone similar transformations within just a few decades (Grigg, 1995; Popkin, 2003). As a result, undernutrition, overweight, and obesity increasingly coexist within the same populations, households, and even individuals, giving rise to the double burden of malnutrition and posing significant challenges for public health systems (FAO et al., 2024).

Overall, the literature demonstrates that child nutritional outcomes are shaped by a complex interplay of individual, household, community, and structural factors. Maternal education, economic resources, ethnicity, geographic location, dietary practices, and access to adequate water and sanitation services all contribute to children's nutritional status through multiple and interconnected pathways. These determinants rarely operate in isolation; rather, they reinforce one another, producing persistent inequalities in health and nutrition. While understanding the determinants of malnutrition is essential, it is equally important to examine the consequences that nutritional deficiencies can have throughout the life course. The next section therefore examines the short- and long-term consequences of malnutrition across the life course.

3.4 CONSEQUENCES OF CHILD MALNUTRITION

Human development unfolds through a series of sensitive periods in which physiological systems are especially responsive to environmental inputs. Growth faltering begins during gestation and continues throughout the first two years of life (Victora et al., 2010). This critical phase, commonly referred to as the *"window of opportunity"*, spans from conception to a child's second birthday and encompasses the first 1,000 days of life.

During this period, children experience their highest growth velocity and developmental plasticity, they present rapid physical growth and acquire essential motor and developmental skills making nutrition particularly influential for long-term outcomes (Prado & Dewey, 2014; Reinhardt & Fanzo, 2014; Victora et al., 2015). Although growth continues beyond this period, it occurs at a slower pace until puberty (Prentice et al., 2013).

A large body of research has shown that inadequate nutrition during early life can negatively affect children's cognitive, motor, and socio-emotional development (Gale et al., 2009; Grantham-McGregor et al., 2007; Northstone et al., 2012). Furthermore, malnourished children often exhibit lower energy levels, apathy, insecure attachment, reduced attention capacity, and poorer social relationships. These developmental disadvantages may persist into later childhood and adulthood, influencing educational attainment, productivity, and overall well-being (Walker et al., 2007). Consequently, children who experience undernutrition are more likely to face learning difficulties, poorer school performance, higher dropout rates, and long-term cognitive and physical impairments (Gale et al., 2009; Prado & Dewey, 2014; Victora et al., 2008).

Globally, undernutrition is associated with nearly half of all deaths among children under the age of five, with the vast majority occurring in low- and middle-income countries (WHO, 2024). However, mortality represents only one dimension of the burden of malnutrition, as its effects often persist throughout the life course.

The following sections distinguish between the short-term and long-term consequences of child malnutrition.

3.4.1 Short term consequences

Early nutritional exposures influence physical growth, immune function, metabolic regulation, and brain development, with potential consequences that extend throughout the life course (Wells et al., 2019).

This phase is dominated by cell proliferation that establishes organ structure, in contrast to later growth stages driven mainly by cell enlargement (Winick & Noble, 1966). As a result, variations in early growth can lead to persistent differences in organ size and function (Crispi et al., 2018; Latini et al., 2004), and modulate hormonal systems involved in growth regulation, metabolism, and appetite control (Martin-Gronert & Ozanne, 2012).

The brain is particularly sensitive to nutritional and environmental influences during this period, undergoing rapid structural and functional development (Prado & Dewey, 2014) to the extent that early dietary experiences may also shape taste preferences and eating behaviors (De Cosmi et al., 2017).

This process requires adequate energy and nutrient intake and key nutrients include high-quality proteins, essential fatty acids, and micronutrients such as iron, iodine, zinc, vitamin A and thiamine, all of which are critical for cognitive development, immune function, and overall growth (Black et al., 2008, 2013; Prado & Dewey, 2014).

Good nutrition beginning in pregnancy is crucial for healthy child development. Fetal nutrition represents a critical period for brain development, and poor maternal nutrition and infections are important risk factors (Walker et al., 2007). Therefore, intrauterine growth restriction (IUGR) represents an early manifestation of malnutrition and often results from inadequate maternal nutrition during pregnancy (Sharma et al., 2016).

Low birth weight is associated with increased infant mortality (Jana et al., 2023; Vilanova et al., 2019) particularly due to infectious diseases and malnutrition during childhood (Aryastami et al., 2017; Xiao et al., 2010). It may also contribute to a vicious intergenerational cycle through the link between maternal and child nutritional status. In fact, maternal stature, reflecting both genetic and environmental influences during her childhood growth, has been associated with higher child mortality risk and increased likelihood of underweight, stunting and wasting in infancy and childhood (Black et al., 2013; Martorell & Young, 2012; Özaltin et al., 2010). Therefore, children suffering from conditions related to undernutrition are reported to have an higher risk of death from diarrhoea, pneumonia, measles, and other infectious diseases and deficiencies in vitamins and minerals (Black et al., 2013).

Beyond increasing the risk of illness and mortality, inadequate nutrition during early life can also compromise cognitive and neurological development. Northstone and collegues (2012) found that children who consumed diets high in processed foods, fats, and sugars at age three had lower IQ scores five years later. Similarly, another study reported that children following diets rich in fruits, vegetables, and home-prepared foods consistent with "infant guidelines" demonstrated higher full-scale and verbal IQ and better memory performance at age four (Gale et al., 2009).

Inadequate breastfeeding has important consequences for child mortality, morbidity, and development. Evidence shows that infants aged 0-5 months who are not exclusively breastfed face substantially higher risks of all-cause mortality and death from infectious diseases compared with exclusively breastfed infants, with protective effects extending beyond infancy (Sankar et al., 2015; WHO, 2000). Adequate breastfeeding has also been associated with lower rates of diarrhea, respiratory infections, and hospitalization (Horta &Victora, 2013). Beyond its effects on physical health, longer breastfeeding duration has been linked to improved cognitive development and higher cognitive function scores later in childhood and adolescence, even after accounting for socioeconomic and maternal characteristics (Gale, 2004; Horta, Loret de Mola, et al., 2015; Victora et al., 2016).

3.4.2 Long term consequences

The consequences of malnutrition extend far beyond childhood and may affect health, educational attainment, and socioeconomic outcomes throughout the life course. Poor growth can be interpreted as an adaptive biological response to nutritional scarcity, in which the body preserves vital functions by slowing linear growth and reallocating energy for survival. Despite its short-term adaptive value, extensive evidence shows that growth failure carries substantial long-term costs (Victora et al., 2008).

One of the most important consequences concerns human capital development. Children who experience undernutrition are more likely to perform poorly in school, leave education earlier, and achieve lower levels of educational attainment and productivity in adulthood (Victora et al., 2008). Adult height, often considered an indicator of early-life nutritional conditions, has also been associated with educational and economic outcomes later in life (Victora et al., 2010). More broadly, deficits in cognitive development acquired during childhood may persist into adulthood, limiting individuals' opportunities and earning potential (Black et al., 2008, 2013; Victora et al., 2008).

Malnutrition also has important implications for adult health. In populations undergoing rapid nutritional transitions, early undernutrition followed by rapid weight gain may increase the risk of overweight, obesity, cardiovascular diseases, and other metabolic disorders later in life (Baird et al., 2005; Shrimpton & Rokx, 2012). Evidence from low- and middle-income countries suggests that patterns of growth during childhood influence adult cardiometabolic outcomes. Adair and collegues (2013) found that higher birth weight and greater weight gain in infancy and childhood were associated with increased risks of adult overweight and, in some cases, higher blood pressure, while excessive weight gain later in childhood showed the strongest association with adult cardiometabolic risk.

Breastfeeding has likewise been linked to long-term benefits. Meta-analyses indicate that individuals who were breastfed are less likely to develop overweight, obesity, and type 2 diabetes later in life (Horta et al., 2015). In addition, a 30-year follow-up study in Brazil found that longer breastfeeding duration was associated with higher educational attainment, higher intelligence scores, and greater adult income, with much of the income advantage operating through improvements in cognitive development (Victora et al., 2015).

Finally, the consequences of malnutrition often extend across generations. Women who experienced poor nutritional conditions during childhood are more likely to have short stature and poorer health as adults, factors that increase the risk of adverse birth outcomes and undernutrition among their own children. In this way, malnutrition contributes to the persistence of intergenerational cycles of poor health, nutritional disadvantage, and socioeconomic inequality (Black et al., 2013; Martorell & Young, 2012).

3.4.3 The double burden of malnutrition

Although undernutrition and overnutrition are often treated as distinct nutritional problems, growing evidence suggests that undernutrition during critical stages of development may increase the risk of overweight and obesity later in life. This phenomenon, commonly referred to as the Double Burden of Malnutrition (DBM), describes the coexistence of undernutrition and overweight or obesity within individuals, households, or populations (Shrimpton & Rokx, 2012).

One explanation for this relationship is that nutritional deprivation during fetal development and early childhood may induce metabolic adaptations that favor energy conservation and rapid catch-up growth when food becomes more available. While these adaptations may increase survival under conditions of scarcity, they can also increase susceptibility to excess weight gain and metabolic disorders later in life. Evidence from the Dutch famine of 1944–1945 demonstrated that exposure to undernutrition during critical stages of prenatal development was associated with a higher risk of obesity in adulthood (Ravelli et al., 1976). Similarly, other studies have shown that children who experience intrauterine growth restriction and rapid catch-up growth are more likely to develop increased adiposity later in life (Baird et al., 2005; Ong et al., 2000).

However, evidence remains mixed, suggesting that the relationship between early undernutrition and later obesity may vary across populations and contexts (Said-Mohamed et al., 2012).

The double burden of malnutrition is particularly relevant in Guatemala. Despite reductions in child stunting over recent decades, overweight and obesity have increased, especially among women. National evidence indicates that more than one quarter of Guatemalan households simultaneously experience undernutrition and overweight or obesity among different household members. Furthermore, the coexistence of a stunted child and an overweight mother has been observed in approximately one fifth of households and is particularly common among Indigenous populations living in the western highlands (Ramirez-Zea et al., 2014).

These findings highlight that undernutrition and overnutrition should not be viewed as separate phenomena. Rather, they represent interconnected manifestations of malnutrition that can coexist within the same households and populations. This poses a major challenge for Guatemala, where persistent child undernutrition coexists with increasing levels of overweight and obesity, requiring integrated policy responses that address both forms of malnutrition simultaneously.

The literature reviewed in this chapter highlights the multifaceted nature of child malnutrition and the complex set of factors that shape nutritional outcomes. Drawing on the UNICEF conceptual framework (2021), the evidence demonstrates that child nutrition is influenced by a combination of immediate, underlying, and basic determinants operating at individual, household, community, and structural levels. Maternal education emerges as a consistent predictors of child nutritional status, influencing health knowledge, caregiving practices, healthcare utilization, and socioeconomic opportunities (Arriaza et al., 2022; Chowdhury et al., 2018). At the same time, economic conditions, ethnicity, geographic inequalities, dietary patterns, and access to adequate water and sanitation services contribute to persistent disparities in nutritional outcomes (Black et al., 2013; M. Chowdhury et al., 2018; Cristiano, 2022; Gracey & King, 2009; Jensen et al., 2016).

The literature also shows that the consequences of malnutrition extend well beyond childhood. Undernutrition can negatively affect physical growth, cognitive development, educational attainment, and adult health, while contributing to the persistence of intergenerational cycles of disadvantage (Victora et al., 2008, 2010). Furthermore, the coexistence of undernutrition and overweight increasingly characterizes many low- and middle-income countries, including Guatemala, highlighting the complexity of contemporary nutritional challenges (Shrimpton & Rokx, 2012).

Taken together, these findings provide the theoretical foundation for the empirical analysis presented in this thesis. They suggest that maternal education is likely to play a central role in shaping child nutritional outcomes, while its effects may vary across ethnic and geographical contexts and operate through multiple socioeconomic and household mechanisms. The following chapter describes the data, variables, and methodological approach used to examine these relationships in the Guatemalan context.

4. DATA & METHODS

This study is based on a secondary data analysis of the 2014–2015 Guatemala Demographic and Health Survey (DHS) and examines the relationship between maternal education and child nutritional status. The 2014–2015 survey represents the fifth DHS conducted in Guatemala since 1987 and corresponds to Phase VII of the DHS Program, with data structured according to the DHS Recode VI format. DHS surveys are nationally representative household surveys designed to provide data for monitoring and evaluating key indicators related to population, health, and nutrition. The DHS Program employs standardized questionnaires and methodologies to ensure cross-country comparability.

Data collection includes household and individual questionnaires, biomarker measurements, and geographic information. The core questionnaire gathers detailed information on women aged 15–49, including socio-demographic characteristics, reproductive histories, contraceptive knowledge and use, breastfeeding practices, child health and nutrition, and partner characteristics. The sampling strategy is based on a stratified two-stage cluster design to ensure representativeness at national, urban–rural, and regional levels. In the first stage, enumeration areas are selected from national census sampling frames. In the second stage, households are systematically sampled from updated household listings within each selected cluster. Further methodological details are available in the Guide to DHS Statistics (Croft et al., 2018).

The analysis presented in this thesis relies on the Children's Recode (KR) dataset, which contains one record for each child born in the five years preceding the survey to interviewed women aged 15–49. The unit of analysis is therefore children aged 0–59 months. Because the dataset is child-based, mothers may appear multiple times if they have more than one child under five years of age. This underlines a potential limitation of this analysis related to the hierarchical structure of the data (see *4.2.5 Sensitivity analysis: multilevel model*).

Sampling weights provided by the DHS were applied in all analyses to account for the survey design.

A total of 12,440 children were initially present in the dataset, corresponding to 9,542 mothers. Special codes (such as 9999, 998, 99.97, etc.), as defined in the DHS recode manual (USAID, 2013), were recoded as missing values. However, only children with valid data for at least one of the three anthropometric measures selected as dependent variables were retained. At the end of the first data cleaning process, no missing values were present in the three anthropometric indicators. Moreover, the variable related to maternal educational level did not present any missing values.

The final analytical sample consisted of **11,744 children** and **9,197 mothers.**

4.1 VARIABLES

4.1.1 Dependent variables

The dependent variables were constructed using three anthropometric indicators. Each child in the dataset had three separate z-scores calculated based on the 2006 WHO Child Growth Standards (Onis et al., 2006): weight-for-age (WAZ), height-for-age (HAZ), and weight-for-height (WHZ). The WHO Child Growth Standards provide an international reference for assessing child growth by comparing a child's anthropometric measurements with those of healthy children raised under optimal environmental and nutritional conditions. The resulting z-scores indicate how many standard deviations a child's measurement deviates from the WHO reference median, allowing the identification of different forms of malnutrition (Onis et al., 2006; WHO, 2006). Therefore, children were classified following the WHO classification of nutritional status of infants and children (WHO, 2017).

Moderately stunted, underweight, or wasted if their HAZ, WAZ, or WHZ scores were below −2 standard deviations from the WHO median, respectively. Severe forms of stunting, underweight, and wasting were defined as z-scores below −3 standard deviations.
Overweight and obesity—based on the same indicator as wasting but representing the upper tail of the distribution—were defined using WHZ scores above +2 and +3 standard deviations, respectively.
Normal nutritional status was defined as z-scores between −2 and +2 for all three indicators (see *Table 1*).

Table 1: Classification of the dependent variables

Nutritional Status	Indicator*	Cutoffs		
		Severe	**Moderate**	**Normal**
Stunting	Height-for-Age	-6 < z-score < −3	−3 ≤ z-score ≤ −2	-2 < z-score ≤ 2
Wasting	Weight-for-Height	-5 < z-score < −3	−3 ≤ z-score ≤ −2	-2 < z-score ≤ 2
Underweight	Weight-for-Age	-6 < z-score < −3	−3 ≤ z-score < −2	-2 ≤ z-score ≤ 2
Overweight/Obesity	Weight-for-Height	**Obese**	**Overweight**	**Normal**
		5 > z-score >3	3 ≥ z-score > 2	2 ≥ z-score > -2

*Children younger than 24 months were measured in the supine position (length), whereas older children were measured standing (height). Source: (Benedict et al., 2022; WHO, 2017).

Implausible values for HAZ, WHZ, and WAZ were excluded from the sample and coded as missing (NA) using the WHO-recommended flagging system (Benedict et al., 2022). Specifically, these values were defined as HAZ below −6 or above +6 standard deviations, WHZ below −5 or above +5 standard deviations, and WAZ below −6 or above +5 standard deviations.

Additionally, for HAZ and WAZ, observations above +2 standard deviations were recoded as missing, as these indicators are not appropriate for identifying overnutrition, which should be assessed exclusively using weight-for-height.
As a result, 14 observations were missing for the stunting outcome and 88 for the underweight outcome, while no missing values were observed for wasting or overweight/obesity.

To distinguish between different forms of malnutrition in the regression analysis, two separate variables were created for weight-for-height: one capturing wasting (including severe, moderate, and normal conditions) and another capturing overweight and obesity (including obese, overweight, and normal conditions).

4.1.2 Explanatory and control variables

Maternal educational attainment was used as the primary explanatory variable and was categorized by the DHS into four levels: no education, primary, secondary, and higher education. This is a country-specific variable; in Guatemala, the school system is structured as follows: primary education typically covers ages 7 to 12 (Grades 1–6), secondary education spans ages 13 to 17—including lower secondary (Grades 7–9) and upper secondary (Grades 10–11)—and tertiary education generally ranges from ages 18 to 22 (CIEN, 2019).

Control variables were selected based on prior literature and the UNICEF Conceptual Framework (2021), which provides a comprehensive overview of the determinants of maternal and child nutrition. This framework highlights the multidimensional nature of malnutrition, identifying immediate, underlying, and basic determinants. The present analysis focuses primarily on basic determinants, including resources and norms—such as environmental, financial, social, and human resources—as well as cultural factors that shape nutritional behaviors and outcomes. The variables included in the analysis are summarized in *Table 2.*

Table 2: Variables selected for the analysis

Exposure variable	Outcome variables	Confounders	Mediators
Maternal education	Stunting	Age child	Wealth index
	Wasting	Sex child	BMI mother
	Underweight	Age mother	Number of children
	Overweight/obesity	Ethnicity	Occupation of mother
		Religion	
		Type of residence	
		Region	
		Height of mother	

A range of **confounding variables** was included to account for factors that may influence both maternal education (the exposure) and child nutritional status (the outcome), but are not part of the causal pathway between them.

Child age is measured in months and ranges from 0 to 59 months (up to five years of age). **Child sex** is coded as male or female. **Maternal age** is recorded in years and therefore treated as a continuous variable in the regression models.

Ethnicity includes several categories: Maya, Ladina/Mestiza, Garífuna, Xinca, and Other, as well as responses such as "don't know." The two largest groups are Maya and Ladina/Mestiza, the latter referring to individuals who do not identify as belonging to an Indigenous group and are of mixed or non-Indigenous descent[2]. For analytical purposes, ethnicity was recoded into three categories: Maya, Ladino, and Other (including Garífuna, Xinca, other groups, and those who were unsure or did not know their ethnicity).

Religion was categorized into three main groups: no religion, Catholic, and Evangelical. A fourth category, "other," was created to include smaller religious groups such as Protestant denominations, Indigenous spirituality, Adventists, Jehovah's Witnesses, and others.

Type of residence was classified by the DHS as rural or urban based on country-specific definitions[3].

The DHS does not provide data at the level of specific administrative departments; instead, **regions** are grouped into broader macro-regions based on geographic location. These include Metropolitana, Nororiente, Central, Suroriente, Suroccidente, Noroccidente, Norte, and Petén (see *Map 1*)

Maternal height is measured in centimeters and was obtained by dividing the DHS variable by 10, as specified in the DHS recode manual (USAID, 2013).

Furthermore, a set of **mediator variables** was considered. These variables lie on the causal pathway between exposure and outcome, as they are partly influenced by maternal education and, in turn, affect child nutrition.

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[2] According to the Guatemalan Ministry of Education (MINEDUC, 2010), the Ladino population is characterized as heterogeneous, Spanish-speaking, and culturally influenced by both Hispanic and Indigenous elements.

[3] In Guatemala, urban areas include not only officially recognized cities, towns, and villages—such as departmental and municipal administrative centers—but also other types of settlements, including colonies, condominium developments, and populated places with more than 2,000 inhabitants. However, these areas are classified as urban only if they meet specific infrastructure criteria, namely that at least half of households have access to electricity and piped water within their homes. (International Labour Organization, n.d.).

The **wealth index** is a composite measure of household living standards provided in the DHS dataset. It is constructed using data on household asset ownership (e.g., televisions, bicycles), housing characteristics, and access to water and sanitation facilities. Households are classified into five quintiles, ranging from poorest to richest. Wealth may mediate the relationship between maternal education and child malnutrition because higher educational attainment is often associated with improved economic opportunities and household resources, which can influence food security, healthcare access, sanitation, and overall living conditions relevant to child growth and nutrition.

Map 1: Map of Guatemala divided into departments and regions

***Note**: Guatemala is divided into eight macro-regions corresponding to their geographical location within the country. Metropolitana corresponds to the department of Guatemala. Suroriente includes the departments of Jalapa, Jutiapa, and Santa Rosa, while Nororiente comprises Chiquimula, El Progreso, Zacapa, and Izabal. The Norte region includes Alta Verapaz and Baja Verapaz. Noroccidente consists of Quiché and Huehuetenango, whereas Suroccidente includes San Marcos, Totonicapán, Quetzaltenango, Sololá, Suchitepéquez, and Retalhuleu. The Central region comprises the departments of Escuintla, Sacatepéquez, and Chimaltenango. Finally, the Petén macro-region corresponds exclusively to the department of Petén.*

Body Mass Index (BMI) was calculated as maternal weight in kilograms divided by the square of height in meters (kg/m²). Since the DHS dataset stores BMI with two implied decimal places, values were divided by 100 to obtain the correct measure. BMI was then categorized into four groups: underweight (<18.5 kg/m²), normal weight (18.5–24.9 kg/m²), overweight (25–29.9 kg/m²), and obese (≥30 kg/m²). Maternal BMI may act as a mediator because maternal education can influence dietary habits, health knowledge, and access to nutrition and healthcare services, which in turn shape maternal and child nutritional status.

Despite the mathematical relationship between maternal height and BMI, both variables were retained in the model because they capture distinct dimensions of maternal nutritional status. Maternal height reflects long-term and intergenerational nutritional conditions (unlikely to be substantially modified by adult educational attainment), whereas BMI represents current nutritional status and body composition. Moreover, their simultaneous inclusion did not indicate substantial multicollinearity, as coefficient estimates and standard errors remained stable across model specifications (see Models 2 and Models 3).

Maternal occupation was recoded into a binary variable: “currently working” and “not currently working.” The former includes women employed in categories such as sales, services, clerical work, professional/technical/managerial roles, manual labor (skilled and unskilled), agriculture (self-employed), and other occupations. Those reporting not working were classified accordingly. Maternal occupation may mediate the association between education and child malnutrition because educational attainment influences women’s participation in the labor market and type of employment.

The variable “**number of children**” refers to the total number of children ever born to a mother. This variable may mediate the relationship between maternal education and child malnutrition because higher maternal education tends to be associated with lower fertility and improved family planning.

Missing values were generally not present in the selected variables, with the exception of maternal height and BMI. Missingness in these variables was primarily due to missing height data (coded as 9996), which also affected BMI calculation, resulting in the same number of missing observations for both variables, equal to 862.

Table 3 presents the descriptive characteristics of the sample stratified by maternal education. Frequencies and percentages are reported for categorical variables, while means and standard deviations are shown for continuous variables. P-values are based on survey-adjusted tests.

Table 3: Selected variables stratified by maternal education.

Variable	**Educational level**				
Stunting	No education	Primary	Secondary	Higher	**P-value**
Severe	645 (29.4%)	1136 (18.3%)	177 (5.9%)	12 (2.9%)	< 0.001
Moderate	826 (37.6%)	2018 (32.5%)	620 (20.7%)	67 (16.2%)	
Normal	724 (33%)	3052 (49.2%)	2193 (73.4%)	334 (80.8%)	
Total (NAs = 14)	2195 (100%)	6206 (100%)	2990 (100%)	413 (100%)	

Wasting	No education	Primary	Secondary	Higher	**P-value**
Severe	1 (0%)	10 (0.2%)	4 (0.1%)	0 (0%)	0.56
Moderate	17 (0.8%)	37 (0.6%)	21 (0.7%)	0 (0.1%)	
Normal	2086 (99.2%)	5910 (99.2%)	2791 (99.1%)	384 (99.9%)	
Total	2104 (100%)	5957 (100%)	2815 (100%)	384 (100%)	

Underweight	No education	Primary	Secondary	Higher	P-value
Severe	92 (4.2%)	117 (1.9%)	32 (1.1%)	3 (0.7%)	< 0.001
Moderate	364 (16.6%)	687 (11.1%)	174 (5.9%)	17 (4.2%)	
Normal	1738 (79.2%)	5389 (87%)	2741 (93%)	386 (95.1%)	
Total (NAs = 88)	2193 (100%)	6192 (100%)	2947 (100%)	406 (100%)	

Overweight/Obesity	No education	Primary	Secondary	Higher	P-value
Obese	16 (0.8%)	40 (0.6%)	42 (1.4%)	8 (2%)	< 0.001
Overweight	75 (3.4%)	213 (3.4%)	139 (4.7%)	22 (5.4%)	
Normal	2086 (95.8%)	5910 (95.9%)	2791 (93.9%)	384 (92.7%)	
Total	2178 (100%)	6163 (100%)	2972 (100%)	414 (100%)	

Age Child (months)	No education	Primary	Secondary	Higher	P-value
Mean (SD)	31.6 (17.5)	29.6 (16.9)	27.3 (17.1)	28.1 (17.2)	< 0.001

Sex Child	No education	Primary	Secondary	Higher	P-value
Male	1102 (50.2%)	3205 (51.6%)	1568 (52.3%)	224 (54.1%)	0.48
Female	1093 (49.8%)	3005 (48.4%)	1428 (47.7%)	190 (45.9%)	
Total	2195 (100%)	6210 (100%)	2996 (100%)	414 (100%)	

Age Mother (years)	No education	Primary	Secondary	Higher	P-value
Mean (SD)	31.3 (6.9)	27.4 (6.7)	25.7 (5.4)	29.7 (5.3)	< 0.001

Ethnicity	No education	Primary	Secondary	Higher	Pvalue
Ladina	642 (29.3%)	3116 (50.2%)	2185 (72.9%)	348 (83.9%)	< 2.2e-16
Maya	1526 (69.5%)	3031 (48.8%)	789 (26.3%)	65 (15.8%)	
Other	28 (1.3%)	63 (1%)	22 (0.7%)	1 (0.4%)	
Total	2195 (100%)	6210 (100%)	2996 (100%)	414 (100%)	

Religion	No education	Primary	Secondary	Higher	P-value
Catholic	894 (40.7%)	2697 (43.4%)	1313 (43.8%)	204 (49.3%)	< 0.001
Evangelical	1011 (46.1%)	2720 (43.8%)	1299 (43.3%)	162 (39%)	
No Religion	236 (10.8%)	734 (11.8%)	307 (10.2%)	31 (7.4%)	
Other	54 (2.5%)	59 (1%)	78 (2.6%)	18 (4.3%)	
Total	2195 (100%)	6210 (100%)	2996 (100%)	414 (100%)	

Type of residence	No education	Primary	Secondary	Higher	P-value
Rural	1746 (79.6%)	4563 (73.5%)	1231 (41.1%)	61 (14.8%)	< 0.001
Urban	449 (20.4%)	1646 (26.5%)	1765 (58.9%)	353 (85.2%)	
Total	2195 (100%)	6210 (100%)	2996 (100%)	414 (100%)	

Region	No education	Primary	Secondary	Higher	P-value
Metropolitana	116 (5.3%)	704 (11.3%)	852 (28.4%)	144 (34.8%)	< 0.001
Norte	407 (18.5%)	732 (11.8%)	187 (6.3%)	25 (6%)	
Nororiente	223 (10.1%)	547 (8.8%)	265 (8.9%)	36 (8.8%)	

Suroriente	154 (7%)	600 (9.7%)	264 (8.8%)	38 (9.1%)	
Central	145 (6.6%)	728 (11.7%)	353 (11.8%)	42 (10.1%)	
Suroccidente	424 (19.3%)	1603 (25.8%)	670 (22.4%)	93 (22.4%)	
Noroccidente	646 (29.4%)	1030 (16.6%)	278 (9.3%)	28 (6.6%)	
Petén	81 (3.7%)	266 (4.3%)	126 (4.2%)	9 (2.2%)	
Total (NAs = 862)	2195 (100%)	6210 (100%)	2996 (100%)	414 (100%)	

Height mother	No education	Primary	Secondary	Higher	**P-value**
Mean (SD) (NAs = 862)	145.7 (5.4)	147.8 (5.5)	151.0 (5.8)	153.1 (5.99)	< 0.001

Wealth index	No education	Primary	Secondary	Higher	**P-value**
Poorest	1170 (53.3%)	1805 (29.1%)	160 (5.3%)	1 (0.3%)	< 0.001
Poorer	583 (26.5%)	1745 (28.1%)	305 (10.2%)	3 (0.7%)	
Middle	313 (14.3%)	1450 (23.4%)	563 (18.8%)	15 (3.6%)	
Richer	105 (4.8%)	939 (15.1%)	1012 (33.8%)	63 (15.2%)	
Richest	25 (1.1%)	271 (4.4%)	956 (31.9%)	332 (80.2%)	
Total	2195 (100%)	6210 (100%)	2996 (100%)	414 (100%)	

BMI mother	No education	Primary	Secondary	Higher	**P-value**
Underweight	15 (0.7%)	85 (1.5%)	78 (2.8%)	4 (0.9%)	< 0.001
Normal	1036 (51.4%)	2821 (49.4%)	1262 (44.5%)	146 (36.3%)	
Overweight	695 (34.5%)	1848 (32.4%)	945 (33.3%)	160 (39.7%)	
Obese	270 (13.4%)	953 (16.7%)	548 (19.3%)	93 (23.1%)	
Total (NAs = 862)	2015 (100%)	5708 (100%)	2832 (100%)	403 (100%)	

Number of children	No education	Primary	Secondary	Higher	**P-value**
Mean (SD)	4.8 (2.6)	3.2 (2.0)	1.9 (1.0)	1.8 (0.9)	< 0.001

Occupation	No education	Primary	Secondary	Higher	**P-value**
Currently Working	612 (27.9%)	2020 (32.5%)	1393 (46.5%)	324 (78.2%)	< 0.001
Not Currently Working	1583 (72.1%)	4189 (67.5%)	1603 (53.5%)	90 (21.8%)	
Total	2195 (100%)	6210 (100%)	2996 (100%)	414 (100%)	

Note*: For categorical variables: n (%); for continuous variables: mean (SD). P-values are based on survey-adjusted tests.*

4.2 ORDERED LOGISTIC REGRESSION MODEL

To analyse the association between maternal education and child malnutrition, an ordered logistic regression model was estimated. The dependent variable Y_i represents the malnurished status (stunting, wasting, underweight and overweight/obesity) of child *i,* defined as an ordinal variable with three categories:

$$Y_i = \begin{cases} 0 & \text{Severe condition} \\ 1 & \text{Moderate condition} \\ 2 & \text{Normal condition} \end{cases} \quad \text{or} \quad Y_i = \begin{cases} 0 & \text{Obese condition} \\ 1 & \text{Overweight condition} \\ 2 & \text{Normal condition} \end{cases}$$

Given the ordered nature of the outcome, a proportional odds model was specified as follows:

$$[\log\left(\frac{P(Y_i > j)}{P(Y_i \le j)}\right) = \alpha_j + \beta_1 \text{Primary}_i + \beta_2 \text{Secondary}_i + \beta_3 \text{Higher}_i + \gamma Z_i + \delta M_i]$$

$for\ (j = 0, 1),\ where:$

- $P(Y_i > j)$ is the cumulative probability of being in category higher than j (i.e., better nutritional status);
- $P(Y_i \le j)$ is the cumulative probability of being in category j or lower (i.e., worse nutritional status);
- α_j are the threshold (cut-point) parameters separating adjacent categories;
- $\text{Primary}_i,\ \text{Secondary}_i,\ \text{Higher}_i$ are dummy variables for maternal education, with "no education" as the reference category;
- $\beta_1,\ \beta_2,\ \beta_3$ are the corresponding regression coefficients
- γZ_i represents a vector of confounding variables and the respective regression coefficients
- δM_i represents a set of potential mediators and the respective regression coefficients

The same model specification was applied separately to each nutritional indicator (stunting, wasting, underweight, and overweight/obesity). In *Model 1* only maternal education is included, *Model 2* adds confounders, and *Model 3* further incorporates mediators (see *4.2.2 Model-building strategy*).

A key assumption of the ordered logistic regression model is the proportional odds (or parallel lines) assumption. It implies that the effect of each explanatory variable is constant across all cumulative splits of the outcome variable. In other words, the relationship between maternal education and the odds of being in a higher versus lower nutritional category is assumed to be the same regardless of the threshold considered (e.g., severe vs. moderate/normal, and severe/moderate vs. normal). It is an important assumption because it allows the model to estimate a single coefficient for each explanatory variable, thereby simplifying interpretation.

4.2.1 Interpretation of coefficients and odds ratios

The coefficients of the ordered logistic regression model represent the effect of the explanatory variables on the log-odds of being in a higher (i.e., better) category of the outcome variable.

Given the model specification, which is expressed in terms of the cumulative probability of being above a certain category, positive coefficients indicate a higher likelihood of being in better nutritional status categories (e.g., normal rather than stunted), while negative coefficients indicate a higher likelihood of being in worse categories.

For ease of interpretation, results are presented as odds ratios (OR), obtained by exponentiating the estimated coefficients. An odds ratio greater than one (OR > 1) indicates that the variable is associated with higher odds of being in a better nutritional category, whereas an odds ratio lower than one (OR < 1) indicates higher odds of being in worse nutritional categories.

In this study, maternal education is included as a set of dummy variables, with "no education" as the reference category. Therefore, the estimated coefficients and corresponding odds ratios for primary, secondary, and higher education represent the relative change in the odds of being in a better nutritional status category compared to children of mothers with no education.

For example, an odds ratio greater than one for secondary or higher education indicates that children of more educated mothers have higher odds of being in a better nutritional category (e.g., normal), with the magnitude of the odds ratio reflecting the strength of the association. Under the proportional odds assumption, these effects are assumed to be constant across all thresholds of the outcome variable.

4.2.2 Model-building strategy

The regression analysis was structured in three sequential models for each dependent variable to disentangle the relationship between maternal education and child nutritional outcomes, and to distinguish between total and direct effects.

Model 1 includes only maternal education. This baseline specification captures the unadjusted association between education and child malnutrition, providing an estimate of the total effect without accounting for any other factors.

Model 2 introduces a set of confounders, defined as variables that are associated with both maternal education (the exposure) and child nutritional outcomes, but are not part of the causal pathway linking the two. Adjusting for these variables allows for a more accurate estimation of the relationship by reducing spurious associations due to confounding.

Model 3 further includes potential mediators. Mediators are variables that lie on the causal pathway between maternal education and child nutrition: they are partly influenced by education and, in turn, affect child nutritional outcomes. Controlling for these variables isolates the direct effect of maternal education, net of the selected pathways.

However, including mediators may introduce what is known as *overcontrol bias*, as part of the total effect of education operates precisely through these intermediary mechanisms. As a result, the coefficient for maternal education in Model 3 is expected to attenuate compared to previous models. This attenuation should not be interpreted as a reduction in the importance of education, but rather as evidence that part of its effect is transmitted through the mediating variables included in the model.

Comparing the coefficient of maternal education across the three models therefore provides insight into the mechanisms underlying the relationship. Specifically, differences between Model 2 and Model 3 can be interpreted as the portion of the education effect that operates through the included mediators.

All analyses are conducted in RStudio using the relevant survey and regression packages.

4.2.3 Adequacy of methods

4.2.3.1 Descriptive results

An initial bivariate and multiple descriptive analysis provides an overview of the relationship between maternal education and children's nutritional status. To assess the association between these variables, survey-adjusted chi-square tests were employed. This approach is appropriate because both maternal education and nutritional outcomes are categorical variables, and the objective is to examine whether the distribution of nutritional conditions differs across educational groups.

Alternative methods, such as analysis of variance (ANOVA), were not suitable in this context, as they require a continuous dependent variable and are designed to compare group means rather than category distributions. In contrast, the chi-square test evaluates whether the observed distribution across categories differs significantly from what would be expected under independence. Furthermore, the survey-adjusted version of the test accounts for the complex DHS sampling design, including stratification, clustering, and sampling weights, thereby ensuring valid statistical inference.

4.2.3.2 Regression results

The use of an ordered logistic regression is appropriate given the ordinal nature of the dependent variables, which classify child nutritional status into ordered categories reflecting increasing severity (e.g., severe, moderate, and normal). This approach allows for the simultaneous consideration of both the presence and the degree of malnutrition, which is central to the research question.

Alternative modelling strategies were considered. First, continuous anthropometric z-scores of the selected indicators (height-for-age, weight-for-age and weight-for-height) could be analysed using linear regression. However, this approach would not align with the World Health Organization classification framework (WHO, 2017), which defines clinically meaningful thresholds for nutritional status. Using continuous measures would also make the interpretation of results less intuitive from a public health perspective.

Second, binary logistic regression models could be used by collapsing the outcome into dichotomous categories (e.g., stunted vs. not stunted). However, this would result in a loss of information by ignoring differences in severity, which are substantively important for understanding the extent of malnutrition.

Third, multinomial logistic regression could be applied to model the categorical outcomes without imposing an ordering structure. Nevertheless, this approach does not exploit the natural ordering of the categories and would lead to less efficient estimates, as well as more complex interpretation.

In contrast, the ordered logistic regression model accounts for the ordinal structure of the outcome while preserving information on severity. It therefore represents a theoretically appropriate approach for analysing the relationship between maternal education and child nutritional status.

4.2.4 Assumption checks

Due to the use of survey-weighted estimation, formal tests of the proportional odds assumption (such as the Brant test) are not directly applicable. Therefore, the assumption was assessed by comparing parallel and non-parallel specifications in Model 1 (see *Table 4*). Overall, the estimated coefficients were largely consistent across thresholds, suggesting that the assumption holds reasonably well for most of the nutritional outcomes considered.

However, some variability across thresholds was observed for the wasting outcome, indicating a potential partial deviation from the proportional odds assumption. This variation may be partly explained by the relatively small number of observations in the severe and moderate wasting categories, which can lead to less stable estimates and greater sensitivity to model specification.

Given the limited sample size in these categories, the observed differences were not considered substantial enough to justify the use of a more complex modelling strategy. Therefore, the ordered logistic regression model was retained for consistency and comparability across outcomes. Nevertheless, results for wasting should be interpreted with some caution.

Table 4: Reported results of the assumption check. Comparison between parallel and non-parallel specifications in Model1 for each outcome variable

Stunting	Coef Non-parallel model		Coef Parallel model
Intercept1	0.87		0.87
Intercept2	-0.72		- 0.71
Primary	Primary1	0.61	0.66
	Primary2	0.68	
Secondary	Secondary1	1.88	1.73
	Secondary2	1.73	
Higher	Higher1	2.61	2.15
	Higher2	2.14	

Wasting	Coef Non-parallel model		Coef Parallel model
Intercept1	4.81		4.73
Intercept2	-7.98		-6.96
Primary	Primary1	0.24	0.36
	Primary2	1.57	
Secondary	Secondary1	0.09	0.18
	Secondary2	1.29	
Higher	Higher1	1.16	0.68
	Higher2	13.7	

Underweight	Coef Non-parallel model		Coef Parallel model
Intercept1	3.12		3.27
Intercept2	1.33		1.33
Primary	Primary1	0.82	0.57
	Primary2	0.56	
Secondary	Secondary1	1.39	1.25
	Secondary2	1.24	
Higher	Higher1	1.80	1.63
	Higher2	1.62	

Overweight/ Obesity	Coef Non-parallel model		Coef Parallel model
Intercept1	-3.12		-3.12
Intercept2	-3.33		-3.35
Primary	Primary1	-0.02	-0.02
	Primary2	0.00	
Secondary	Secondary1	0.39	0.38
	Secondary2	0.31	
Higher	Higher1	0.59	0.58
	Higher2	0.46	

4.2.5 Sensitivity analysis: multilevel model

The unit of analysis in this study is the child; however, some mothers contribute more than one child to the sample. Approximately 22% of the children included in the dataset have at least one sibling who is also represented in the survey, as the analytical sample comprises 11,744 children born to 9,197 mothers. Children born to the same mother are likely to share unobserved characteristics, including genetic factors, household environments, socioeconomic conditions, and maternal behaviours, which may generate correlation in nutritional outcomes among siblings. As a result, a proportion of the observations cannot be considered fully independent, and some degree of within-mother clustering may be present.

Although the DHS survey design accounts for clustering at the primary sampling unit (PSU) level, it does not explicitly address the additional dependence arising from the presence of multiple children belonging to the same mother.

To assess the robustness of the findings, a sensitivity analysis was conducted using a multilevel ordered logistic regression model for child stunting, the strongest nutritional outcome observed in the analysis. Specifically, a cumulative link mixed model (CLMM) with a random intercept at the mother level ((1 | caseid)) was estimated to account for the hierarchical structure of the data, with children nested within mothers. The random intercept allows the baseline probability of stunting to vary across mothers and captures unobserved family-level characteristics shared among siblings.

Because survey weights could not be incorporated into the multilevel specification due to software limitations, the model was estimated without weights and should be interpreted as a robustness check rather than as the primary analytical approach. As reported in the *Appendix*, the results of the multilevel model were broadly consistent with those obtained from the main survey-weighted analyses. The coefficients for primary, secondary, and higher education remained positive and of similar magnitude compared to the single-level ordered logistic models, indicating that the main findings are robust to the hierarchical structure of the data. The estimated mother-level variance was 0.85, corresponding to an intraclass correlation coefficient (ICC) of approximately 21%. This indicates that roughly one-fifth of the total variation in child stunting can be attributed to factors shared by children of the same mother, including common household and family characteristics.

Nevertheless, some caution remains warranted when interpreting the precision of the estimates, particularly for coefficients that are only marginally statistically significant.

5. RESULTS

5.1 DESCRIPTIVE RESULTS

5.1.1 Nutritional status of children

Children's nutritional status reveals important patterns, particularly with respect to chronic malnutrition. Stunting, measured through height-for-age z-scores (HAZ), presents a mean value of −1.89 (SE = 0.02), indicating that children in the sample are, on average, substantially shorter than the WHO reference population for their age (see *Table 5*). This suggests the widespread presence of chronic growth deficits within the population.

The prevalence of stunting is particularly high. Approximately 30.1% of children are moderately stunted, while 16.6% are severely stunted, meaning that nearly half of all children in the sample experience some form of stunting. According to WHO and UNICEF (2019) classifications, population-level stunting rates exceeding 30% are considered indicative of a "very high" public health burden, underlining the severity of chronic malnutrition in Guatemala. As a result, stunting can have serious consequences for children's cognitive and physical development, ultimately affecting the formation of future human capital and limiting individual capabilities.

Underweight status, measured through weight-for-age z-scores (WAZ), shows a mean value of −0.85 (SE = 0.01), indicating that children also tend to weight less for their age compared to the international reference population. Moderate underweight affects approximately 10.5% of children, while 2.0% are classified as severely underweight. Although underweight prevalence is substantially lower than stunting prevalence, the results still point to notable nutritional deficiencies among children.

Table 5: Prevalence of child malnutrition and distribution of anthropometric indicators

Child malnutrition				
Condition	**Severe** % (n)	**Moderate** % (n)	**Normal** % (n)	**Indicator** (mean, SE)
Stunting	16.6% (1970)	30.1 (3559)	53.1% (6275)	HFA (–1.89, 0.02)
Underweight	2.0% (243)	10.5% (1241)	87.3% (10253)	WFA (–0.85, 0.01)
Wasting	0.1% (14)	0.6% (76)	99.1% (11170)	WFH (0.34, 0.01)
	Obese % (n)	**Overweight** % (n)	**Normal** % (n)	**Indicator** (mean, SE)
Overweight/obesity	0.9% (106)	3.8% (448)	95.2% (11170)	WFH (0.34, 0.01)

Note: *Percentages were calculated within each nutritional condition; therefore, percentages for each condition sum to 100%. Anthropometric indicators are reported as z-scores (HFA = height-for-age, WFA = weight-for-age, and WFH = weight-for-height).*

In contrast, the mean weight-for-height z-score (WHZ) was 0.34 (SE = 0.01), a value that falls well within the normal range.

Acute malnutrition, measured through wasting conditions, is relatively uncommon in the sample, with less than 1% of children classified as moderately or severely wasted. This indicates that short-term nutritional deprivation is less widespread than chronic forms of malnutrition.

However, examining the upper tail of the weight-for-height distribution reveals emerging patterns of overnutrition. Approximately 3.8% of children are classified as overweight and 0.9% as obese. Although these proportions remain relatively low, they suggest the coexistence of undernutrition and overnutrition within the same population underlining the possible presence of the double burden of malnutrition in Guatemala.

5.1.2 Educational level of mothers

Maternal educational attainment remains relatively low within the studied population (see *Table 6*). The majority of mothers have completed only primary education, while approximately one quarter attained secondary education. Around 18% of mothers report having no formal education, whereas only a small proportion achieved higher education. These figures highlight important educational inequalities among women and suggest that a substantial share of children grow up in households where mothers possess limited formal schooling.

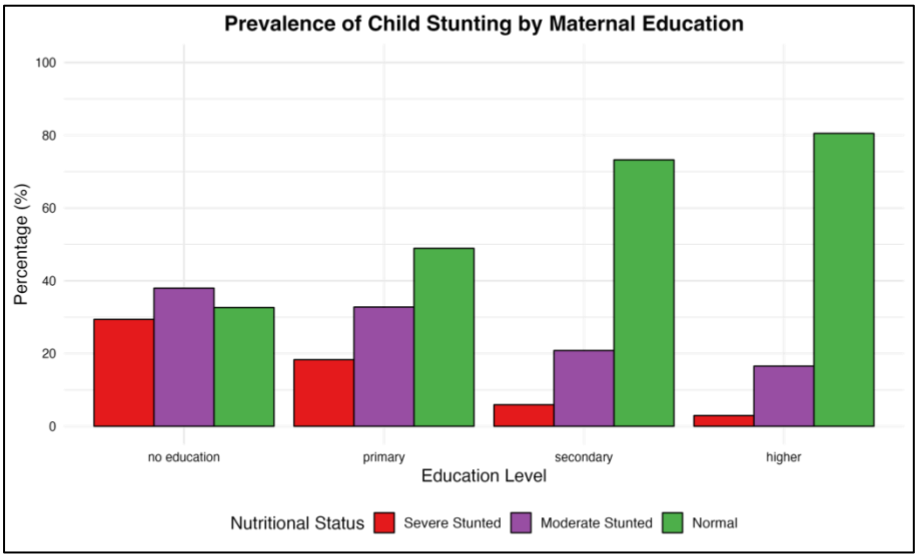
Table 6: Prevalence of educational level of mothers

Maternal education			
No education % (n)	**Primary** % (n)	**Secondary** % (n)	**Higher** % (n)
18.5% (2195)	52.5% (6209)	25.3% (2996)	3.5% (414)

5.1.3 Relationship between maternal education and child nutritional outcomes

With respect to stunting, a clear educational gradient emerges: higher levels of maternal education are associated with substantially improved child nutritional outcomes (see *Figure 2*). This association is highly statistically significant (F = 115.5; p-value < 0.001), indicating that the distribution of stunting differs markedly across educational groups. Among children of mothers with no formal education, the prevalence of both severe and moderate stunting is considerably higher compared to children of more educated mothers. In particular, moderate stunting represents the largest share among children of non-educated mothers (37.9%), even exceeding the proportion of children with normal status (32.6%). As maternal education increases, the prevalence of both severe and moderate stunting declines steadily, while the proportion of children with normal nutritional status rises substantially. The most pronounced improvement is observed between primary and secondary maternal education, where both severe and moderate stunting decrease sharply: severe stunting declines from 18.2% to 5.9%, while moderate stunting decreases from 32.7% to 22.8%. Overall, these findings underline the important protective role of maternal education, particularly secondary education, in reducing chronic child malnutrition.

Figure 2: Distribution of child stunting outcomes across maternal education level

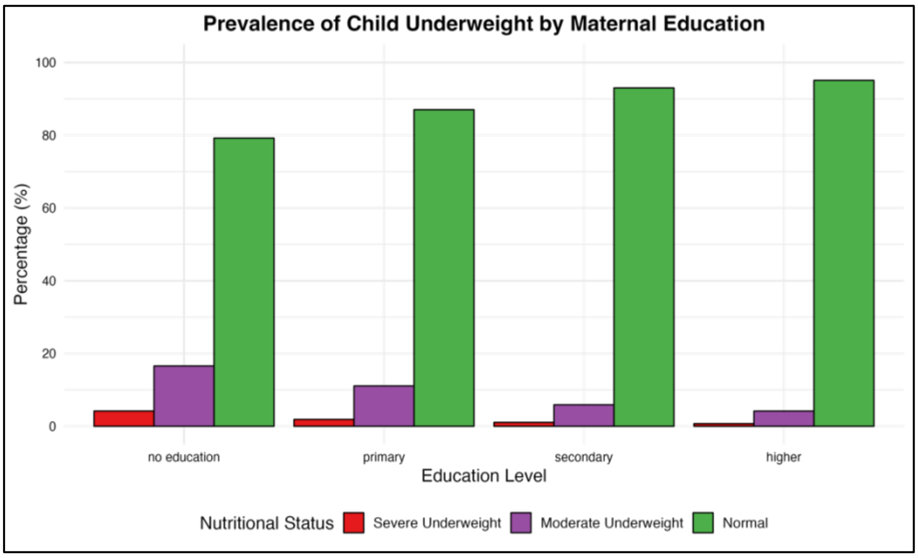


__Note__: The figure presents the percentage distribution of children across severe stunting, moderate stunting, and normal nutritional status categories according to maternal educational attainment. Stunting status is measured using height-for-age anthropometric indicators. Percentages are calculated within each maternal education category. See Table3 for the full table.

A similar pattern is observed for underweight status, although the overall prevalence of underweight conditions is substantially lower than that of stunting (see *Figure 3*). Across all educational groups, moderate underweight conditions are more common than severe conditions, yet both decline progressively with increasing maternal education. Children of mothers with no education display the highest prevalence of severe and moderate underweight

(4.1% and 16.5%, respectively), whereas children of secondary- and higher-educated mothers exhibit considerably lower levels. In particular, a pronounced reduction in moderate underweight is observed between children of non-educated mothers and those whose mothers attained secondary education, with the proportion decreasing by 10.6 percentage points. The association between maternal education and underweight is also highly statistically significant (F = 29.07, p-value < 0.001), further supporting the presence of a strong educational gradient in child nutritional outcomes.

Figure 3: Distribution of child underweight outcomes across maternal education levels

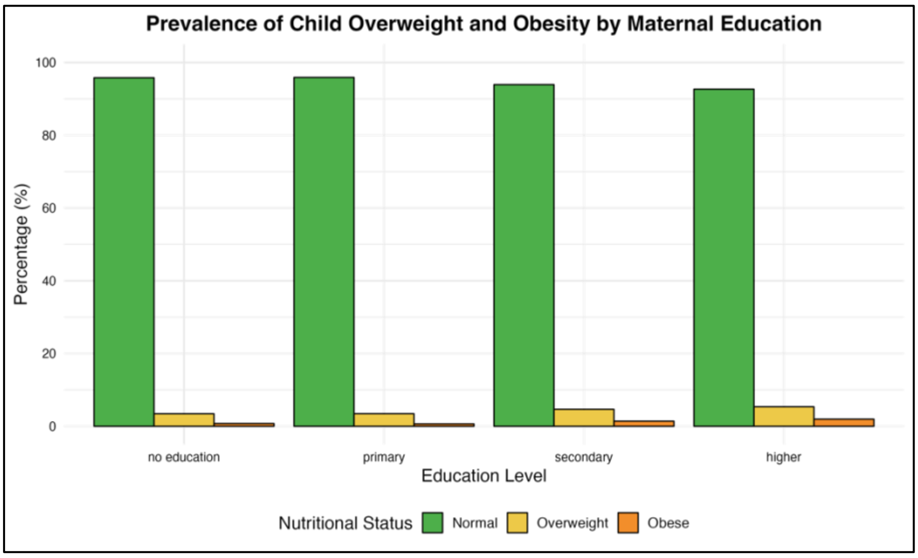


***Note**: The figure presents the percentage distribution of children across severe underweight, moderate underweight, and normal nutritional status categories according to maternal educational attainment. Underweight status is measured using weight-for-age anthropometric indicators. Percentages are calculated within each maternal education category. See Table3 for the full table.*

In contrast, the relationship between maternal education and wasting does not appear to be statistically significant (F = 0.62, p-value = 0.680). This result is likely explained by the relatively small proportion of children experiencing moderate or severe wasting conditions within the sample. Indeed, the vast majority of children fall within the normal category, leaving limited variability across educational groups. Detailed distributions are reported in *Table 3*.
Given the absence of a statistically significant association between maternal education and wasting, this condition will receive less emphasis in the subsequent analysis. Greater attention will instead be devoted to other conditions.

A different pattern emerges for overweight and obesity, where the association with maternal education is statistically significant (F = 4.09, p-value < 0.001). In this case, higher levels of maternal education are associated with a greater prevalence of overweight and obesity among children (see *Figure 4*). Although the overall prevalence of these conditions remains relatively low in the population, differences across educational groups are observable. Overweight conditions are present among children of mothers with no or primary education, but become more frequent among children of secondary- and higher-educated mothers. This suggests that children of more educated mothers may be increasingly exposed to nutritional and lifestyle changes associated with obesogenic enviroments. This pattern is consistent with the early stages of the obesity transition, in which overweight and obesity initially become more prevalent among higher socioeconomic groups (Jaacks et al., 2019). As countries undergo economic development and urbanization, wealthier and more educated households are often the first to experience shifts toward more energy-dense diets, increased consumption of processed foods, and more sedentary lifestyles.

Figure 4: Distribution of child underweight outcomes across maternal education levels



***Note**: The figure presents the percentage distribution of children across obese, overweight and normal nutritional status categories according to maternal educational attainment. Stunting status is measured using weight-for-height anthropometric indicators. Percentages are calculated within each maternal education category. See Table3 for the full table.*

Taken together, these findings indicate that maternal education is strongly associated reductions in undernutrition, particularly stunting and underweight, while at the same time being linked to a higher likelihood of overweight and obesity. This pattern reflects the coexistence of undernutrition and overnutrition within the same population, highlighting the relevance of the double burden of malnutrition in Guatemala. More broadly, these results suggest that improvements in educational attainment do not automatically translate into uniformly healthier nutritional outcomes. Instead, it may simultaneously reduce traditional forms of deprivation while increasing exposure to dietary and lifestyle changes associated with the nutritional transition, thereby generating new forms of nutritional risk within the population.

5.1.4 Subgroup analysis

An intersectional perspective is essential when analysing child malnutrition in Guatemala, as different forms of social disadvantage often overlap and may produce distinct nutritional outcomes. Maternal education is a key determinant of child health; however, its effects may vary according to broader structural and contextual factors such as ethnicity, place of residence, region of provenience. Examining these subgroup differences is therefore important to understand whether the educational gradient in child nutrition is equally distributed across the population or whether some groups remain disproportionately disadvantaged despite educational improvements.

5.1.4.1 Subgroup analysis - Ethnicity

Ethnicity represents a particularly important dimension in the Guatemalan context. Indigenous Maya populations constitute a large share of the national population and continue to experience substantial social and economic disadvantages rooted in long-standing historical exclusion, discrimination, and unequal access to healthcare, education, infrastructure, and economic opportunities (UNHCR, 2018). Moreover, many Indigenous communities are concentrated in rural and geographically isolated areas, where poverty and food insecurity remain especially severe. For these reasons, the relationship between maternal education and child nutritional outcomes may differ across ethnic groups[4].

Stunting

The results in *Table 7* show a clear and statistically significant education gradient in child malnutrition in both Ladina and Maya populations (Ladina: F = 47.862, p-value < 0.001; Maya: F = 27.759, p-value < 0.001). In both ethnic groups, higher maternal education is consistently associated with a lower prevalence of severe and moderate malnutrition and a higher proportion of children in normal nutritional status. However, important differences emerge between the two ethnic groups.

Table 7: Prevalence of stunting condition according to ethnic group

	Ladina % (n)			**Maya** % (n)		
	Severe	**Moderate**	**Normal**	**Severe**	**Moderate**	**Normal**
No education	21.1% (136)	36.0% (231)	42.9% (275)	32.8% (501)	38.9% (593)	28.3% (432)
Primary	11.7% (363)	28.1% (876)	60.2% (1875)	25.0% (756)	37.6% (1138)	37.5% (1135)
Secondary	4.1% (89)	17.4% (380)	78.5% (1711)	11.1% (88)	30.3% (239)	58.6% (463)
Higher	2.7% (9)	15.8% (55)	81.6% (283)	4.5% (3)	20.9% (14)	74.5% (49)
	F = 47.862, p-value < 0.001			F = 27.759, p-value < 0.001		

Note: *Percentages were measured within each maternal education level for each ethnic group.*

At all levels of maternal education, Maya children exhibit higher levels of malnutrition compared to Ladina children. For example, among mothers with no education, severe malnutrition is substantially higher among Maya children (32.8%) than among Ladina children (21.1%). Even among highly educated mothers, disparities persist, with Maya children still showing a higher prevalence of severe malnutrition (4.5%) compared to Ladina children

[4] Only Maya and Ladina ethnicity were taken into consideration for this analysis.

(2.7%). These patterns indicate that, although maternal education plays a strong protective role in both groups, it does not fully eliminate ethnic disparities in child nutritional outcomes. However, the protective effect of education appears to be slightly stronger among the Maya population, as the reduction in malnutrition prevalence between children of non-educated and highly educated mothers reaches 46.2 percentage points, compared to less than 40 percentage points among Ladina children. This underlines that, although Maya children continue to experience poorer stunting outcomes even at higher levels of maternal education, education nevertheless plays a crucial role in narrowing the nutritional gap between Maya and Ladina populations.

Underweight

In both ethnic groups, as maternal education increases, the prevalence of both severe and moderate malnutrition declines steadily, while the proportion of children with normal nutritional status rises (see *Table 8*). Despite these improvements, important differences between the groups persist. At lower levels of maternal education, Maya children exhibit slightly higher levels of underweight conditions compared to Ladina children, particularly in terms of moderate malnutrition (17.5% vs. 14.5% among those with no education). However, these disparities tend to narrow at higher levels of education, where both groups reach similarly low levels of malnutrition and high shares of normal nutritional status. In fact, among mothers with higher education, Maya children even display a slightly higher proportion of normal nutritional status compared to their Ladina counterparts. The Rao–Scott adjusted chi-square tests confirm that the association between maternal education and child nutritional status is statistically significant in both groups (Ladina: F = 9.48, p-value < 0.001; Maya: F = 14.28, p-value < 0.001).

Table 8: Prevalence of underweight condition according to ethnic group

	Ladina % (n)			**Maya** % (n)		
	Severe	**Moderate**	**Normal**	**Severe**	**Moderate**	**Normal**
No education	3.5% (22)	14.5% (93)	82.0% (526)	4.5% (68)	17.5% (266)	78.1% (1191)
Primary	1.5% (47)	10.3% (318)	88.2% (2737)	2.2% (65)	11.9% (360)	86.0% (2601)
Secondary	1.2% (26)	6.1% (130)	92.7% (1984)	0.7% (5)	5.6% (44)	93.7% (736)
Higher	0.9% (3)	4.6% (16)	94.5% (320)	0.0% (0)	2.0% (1)	98.0% (64)
	F = 9.4768, p-value < 0.001			F = 14.275, p-value < 0.001		

Note: *Percentages were measured within each maternal education level for each ethnic group.*

Nevertheless, these findings should be interpreted with caution, as the number of Maya children born to highly educated mothers is substantially smaller than in the Ladina population. The limited population size within this subgroup may therefore affect the stability and representativeness of the observed percentages.

Overall, these findings suggest that maternal education plays a strong protective role against child undernutrition across both ethnic groups. Moreover, the association appears particularly strong among the Maya population, where higher levels of maternal education seem to contribute to narrowing ethnic disparities in child nutritional outcomes.

Overweight/obesity

When examining overweight and obesity in *Table 9*, the relationship with maternal education appears markedly different compared to undernutrition. Among Ladina children, there is evidence of a modest but statistically significant gradient ($F = 3.65$; p-value < 0.001), with the prevalence of overweight and obesity increasing as maternal education rises. Specifically, the share of children classified as overweight increases from 3.0% among those with no maternal education to 5.6% among those with higher education, while obesity rises from 0.6% to 2.2%. At the same time, the proportion of children with normal weight declines slightly from 96.3% to 92.1%.

In contrast, no statistically significant association is observed among Maya children ($F = 0.39$; p-value $= 0.85$). The distribution of nutritional status remains relatively stable across all education levels, with the vast majority of children consistently classified as normal weight and only minor variations in overweight and obesity rates.

Comparing the two groups, a notable divergence emerges: while higher maternal education is associated with an increased prevalence of overweight and obesity among Ladina children, no such gradient is observed among Maya children. This suggests that the obesity transition may be more advanced among the Ladina population, where higher socioeconomic status is linked to a shift towards overnutrition. In contrast, Maya children do not exhibit the same pattern, indicating that structural or cultural factors may limit the emergence of overweight and obesity even at higher levels of maternal education.

Table 9: Prevalence of overweight and obesity condition according to ethnic group

	Urban % (n)			**Rural** % (n)		
	Severe	**Moderate**	**Normal**	**Severe**	**Moderate**	**Normal**
No education	96.3% (616)	3.0% (19)	0.6% (4)	95.6% (1445)	3.5% (54)	0.8% (12)
Primary	95.8% (2953)	3.5% (109)	0.7% (21)	96.1% (2900)	3.3% (100)	0.6% (17)
Secondary	93.2% (2016)	5.2% (113)	1.6% (34)	95.9% (755)	3.0% (24)	1.1% (8)
Higher	92.1% (319)	5.6% (20)	2.2% (8)	96.3% (63)	3.1% (2)	0.6% (0)
	$F = 3.6499$, p-value < 0.01			$F = 0.39472$, p-value $= 0.85$		

Note: *Percentages were measured within each maternal education level for each type of residence.*

5.1.4.2 Subgroup Analysis - Type of residence: rural and urban areas

Place of residence constitutes another important dimension through which inequalities in child nutritional outcomes may emerge. In Guatemala, rural and urban areas differ substantially in terms of infrastructure, healthcare accessibility, sanitation, educational opportunities, labour market conditions, and food availability (Monroy-Valle et al., 2025; Pons, 2012; UNHCR, 2018). Rural populations are generally more exposed to poverty, food insecurity, and limited access to public services, all of which can negatively affect child nutrition. Moreover, rural areas in Guatemala are disproportionately populated by Indigenous communities, meaning that geographical and ethnic disadvantages often overlap (MSPAS et al., 2015; UNHCR, 2018). For this reason, it is important to examine whether the relationship between maternal education and child malnutrition differs between rural and urban settings, and whether maternal education is equally protective across different residential contexts.

Stunting

The results in *Table 10* reveal a strong and statistically significant education gradient in child stunting in both urban and rural areas, as confirmed by the Rao–Scott adjusted chi-square tests (urban: F = 36.92, p-value < 0.001; rural: F = 56.10, p-value < 0.001). In both contexts, higher maternal education is associated with a substantial reduction in the prevalence of severe and moderate stunting and a corresponding increase in the proportion of children with normal status.

However, important differences emerge between urban and rural areas. At all levels of maternal education, children living in rural areas exhibit higher levels of stunting compared to their urban counterparts. For example, among mothers with no education, severe stunting affects 31.2% of rural children compared to 22.2% of urban children, while the share of children with normal nutritional status is lower in rural areas (31.2% vs. 38.4%). This gap persists across education levels, although it narrows at higher levels of maternal education.

Table 10: Prevalence of stunting condition according to type of residence

	Urban % (n)			**Rural** % (n)		
	Severe	**Moderate**	**Normal**	**Severe**	**Moderate**	**Normal**
No education	22.2% (99)	39.5% (177)	38.4% (172)	31.2% (546)	37.6% (656)	31.2% (544)
Primary	13.4% (220)	30.3% (498)	56.4% (927)	20.1% (916)	33.7% (1537)	46.2% (2109)
Secondary	4.5% (78)	18.6% (327)	77.0% (1354)	8.0% (99)	24.1% (296)	67.9% (835)
Higher	3.2% (11)	16.8% (59)	80.0% (281)	1.2% (1)	15.0% (9)	83.7% (51)
	F = 36.917, p-value < 0.001			F = 56.101, p-value < 0.001		

Note: *Percentages were measured within each maternal education level for each type of residence.*

The education gradient appears steeper in rural areas, where improvements in maternal education are associated with larger gains in child nutritional outcomes. For instance, the share of children with normal status increases from 31.2% to 83.7% across education levels in rural areas, compared to an increase from 38.4% to 80.0% in urban areas. This suggests that maternal education may play an even more critical role in improving child nutrition in more disadvantaged rural settings.

Underweight

The results indicate a clear and statistically significant educational gradient in both urban and rural areas as observed in *Table 11* (urban: $F = 9.62$, p-value < 0.001; rural: $F = 17.36$, p-value < 0.001). At lower levels of maternal education, children living in rural areas display slightly higher levels of severe undernutrition compared to children in urban areas.

However, as maternal education increases, these marginal disparities progressively narrow. The prevalence of both severe and moderate underweight declines steadily across educational categories in both settings, while the proportion of children with normal nutritional status increases. Among children of highly educated mothers, severe underweight is almost entirely absent in both urban and rural areas.

These findings suggest that maternal education exerts a strong protective effect against underweight irrespective of place of residence. Compared to stunting, the differences between urban and rural areas appear almost absent, indicating that underweight conditions may be less strongly determined by long-term structural and territorial inequalities. Instead, the results suggest that improvements associated with maternal education (such as better childcare practices, nutritional knowledge, healthcare utilization, and household resource management) may contribute relatively uniformly across both urban and rural settings.

Table 11: Prevalence of underweight condition according to type of residence

	Urban % (n)			**Rural** % (n)		
	Severe	**Moderate**	**Normal**	**Severe**	**Moderate**	**Normal**
No education	2.6% (12)	17.0% (76)	80.3% (360)	4.6% (80)	16.5% (287)	78.9% (1378)
Primary	1.8% (30)	9.1% (149)	89.1% (1460)	1.9% (87)	11.8% (537)	86.3% (3928)
Secondary	1.1% (18)	5.3% (91)	93.7% (1620)	1.1% (14)	6.8% (83)	92.1% (1122)
Higher	0.8% (3)	4.3% (15)	95.0% (328)	0.5% (0)	3.6% (2)	95.9% (58)
	F = 9.6217, p-value < 0.001			F = 17.363, p-value < 0.001		

Note*: Percentages were measured within each maternal education level for each type of residence.*

Overweight/Obesity

In urban settings, there is a modest but statistically significant relationship ($F = 2.73$, p-value < 0.05), with the prevalence of overweight and obesity increasing as maternal education rises (see *Table 12*). Specifically, the share of overweight children increases from 2.7% among those with no maternal education to 6.0% among those with higher education, while obesity rises from 0.8% to 2.1%. This suggests that overweight and obesity are more closely associated with urban environments, where children, particularly those born to highly educated mothers, are more exposed to dietary changes, processed foods, and increasingly sedentary lifestyles characteristic of the nutritional transition.

In contrast, no statistically significant association is observed in rural areas (F = 1.14, p-value = 0.33). The distribution of nutritional status remains relatively stable across education levels, with the vast majority of children classified as normal weight and only minor variations in overweight and obesity rates. Children from secondary educated mothers present the highest share of overweight condition compared to other educational statuses. Notably, even among children of highly educated mothers, overweight and obesity remain low in rural areas.

Table 12: Prevalence of overweight/obesity condition according to type of residence

	Urban % (n)			**Rural** % (n)		
	Normal	**Overweight**	**Obese**	**Normal**	**Overweight**	**Obese**
No education	96.5% (431)	2.7% (12)	0.8% (4)	95.6% (1655)	3.6% (63)	0.7% (13)
Primary	96.1% (1567)	3.3% (53)	0.7% (11)	95.8% (4343)	3.5% (160)	0.6% (29)
Secondary	93.5% (1634)	5.0% (87)	1.5% (26)	94.5% (1157)	4.2% (52)	1.3% (16)
Higher	91.9% (324)	6.0% (21)	2.1% (7)	97.0% (59)	1.9% (1)	1.1% (1)
	F = 2.7329, p-value < 0.05			F = 1.1413, p-value = 0.33		

Note: *Percentages were measured within each maternal education level for each type of residence.*

5.1.4.3 Subgroup Analysis - Regional differences

Regional disparities are also highly relevant in the Guatemalan context, as nutritional conditions vary considerably across departments and macro-regions of the country. Guatemala is characterized by strong territorial inequalities linked to differences in economic development, healthcare provision, agricultural productivity, infrastructure, levels of urbanization, and ethnic composition (UNHCR, 2018). Certain regions, particularly those with larger Indigenous and rural populations, have historically experienced higher degrees of disadvantage. Analysing regional differences therefore allows for a more nuanced understanding of how the association between maternal education and child nutrition may vary across distinct geographical contexts within the country.

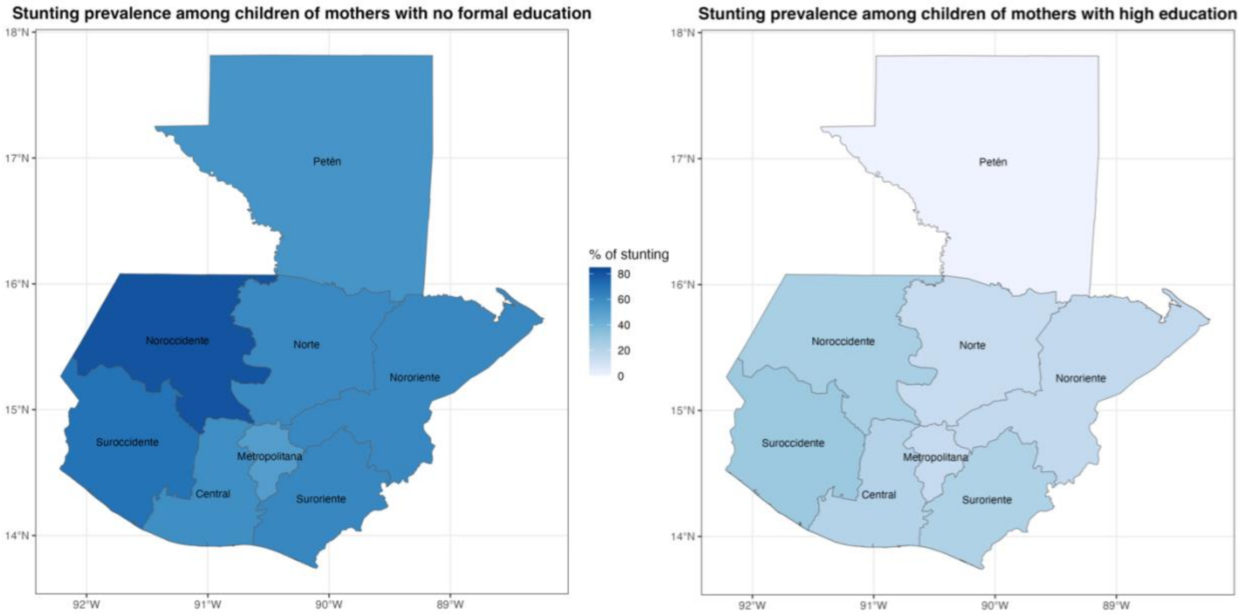
Stunting

Marked regional differences emerge in the relationship between maternal education and child stunting across Guatemala, highlighting that the association between education and nutritional outcomes is strongly shaped by the regional context. Although higher maternal education is consistently associated with lower levels of stunting in all regions, the magnitude of this improvement varies substantially across the country. Sample sizes, percentages, and test statistics are reported in the *Appendix*

The most disadvantaged nutritional profiles are concentrated in the western regions, particularly Noroccidente and Suroccidente, where stunting remains highly prevalent even among children of mothers with some level of education. Within primary educated mothers, 20.2% of children suffer from severe stunting condition in Suroccidente while it reaches 31.1% in Noroccidente.

In these regions, only secondary and higher levels of maternal education are associated with substantial improvements in nutritional conditions, suggesting that lower levels of schooling may not be sufficient to face the issue.

Map 2: Contrasting regional patterns of child stunting by maternal education level (no formal vs high education)



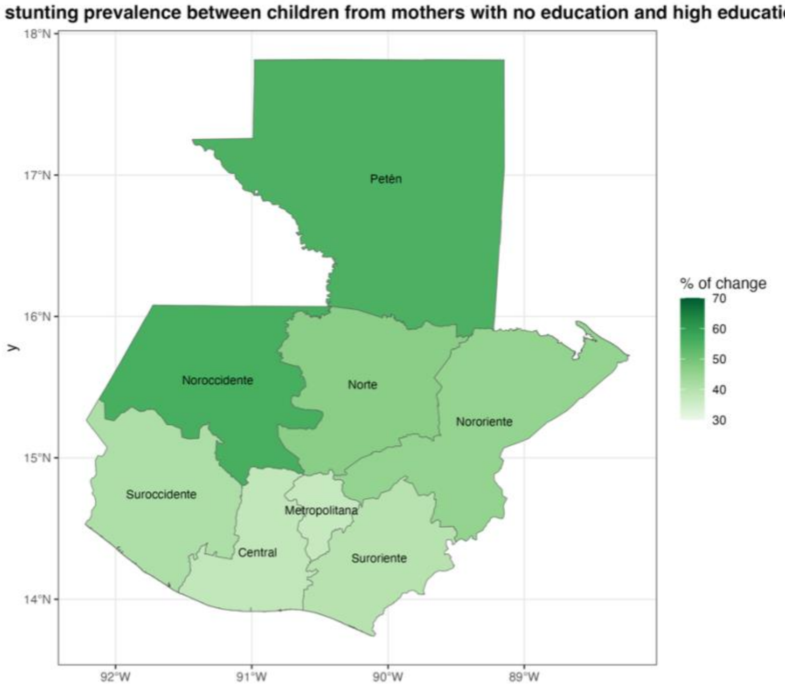
Note: *The maps display the prevalence of child stunting across Guatemala's eight macro-regions among children whose mothers have no formal education (left panel) and higher education (right panel). Stunting prevalence in each region is calculated as the proportion of children experiencing either moderate or severe stunting (100% − normal nutritional status). Darker shades indicate higher prevalence of stunting, while lighter shades indicate lower prevalence. The figure illustrates both regional disparities in child malnutrition and the differences in stunting prevalence associated with maternal educational attainment.*

Patterns are visible in *Map 2*, where Noroccidente and Suroccidente display the darkest shades linked to higher shares of stunting conditions, not only among children of non-educated mothers, but also among those whose mothers have higher educational attainment. Even at high levels of maternal education, these regions continue to exhibit substantially worse nutritional outcomes compared to other areas of the country.

At the same time, *Map 3* highlights the strong protective role of education, particularly in Noroccidente, which shows one of the largest reductions in stunting prevalence between children of non-educated and highly educated mothers.

Nevertheless, despite this substantial improvement, the nutritional conditions observed in these western regions do not converge to the levels reached in more economically developed regions such as Metropolitana or Norte. Even among children of highly educated mothers, stunting prevalence in Noroccidente and Suroccidente remains approximately 10 percentage points higher than in the best-performing regions.

Map 3: Change in child stunting prevalence between children of mothers with no formal education and higher education



Note: *The map displays the percentage-point reduction in child stunting prevalence between children whose mothers have no formal education and those whose mothers have higher education across Guatemala's eight macro-regions. Stunting prevalence in each region is calculated as the proportion of children experiencing either moderate or severe stunting (100% − normal nutritional status). Darker shades indicate larger reductions in stunting prevalence associated with higher maternal education, while lighter shades indicate smaller reductions.*

In contrast, the Metropolitana region displayed considerably more favourable nutritional outcomes across all educational groups. Levels of stunting were consistently lower, even among children of mothers with limited educational attainment, suggesting that the broader urban and economically advantaged context of the region may reinforce the protective effect of maternal education on child nutrition. Greater access to healthcare services, sanitation, infrastructure, and employment opportunities likely contributes to these improved conditions.

Intermediate situations were observed in regions such as Central, Suroriente, Norte, and Nororiente. In these areas, maternal education remained strongly associated with improved nutritional outcomes, although baseline levels of stunting continued to be substantially higher than those observed in Metropolitana. This indicates that while education provides an important protective mechanism, regional socioeconomic and environmental conditions still play a significant role in shaping child nutritional status. Petén also exhibited comparatively lower levels of severe stunting overall and a pronounced educational gradient. However, the relatively small number of observations among highly educated mothers in this region limits the robustness of these results and calls for cautious interpretation.

Overall, the findings suggest that the protective effect of maternal education is not uniform across Guatemala. Although maternal education is associated with improved child nutritional outcomes in the western regions, these areas start from substantially higher levels of deprivation than other economically developed regions. As a result, even sizeable educational gains may translate into more limited improvements in absolute nutritional outcomes. This highlights that education alone has a crucial role, but it may not be sufficient to fully overcome the broader structural and territorial inequalities that continue to shape child chronic malnutrition outcomes across the country.

Overweight/obesity

Regional differences in the relationship between maternal education and childhood overweight/obesity appear substantially weaker and less consistent than those observed for stunting. Overall, the prevalence of overweight and obesity remained relatively low across all regions and educational groups, as shown in *Table 13*.

The clearest educational gradient emerged in Nororiente, where the proportion of overweight and obese children increased with maternal education. Among children of mothers with no education, the vast majority were classified as normal weight and virtually no cases of obesity were observed. In contrast, among children whose mothers had higher educational attainment, the prevalence of overweight and obesity increased noticeably. The association was statistically significant (p-value < 0.001), suggesting that in this region higher maternal education may be linked to nutritional transitions associated with greater access to calorie-dense foods, dietary changes, and more sedentary lifestyles. Given the simultaneously high prevalence of stunting in the region—particularly among children of non-educated mothers—Nororiente appears to represent a context in which the double burden of malnutrition is clearly observable.

A similar, although less pronounced, pattern was observed in Metropolitana, where overweight and obesity were more common among children of mothers with secondary and higher education. However, the overall association was not statistically significant (p-value = 0.30), likely reflecting the relatively small number of overweight and obese cases within the sample.

In contrast to the patterns observed for stunting, western regions such as Suroccidente and Noroccidente did not display strong or consistent educational gradients. In Suroccidente, despite the presence of a statistically significant association (p-value < 0.05), children of highly educated mothers showed only slightly higher levels of overweight and obesity, while the overall prevalence remained relatively stable across educational groups. Noroccidente, on the other hand, did not present a statistically significant relationship and showed no clear educational gradient. This contrasts sharply with the severe stunting inequalities previously identified in these same regions and suggests that chronic undernutrition continues to represent the dominant nutritional challenge, while overweight and obesity remain comparatively limited phenomena.

Table 13: Prevalence of overweight and obesity condition according to region

	Metropolitana % (n)			Nororiente % (n)		
	Normal	**Overweight**	**Obese**	**Normal**	**Overweight**	**Obese**
No education	98.9% (114)	0.0% (0)	1.1% (1)	97.6% (215)	2.2% (5)	0.2% (0)
Primary	96.0% (668)	3.2% (22)	0.7% (5)	95.1% (515)	4.1% (22)	0.9% (5)
Secondary	92.8% (781)	5.3% (45)	1.9% (16)	91.8% (242)	4.6% (12)	3.6% (9)
Higher	93.0% (134)	5.2% (7)	1.8% (3)	87.9% (31)	8.2% (3)	3.9% (1)
	F = 1.2097, p-value = 0.30			F = 5.229, p-value < 0.001		

	Central % (n)			Suroriente % (n)		
	Normal	**Overweight**	**Obese**	**Normal**	**Overweight**	**Obese**
No education	96.5% (139)	3.5% (5)	0.0% (0)	95.1% (146)	4.5% (7)	0.4% (1)
Primary	94.8% (684)	4.2% (31)	0.9% (7)	95.7% (569)	3.5% (21)	0.8% (5)
Secondary	94.0% (328)	5.5% (19)	0.5% (2)	90.9% (238)	6.8% (18)	2.2% (6)
Higher	95.1% (40)	4.9% (2)	0.0% (0)	96.2% (36)	1.6% (1)	2.2% (1)
	F = 0.48917, p-value = 0.77			F = 2.2747, p-value < 0.05		

	Suroccidente % (n)			Noroccidente % (n)		
	Normal	**Overweight**	**Obese**	**Normal**	**Overweight**	**Obese**
No education	96.0% (406)	3.1% (13)	0.9% (4)	94.2% (604)	4.4% (28)	1.4% (9)
Primary	96.4% (1530)	3.1% (49)	0.5% (8)	95.5% (982)	4.0% (41)	0.5% (5)
Secondary	94.8% (631)	4.3% (28)	0.9% (6)	96.3% (268)	3.7% (10)	0.0% (0)
Higher	89.0% (83)	8.7% (8)	2.3% (2)	100.0% (28)	0.0% (0)	0.0% (0)
	F = 2.2217, p-value < 0.05			F = 0.6675, p-value = 0.63		

	Norte % (n)			Petén % (n)		
	Normal	**Overweight**	**Obese**	**Normal**	**Overweight**	**Obese**
No education	95.7% (383)	3.9% (16)	0.4% (1)	98.7% (79)	1.3% (1)	0.0% (0)
Primary	96.5% (703)	2.9% (21)	0.6% (5)	97.5% (259)	2.3% (6)	0.2% (1)
Secondary	97.2% (182)	1.1% (2)	1.7% (3)	96.9% (122)	3.1% (4)	0.0% (0)
Higher	93.6% (23)	1.9% (0)	4.4% (1)	93.1% (8)	6.9% (1)	0.0% (0)
	F = 1.5411, p-value = 0.17			F = 0.26632, p-value = 0.90		

Note: *Percentages were measured within each maternal education level for each region.*

In Central, Norte, and Petén, prevalence levels were generally low and differences across educational categories were relatively small, with no statistically significant associations observed.

Overall, excess weight-for-height appears to emerge more selectively in specific regional and socioeconomic contexts, particularly among children of more educated mothers and in more urbanized or economically advantaged regions. These findings reflect the coexistence of different forms of malnutrition across Guatemala, where chronic undernutrition remains predominant in poorer and historically disadvantaged areas, while overweight and obesity emerge alongside processes of urbanization, economic development, and nutritional transition.

Tables showing the prevalence of underweight and wasting by region are provided in the Appendix.

Overall, the subgroup analyses reveal that the relationship between maternal education and child nutritional outcomes is not uniform across the population but varies according to ethnicity, place of residence, and regional context. Although higher maternal education is consistently associated with better nutritional outcomes, important structural disparities persist across social groups. Indigenous Maya children, rural households, and children living in historically disadvantaged western regions continue to experience substantially higher levels of undernutrition, even at similar educational levels. At the same time, patterns of overweight and obesity tend to emerge more clearly among children of more educated mothers, particularly in more urbanized and socioeconomically advantaged settings, suggesting the coexistence of different forms of malnutrition within the country. These findings suggest that socioeconomic improvement and educational advancement may simultaneously reduce traditional forms of deprivation while increasing exposure to new nutritional risks associated with dietary change, urbanization, and sedentary lifestyles.

Furthermore, the results indicate that in more disadvantaged regions, substantial improvements in child nutritional status often become visible only at secondary (or higher) levels of maternal education, suggesting that lower levels of schooling may be insufficient to overcome entrenched structural disadvantages.

The descriptive subgroup analysis therefore provides important insights into the heterogeneity of the education–nutrition relationship; however it does not allow for the isolation of the independent effect of maternal education from other correlated demographic, socioeconomic, and contextual factors.

For this reason, the next section turns to multivariate regression analysis to more rigorously assess the association between maternal education and child nutritional outcomes while controlling for relevant covariates.

5.2 REGRESSION RESULTS

5.2.1 Model 1

Model 1 shows the relationship between maternal education and child malnutrition variables.

5.2.1.1 Stunting – Model 1

Model 1 for stunting condition evaluates the relationship between maternal education and children's stunting status using an ordered logistic regression model. The results in *Table 14* indicate that maternal education is strongly and positively associated with improved child nutritional outcomes. All education categories are statistically significant at p-value < 0.001, showing that the observed associations are highly unlikely to have occurred by chance. In addition, the relatively small standard errors indicate that the estimates are precise and stable.

Table 14: Ordered logistic regression estimates for child stunting – Model 1

Model1 – Stunting					
Variables	**Coef**	**OR**	**SE**	**95% CI**	**P-value**
Reference category: No education					
Intercept 1	0.87	2.38	0.07	2.06 – 2.76	< 0.001
Intercept 2	-0.71	0.48	0.06	0.43 – 0.55	< 0.001
Primary	0.66	1.93	0.06	1.70 – 2.20	< 0.001
Secondary	1.73	5.69	0.08	4.84 – 6.68	< 0.001
Higher	2.15	8.66	0.15	6.33 – 11.84	< 0.001

Using mothers with no formal education as the reference category, children whose mothers had primary education were almost twice as likely to belong to a better stunting category (OR = 1.94; p-value < 0.001). This suggests that even a basic level of maternal education contributes positively to child growth and nutritional status.

The association becomes substantially stronger at higher educational levels. Children of mothers with secondary education had 5.69 times higher odds of being in a better nutritional category compared with children of uneducated mothers (p-value < 0.001). Likewise, children whose mothers attained higher education had the strongest advantage, with 8.66 times greater odds of improved stunting status (p-value < 0.001).

These findings reveal a clear educational gradient, whereby increasing levels of maternal education are associated with progressively lower severity of stunting and a higher likelihood of normal height-for-age status.

5.2.1.2 Underweight – Model 1

Similar to the relationship observed for stunting, maternal education also shows a positive and statistically significant association with children's underweight status (see *Table 15*). The results indicate that increasing levels of maternal education are associated with progressively better nutritional outcomes among children, confirming the important role of education in reducing child malnutrition.

Table 15: Ordered logistic regression estimates for child underweight – Model 1

Model1 - Underweight					
Variables	**Coef**	**OR**	**SE**	**95% CI**	**P-value**
Reference category: No education					
Intercept 1	3.27	26.43	0.11	21.17 – 33.0	< 0.001
Intercept 2	1.33	3.78	0.08	3.23 – 4.43	< 0.001
Primary	0.57	1.77	0.08	1.49 – 2.10	< 0.001
Secondary	1.25	3.51	0.11	2.78 – 4.43	< 0.001
Higher	1.63	5.12	0.25	3.08 – 8.51	< 0.001

Compared with children whose mothers had no formal education, children of mothers with primary education were significantly more likely to belong to a healthier nutritional category. In particular, they had approximately 1.7 times higher odds (p-value < 0.001) of improved weight-for-age status. The association became even stronger among children whose mothers attained secondary education, with the odds increasing to more than three times those of children whose mothers had no education (OR = 3.51; p-value < 0.001). The strongest effect was observed among children of highly educated mothers, who were more than five times as likely to fall into a better underweight category (OR = 5.12; p-value < 0.001).

However, compared with the results for stunting, the magnitude of the association is somewhat smaller but still, the model reinforces the idea that maternal education is a key determinant of child health and nutrition.

5.2.1.3 Wasting – Model 1

In contrast to the results observed for stunting and underweight, the relationship between maternal education and wasting shown in *Table 16* appears much weaker and less consistent. Although the direction of the association generally suggests better nutritional outcomes among children of more educated mothers, most of the estimated effects were not statistically significant. This suggests that, unlike stunting and underweight, wasting may not be substantially influenced by maternal education alone.

Only higher education showed a positive association with wasting status (OR = 3.34, p-value = 0.08), with children of highly educated mothers having more than three times the odds of being in a healthier nutritional category. However, this result was only marginally significant, as reflected by the relatively high p-value and the wide confidence interval. The large confidence interval also indicates lower precision in the estimate.

Table 16: Ordered logistic regression estimates for child wasting – Model 1

Model1 – Wasting					
Variables	**Coef**	**OR**	**SE**	**95% CI**	**P-value**
Reference category: No education					
Intercept 1	6.63	762.90	0.39	355.1 – 1639.0	< 0.001
Intercept 2	4.77	117.94	0.30	65.41 – 212.6	< 0.001
Primary	0.05	1.05	0.35	0.52 – 2.10	0.87
Secondary	-0.01	0.98	0.39	0.45 – 2.14	0.96
Higher	1.20	3.34	0.69	0.85 – 13.12	0.08

Given the absence of statistically significant relationships, wasting was not included in the subsequent Model 2 and Model 3. This decision suggests that maternal education alone did not provide sufficient explanatory power for variations in wasting status within the study population.

5.2.1.4 Overweight/Obesity – Model 1

Unlike the patterns observed for stunting and underweight, the relationship between maternal education and childhood overweight/obesity observed in *Table 17* shows a different and somewhat reversed trend. The results suggest that higher levels of maternal education are associated with lower odds of children being in the normal nutritional category and, consequently, a greater likelihood of overweight or obesity.

Table 17: Ordered logistic regression estimates for child overweight and obesity – Model 1

Model1 – Overweight/Obesity					
Variables	**Coef**	**OR**	**SE**	**95% CI**	**P-value**
Reference category: No education					
Intercept 1	4.82	124.30	0.16	89.98 – 171.7	< 0.001
Intercept 2	3.13	22.88	0.13	17.7 – 29.57	< 0.001
Primary	0.02	1.02	0.15	0.76 – 1.37	0.87
Secondary	-0.39	0.67	0.15	0.49 – 0.92	< 0.05
Higher	-0.59	0.54	0.22	0.35 – 0.85	< 0.01

Children whose mothers had primary education did not differ significantly from those whose mothers had no formal education in terms of overweight or obesity status (OR = 1.02; p-value = 0.87). The odds ratio was close to 1 and the association was not statistically significant, indicating that primary education alone was not related to meaningful differences in children's risk of overweight or obesity.

However, a different pattern emerged for higher educational levels. Children of mothers with secondary education had significantly lower odds (OR = 0.67; p-value < 0.05) of being in a healthier nutritional category compared with children of mothers without education. Similarly, children whose mothers had higher education showed an even stronger reduction in the odds of normal nutritional status (OR = 0.54; p-value < 0.01). These findings indicate that overweight and obesity become more common among children of more educated mothers.

Therefore, while maternal education appears to reduce the risk of chronic and acute undernutrition, it may simultaneously be associated with emerging risks related to overweight and obesity. These findings are in line with the descriptive results and highlight the double burden of malnutrition, where undernutrition and overnutrition in children coexist within the same population and are, to some extent, shaped by contrasting educational dynamics.

5.2.2 Model 2

Model 2 extended the baseline specification by introducing a set of potential confounding variables, including child characteristics (age and sex), maternal characteristics (age, ethnicity, religion, and height), and household and contextual factors (place of residence and region). These variables were included because they are associated both with maternal education and with child nutritional outcomes and could therefore partially explain the relationship observed in the unadjusted model. By controlling for these factors, Model 2 provides a more accurate estimate of the independent association between maternal education and child malnutrition. Detailed and complete model results are reported in the *Appendix*.

5.2.2.1 Stunting — Model 2

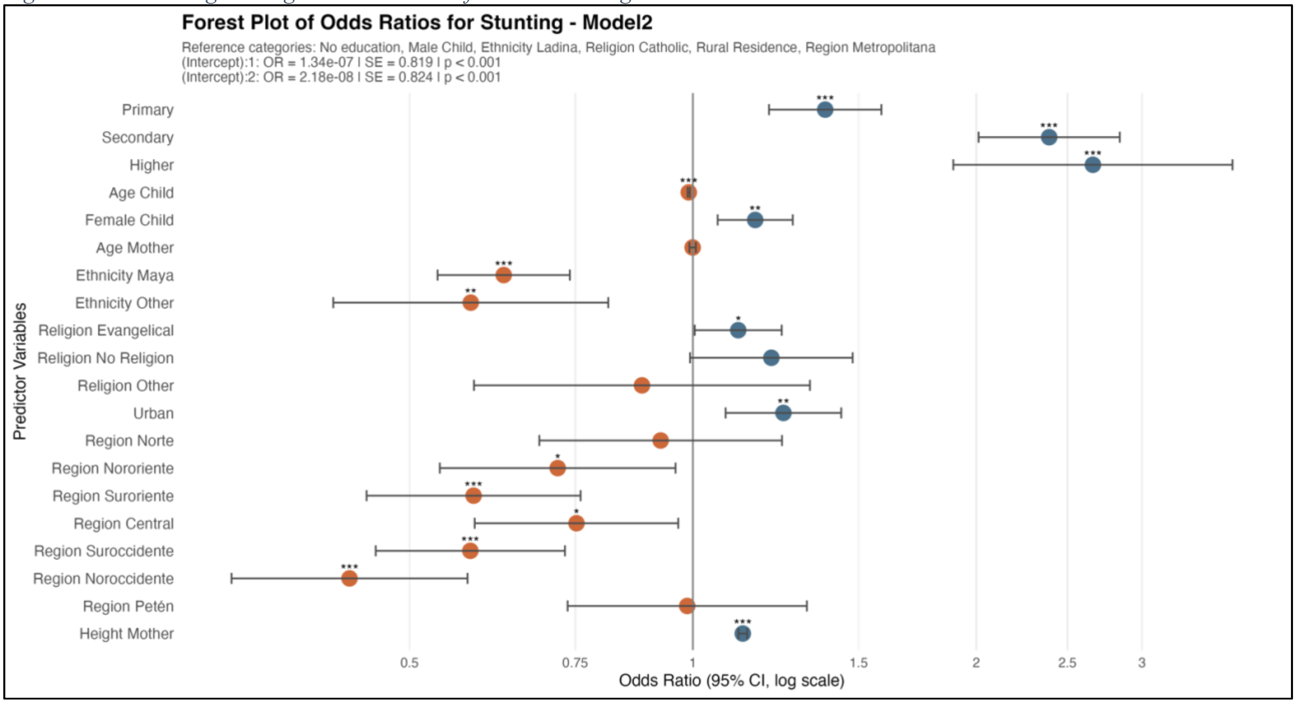
After adjusting for confounding variables, maternal education remained strongly and significantly associated with children's stunting status, although the magnitude of the coefficients was attenuated compared to the unadjusted model (see *Figure 5*). Children of mothers with primary education had 38% higher odds of being in a better nutritional category compared to children of mothers with no education (OR = 1.38; p-value < 0.001). The odds increased for secondary education (OR = 2.39; p-value < 0.001) and higher education (OR = 2.66; p-value < 0.001). In particular, the transition from primary to secondary education represents the most pronounced improvement, suggesting that completing secondary schooling may play a crucial role in reducing the risk of child stunting.

The reduction in effect sizes relative to Model 1 suggests that part of the educational gradient in stunting is explained by socioeconomic and demographic characteristics correlated with maternal education. Nevertheless, the persistence of statistically significant associations indicates that maternal education exerts an independent effect on chronic child malnutrition beyond these confounding factors.

Among the control variables, maternal height emerged as one of the significant predictors of stunting (OR = 1.13, p < 0.001), indicating that taller mothers were substantially more likely to have children in better height-for-age categories. Female children also showed slightly better nutritional outcomes than males (OR = 1.16, p < 0.001), while living in urban areas was associated with improved nutritional status as well (OR = 1.24, p < 0.01).

The region of residence also had a significant impact on children's nutritional outcomes. Compared to the reference region, Metropolitana, children living in other regions—particularly Noroccidente (OR = 0.43, p < 0.001), Suroccidente (OR = 0.58, p < 0.001), and Suroriente (OR = 0.58, p < 0.001)—showed significantly lower odds of being in better nutritional categories.

Figure 5: Ordered logistic regression estimates for child stunting – Model 2



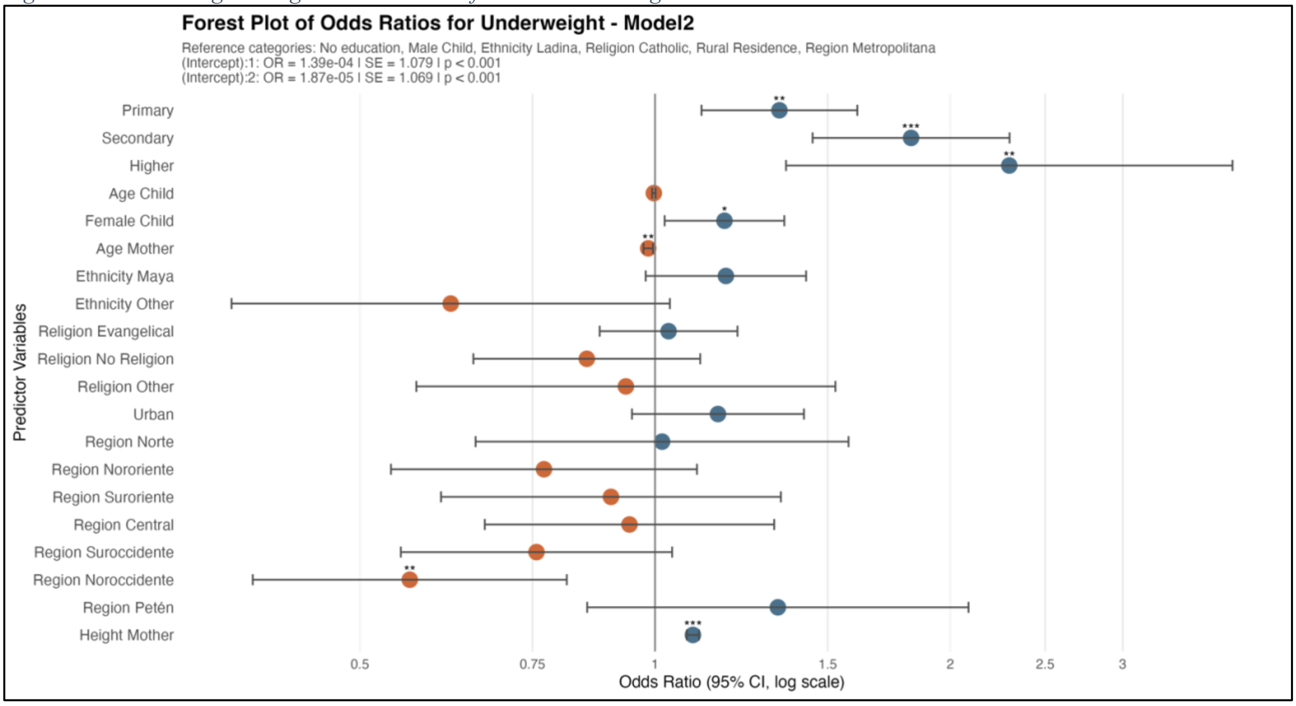
***Note**: Odds ratios (ORs) and 95% confidence intervals are reported from the survey-weighted ordered logistic regression model adjusted for selected confounding variables, including child age, child sex, maternal age, ethnicity, religion, type of residence, region, and maternal height. Colored dots represent odds ratios, while horizontal bars indicate 95% confidence intervals. Odds ratios above 1 (blue dots) indicate higher odds of being in a better nutritional category (i.e., a lower risk of stunting), whereas odds ratios below 1 (orange dots) indicate lower odds of favorable nutritional outcomes. The reference categories are: no maternal education, male child, Ladina ethnicity, Catholic religion, rural residence, and Metropolitana region. Statistical significance is indicated as follows: *** p < 0.001, ** p < 0.01, * p < 0.05. Complete Model 2 estimates are reported in the Appendix*

5.2.2.2 Underweight — Model 2

Maternal education remained significantly associated with underweight status after controlling for confounding variables, although the magnitude of the effects decreased compared to the baseline model (see *Figure 6*). Children of mothers with primary education had 34% higher odds of being in a better nutritional category compared to children of mothers with no education (OR = 1.34; p-value < 0.001). The odds increased for secondary education (OR = 1.82; p-value < 0.001) and higher education (OR = 2.30; p-value < 0.001). These findings indicate that maternal education retains an independent protective association against underweight conditions even after accounting for demographic, maternal, and regional characteristics.

Maternal height again emerged as a predictor of improved nutritional outcomes (OR = 1.09, p-value < 0.001), while female children were more likely than males to be in better nutritional categories. Regional disparities also remained evident; however, only the coefficient for Noroccidente was statistically significant. Children living in this region exhibited significantly lower odds (OR = 0.56, p < 0.01) of being in better nutritional categories compared to those living in the reference region Metropolitana.

Figure 6: Ordered logistic regression estimates for child underweight — Model 2



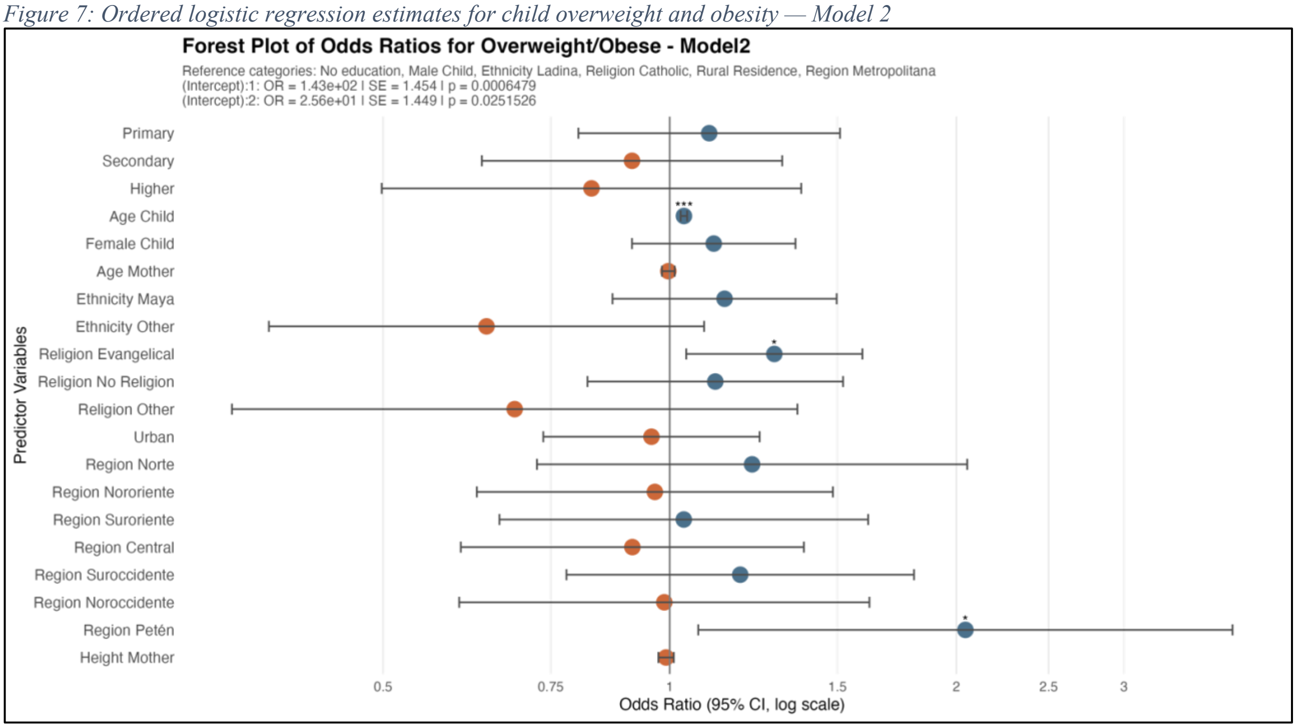
***Note**: Odds ratios (ORs) and 95% confidence intervals are reported from the survey-weighted ordered logistic regression model adjusted for selected confounding variables, including child age, child sex, maternal age, ethnicity, religion, type of residence, region, and maternal height. Colored dots represent odds ratios, while horizontal bars indicate 95% confidence intervals. Odds ratios above 1 (blue dots) indicate higher odds of being in a better nutritional category (i.e., a lower risk of stunting), whereas odds ratios below 1 (orange dots) indicate lower odds of favorable nutritional outcomes. The reference categories are: no maternal education, male child, Ladina ethnicity, Catholic religion, rural residence, and Metropolitana region. Statistical significance is indicated as follows: *** p < 0.001, ** p < 0.01, * p < 0.05. Complete Model 2 estimates are reported in the Appendix*

5.2.2.3 Overweight/obesity — Model 2

After adjusting for confounding variables, maternal education was no longer significantly associated with overweight and obesity outcomes (see *Figure 7*). Nevertheless, secondary and higher levels of maternal education still showed odds ratios below 1, suggesting a higher likelihood of children being in worse nutritional conditions, such as overweight or obesity, compared to children whose mothers had no formal education. However, the coefficients for primary education (OR = 1.10, p-value = 0.554), secondary education (OR = 0.91, p-value = 0.623), and higher education (OR = 0.83, p-value = 0.465) were all statistically non-significant. These results suggest that the association observed in the unadjusted model was largely explained by demographic and socioeconomic characteristics correlated with maternal education rather than by education itself.

Among the control variables, child age (OR = 1.03, $p < 0.001$), Evangelical religion (OR = 1.28, $p < 0.05$), and residence in the Petén region (OR = 2.04, $p < 0.05$) were the only factors positively and significantly associated with overweight and obesity status. Overall, the findings suggest that childhood overweight and obesity are shaped by a more complex set of contextual and behavioural factors that extend beyond maternal education alone.

Figure 7: Ordered logistic regression estimates for child overweight and obesity — Model 2



***Note**: Odds ratios (ORs) and 95% confidence intervals are reported from the survey-weighted ordered logistic regression model adjusted for selected confounding variables, including child age, child sex, maternal age, ethnicity, religion, type of residence, region, and maternal height. Colored dots represent odds ratios, while horizontal bars indicate 95% confidence intervals. Odds ratios above 1 (blue dots) indicate higher odds of being in a better nutritional category (i.e., a lower risk of stunting), whereas odds ratios below 1 (orange dots) indicate lower odds of favorable nutritional outcomes. The reference categories are: no maternal education, male child, Ladina ethnicity, Catholic religion, rural residence, and Metropolitana region. Statistical significance is indicated as follows: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Complete Model 2 estimates are reported in the Appendix.*

5.2.3 Model 3

Model 3 extends the regression analysis by including additional variables that are treated as potential mediators. These are variables that may lie on the causal pathway between maternal education and child nutritional outcomes: they are partly influenced by maternal education and, in turn, may affect children's nutritional status. By controlling for these mediating factors, the model aims to isolate the direct effect of maternal education, net of the pathways captured by the included variables. The coefficients for maternal education in Model 3 are expected to attenuate compared to previous models. This reduction does not imply a weaker role of education, but rather indicates that part of its effect on child nutrition is mediated through the variables included in the model. Detailed and complete model results are reported in the *Appendix*.

5.2.3.1 Stunting – Model 3

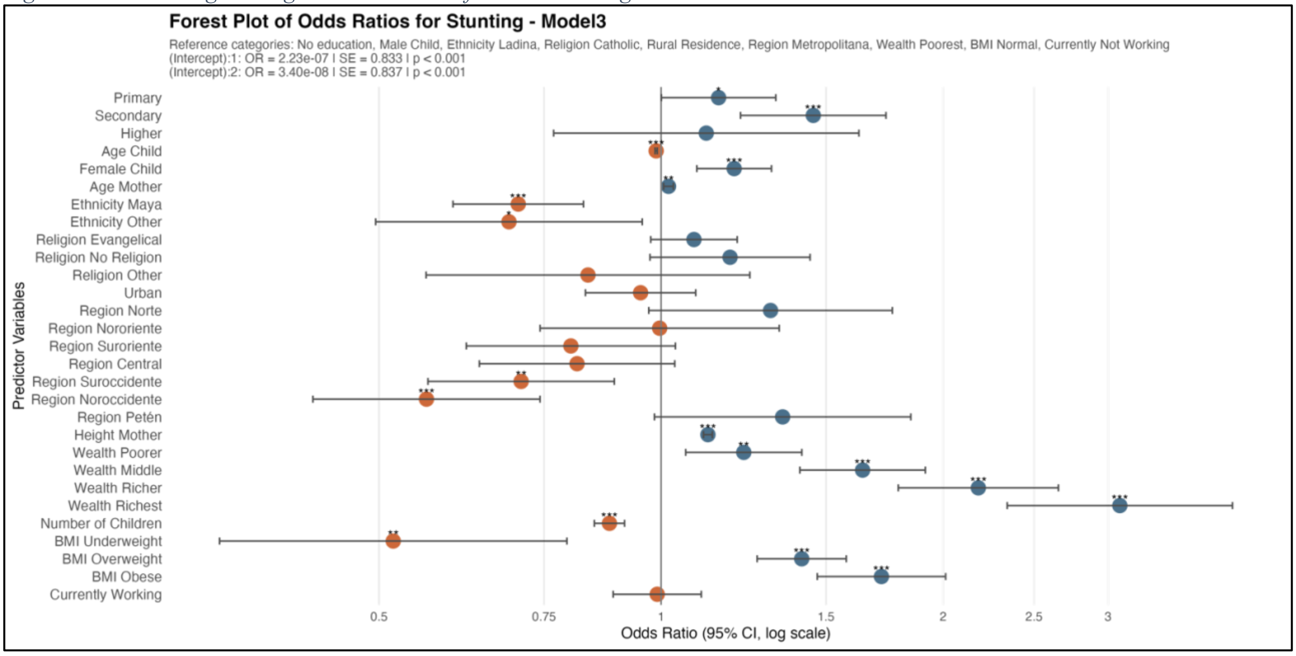
When mediating variables are taken into account, children's stunting conditions appear to be influenced by a broader set of socioeconomic and demographic factors (see *Figure 8*). In this model, only primary and secondary maternal education remain statistically significant, both showing a positive association with children's nutritional outcomes. Mothers with primary education have 15% higher odds of having children in better nutritional categories compared to mothers with no formal education (OR = 1.15, p-value < 0.05), although with lower statistical significance. The effect is stronger for secondary education: children of mothers who completed secondary schooling have 45% higher odds of being in better nutritional categories (OR = 1.45, p-value < 0.001). Higher education also shows a positive relationship, but the coefficient is no longer statistically significant (OR = 1.11; p-value = 0.56).

These coefficients suggest that the effect of maternal education on stunting is attenuated compared to Model 2, indicating that part of the influence of education operates through other socioeconomic and demographic factors that, in turn, affect children's height-for-age outcomes. Nevertheless, the results continue to highlight the particularly important role of secondary education, consistent with both the descriptive findings and the previous models, where the largest improvement in nutritional outcomes was associated with the completion of secondary schooling.

The mediating variables included in Model 3 also display strong and significant associations with stunting. Children from the wealthiest households show progressively higher odds of being in better nutritional categories, reaching roughly 200% higher odds among the wealthiest quintile (OR = 3.08, p-value < 0.001) compared to the poorest quintile. In contrast, a higher number of children negatively affects nutritional outcomes, reducing the odds of being in a better nutritional category by 12% for each additional child (OR = 0.88, p-value < 0.001).

Maternal BMI also emerges as an important factor associated with child stunting outcomes. Compared to mothers with normal BMI, mothers who are overweight (OR = 1.41, p-value < 0.001) or obese (OR = 1.71, p-value < 0.001) present progressively higher odds of having children in better stunting categories, such as moderate or normal height-for-age status. In contrast, mothers classified as underweight (OR = 0.51, p-value < 0.01) tend to have children with worse nutritional outcomes, suggesting that maternal undernutrition may contribute to the intergenerational transmission of poor nutritional conditions. However, the confidence interval for the underweight BMI category is relatively wide, indicating greater variability and lower precision in the estimated effect. This is likely due to the relatively small proportion of mothers falling within the underweight category in the sample.

Figure 8: Ordered logistic regression estimates for child stunting — Model 3



Note: *Odds ratios (ORs) and 95% confidence intervals are reported from the survey-weighted ordered logistic regression model including both confounding and mediating variables. The model adjusts for child age, child sex, maternal age, ethnicity, religion, type of residence, region, maternal height, household wealth, maternal BMI, number of children, and maternal employment status. Colored dots represent odds ratios, while horizontal bars indicate 95% confidence intervals. Odds ratios above 1 (blue dots) indicate higher odds of being in a better nutritional category (i.e., a lower risk of stunting), whereas odds ratios below 1 (orange dots) indicate lower odds of favorable nutritional outcomes. The reference categories are: no maternal education, male child, Ladina ethnicity, Catholic religion, rural residence, Metropolitana region, poorest wealth category, normal maternal BMI, and not currently working. Statistical significance is indicated as follows: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Complete Model 3 estimates are reported in the Appendix*

Overall, the findings suggest that while maternal education remains an important determinant of child stunting conditions, part of its effect is mediated through household economic conditions, family composition, and maternal nutritional status.

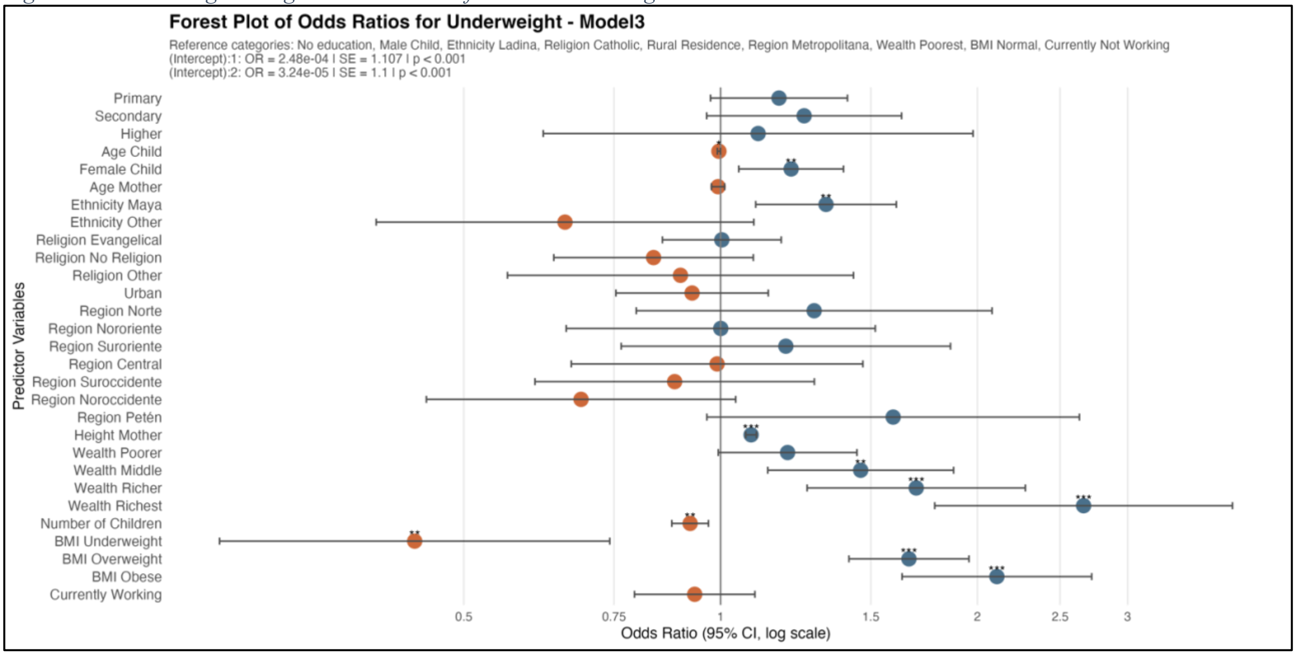
5.2.3.2 Underweight – Model 3

In contrast to the results observed for stunting, underweight conditions in children lose their significant association with maternal education once mediating variables are taken into account (see *Figure 9*). None of the educational categories present statistically significant coefficients (p-value > 0.05), suggesting that the relationship between maternal education and underweight status is largely mediated through other socioeconomic and demographic factors included in the model.

Household wealth and maternal BMI emerge as some of the strongest positive predictors of improved nutritional outcomes. Children living in wealthier households display progressively higher odds of being in better nutritional categories while children of mothers classified as overweight (OR = 1.66, $p < 0.001$) or obese (OR = 2.10, $p < 0.001$) also show significantly higher odds of improved nutritional status compared to children of mothers with normal BMI. These findings underline the central role of household economic conditions and maternal nutritional status in shaping children's weight-for-age outcomes.

In contrast, maternal underweight is associated with lower odds of children being in a better underweight category (OR = 0.43, p-value < 0.01), suggesting that maternal undernutrition negatively affect children's nutritional conditions. However, both the wealth and maternal underweight BMI categories present relatively wide confidence intervals, indicating greater variability and lower precision in the estimated effects.

Figure 9: Ordered logistic regression estimates for child underweight — Model 3



Note: *Odds ratios (ORs) and 95% confidence intervals are reported from the survey-weighted ordered logistic regression model including both confounding and mediating variables. The model adjusts for child age, child sex, maternal age, ethnicity, religion, type of residence, region, maternal height, household wealth, maternal BMI, number of children, and maternal employment status. Colored dots represent odds ratios, while horizontal bars indicate 95% confidence intervals. Odds ratios above 1 (blue dots) indicate higher odds of being in a better nutritional category (i.e., a lower risk of stunting), whereas odds ratios below 1 (orange dots) indicate lower odds of favorable nutritional outcomes. The reference categories are: no maternal education, male child, Ladina ethnicity, Catholic religion, rural residence, Metropolitana region, poorest wealth category, normal maternal BMI, and not currently working. Statistical significance is indicated as follows: *** p < 0.001, ** p < 0.01, * p < 0.05. Complete Model 3 estimates are reported in the Appendix.*

Maternal height also remains positively associated with children's nutritional outcomes (OR = 1.08; pvalue < 0.001), suggesting that better maternal physical conditions are linked to lower risks of underweight among children.

By contrast, the number of children per mother is negatively associated with nutritional status, (OR = 0.92; p-value < 0.01) indicating that each additional child reduces the likelihood of being in a better nutritional category.

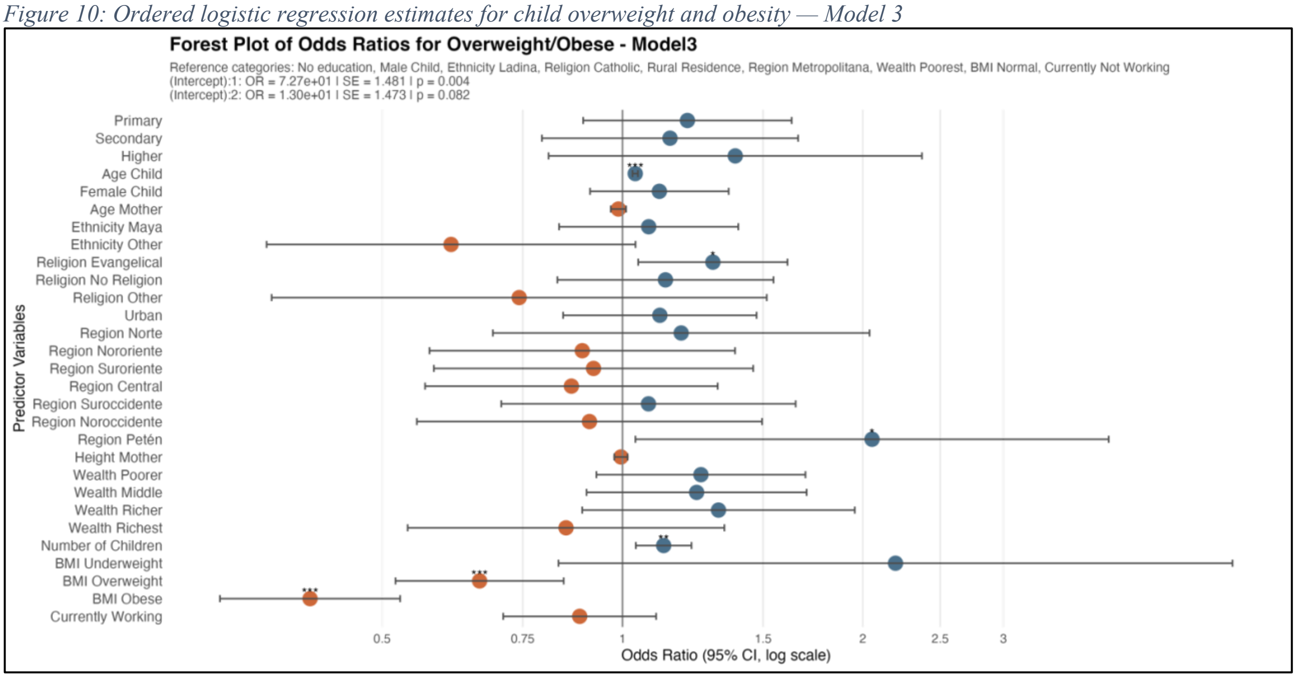
Among the demographic variables, female children appear more likely to be in better nutritional categories than males (OR = 1.20; p-value < 0.01), while Maya ethnicity is positively and significantly associated with improved outcomes in this model (OR = 1.32; p-value < 0.01). Most of the remaining variables do not reach statistical significance, indicating that, once mediating socioeconomic and maternal factors are controlled for, their independent contribution to underweight conditions becomes limited.

Overall, the findings suggest that underweight conditions are shaped less by maternal education directly and more by the socioeconomic and nutritional environment in which children live.

5.2.3.3 Overweight/Obesity – Model 3

Overweight conditions in the final model display a different pattern compared to the previous models (see *Figure 10*). While the earlier models suggested that higher levels of maternal education were associated with worse nutritional outcomes in terms of overweight and obesity, the inclusion of mediating variables changes the direction of the relationship. In Model 3, maternal education appears to be positively associated with better nutritional outcomes; however, none of the educational categories remain statistically significant (p-value > 0.05).

Figure 10: Ordered logistic regression estimates for child overweight and obesity — Model 3



Note: *Odds ratios (ORs) and 95% confidence intervals are reported from the survey-weighted ordered logistic regression model including both confounding and mediating variables. The model adjusts for child age, child sex, maternal age, ethnicity, religion, type of residence, region, maternal height, household wealth, maternal BMI, number of children, and maternal employment status. Colored dots represent odds ratios, while horizontal bars indicate 95% confidence intervals. Odds ratios above 1 (blue dots) indicate higher odds of being in a better nutritional category (i.e., a lower risk of stunting), whereas odds ratios below 1 (orange dots) indicate lower odds of favorable nutritional outcomes. The reference categories are: no maternal education, male child, Ladina ethnicity, Catholic religion, rural residence, Metropolitana region, poorest wealth category, normal maternal BMI, and not currently working. Statistical significance is indicated as follows: *** p < 0.001, ** p < 0.01, * p < 0.05. Complete Model 3 estimates are reported in the Appendix.*

This finding is consistent with the proposed mediation framework. In Models 1 and 2, the association between maternal education and overweight partly reflected the effects of household wealth and maternal BMI, which had not yet been accounted for. More educated mothers tend to belong to wealthier households and to present higher BMI, both of which are associated with a greater likelihood of child overweight and obesity. Once these mediating factors are included in Model 3, the residual direct effect of maternal education largely disappears and the coefficients become unstable and statistically non-significant.

This suggests that overweight conditions among children cannot be directly explained by maternal educational attainment alone. Rather, the relationship observed in the earlier models appears to be mediated by broader socioeconomic, household, and maternal characteristics included in the analysis.

Among the mediator variables introduced in Model 3, only maternal BMI categories related to overweight and obesity remained statistically significant. Mothers classified as overweight (OR = 0.66, p-value < 0.001) and obese (OR = 0.40, p-value < 0.001) presented lower odds of having children in better nutritional categories, implying that higher maternal BMI is associated with increased risks of childhood overweight and obesity. In contrast, maternal underweight showed a positive odds ratio (OR = 2.19, p-value = 0.11), although the estimate was not statistically significant and presented an extremely wide confidence interval. This likely reflects the very low prevalence of maternal underweight within the sample, resulting in greater variability and lower precision of the estimate.

In addition, the number of children ever born was positively associated with better nutritional outcomes (OR = 1.12, p-value < 0.01), suggesting that mothers with a higher number of children presented lower risks of having overweight or obese children. Although this result may initially appear counterintuitive, it could partly reflect differences in household resource allocation, caregiving practices, or lifestyle patterns across family sizes. However, given the complexity of overweight determinants, this association should be interpreted cautiously.

Most control variables lost statistical significance in this model, indicating that overweight and obesity in children are less systematically associated with the socioeconomic and demographic factors considered here compared to other forms of malnutrition such as stunting or underweight. The only control variables that remained statistically significant were child age (OR = 1.03, p-value < 0.001), indicating that older children had higher odds of being in better nutritional categories and therefore lower risks of overweight conditions, as well as Evangelical religion and residence in the Petén region. However, the confidence interval for the Petén coefficient was relatively wide, suggesting substantial variability and lower precision in the estimate; therefore, this result should be interpreted with caution.

Overall, the findings indicate that childhood overweight and obesity are influenced by more complex behavioural and environmental mechanisms that are not fully captured by maternal education or by the socioeconomic variables included in the model. These patterns may reflect broader nutritional transition processes linked to urbanization, dietary change, and increasingly sedentary lifestyles.

5.2.4 Model-fit informations

Approximate model-fit statistics indicate a progressive improvement in explanatory power across all nested models for stunting, underweight, and overweight/obesity as additional variables were introduced. In all three nutritional dimensions reported in *Table 18*, the inclusion of demographic, maternal, and contextual confounding variables in Model 2 substantially reduced deviance and improved log-likelihood compared to the baseline specification, suggesting that child nutritional outcomes are strongly shaped by broader social and territorial conditions beyond maternal education alone.

Table 18: Model-fit information for child stunting, underweight and overweight/obesity

	Stunting		Underweight		Overweight/Obesity	
	Deviance	**Log-likelihood**	**Deviance**	**Log-likelihood**	**Deviance**	**Log-likelihood**
Model1	22344.79	- 11172.4	9992.226	- 4996.113	4985.677	- 2492.838
Model2	18650.43	- 9325.215	8820.375	- 4410.187	4586.063	- 2293.031
Model3	18192.29	- 9096.147	8626.008	- 4313.004	4502.108	- 2251.054

The addition of mediating variables in Model 3 produced a further, although smaller, improvement in model fit across all outcomes, indicating that household wealth, maternal BMI, family composition, and occupation contribute additional explanatory power.

6. DISCUSSION

This study examined the relationship between maternal education and different dimensions of child malnutrition in Guatemala, with particular attention to stunting, wasting, underweight, and overweight/obesity. The findings reveal that stunting represents by far the most severe and widespread nutritional problem within the population. Nearly half of the children experience either moderate or severe stunting, indicating a very high burden of chronic malnutrition. These results suggest that child malnutrition in Guatemala is not primarily characterized by acute nutritional deprivation, but rather by long-term structural disadvantages affecting children's growth and development. In contrast, wasting is relatively uncommon, while underweight conditions remain considerably less prevalent than stunting. At the same time, the presence of overweight and obesity, although still limited, highlights the coexistence of undernutrition and overnutrition within the same population, reflecting the emerging double burden of malnutrition.

Four hypotheses were initially proposed in this study. Overall, the findings provide substantial support for all four hypotheses, although with important differences depending on the specific nutritional outcome considered.

The first hypothesis **(H1)**, which expected higher levels of maternal education to be associated with better child nutritional outcomes, was partially supported by both the descriptive and regression analyses. A clear educational gradient emerged for stunting and underweight, with higher levels of maternal education consistently associated with lower prevalence of severe and moderate undernutrition and with a greater likelihood of normal nutritional status. This relationship remained statistically significant even after controlling for demographic, maternal, and contextual characteristics in Model 2. However, the findings also indicate that the protective role of education is not equally strong across all forms of malnutrition. While primary education appeared to have a relatively similar effect on both stunting and underweight conditions, secondary and higher education exerted a substantially stronger impact on reducing stunting. In Model 2, children of mothers with secondary and higher education showed more than 100% higher odds of belonging to better height-for-age categories compared to children of non-educated mothers.

Once mediating variables were introduced in Model 3, the association between maternal education and child nutrition became more nuanced. Only primary education—although with weaker statistical significance—and secondary education remained significantly associated with improved stunting outcomes, while the relationship with underweight lost statistical significance. In particular, children of mothers with secondary education still presented approximately 45% higher odds of belonging to a better height-for-age category compared to children of mothers with no formal education. Although the magnitude of the coefficient was substantially attenuated compared to Model 2, the persistence of statistical significance suggests that maternal education retains an independent protective role against chronic malnutrition even after accounting for household and socioeconomic mediating factors.

These differences across nutritional outcomes are theoretically meaningful. Stunting reflects long-term and cumulative nutritional deprivation, and is therefore more closely linked to persistent socioeconomic inequalities, maternal conditions, and household environments. Underweight, by contrast, appears to be more sensitive to short-term circumstances such as temporary food insecurity, infectious diseases, seasonal shortages, and sudden economic shocks. Consequently, maternal education may play a stronger role in shaping the long-term conditions influencing children's growth trajectories than in protecting against more immediate forms of nutritional vulnerability.

Wasting displayed no significant relationship with maternal education, likely because it reflects more acute and temporary forms of nutritional deprivation that are strongly influenced by short-term shocks such as food insecurity, infectious diseases, environmental crises, and sudden economic constraints. In addition, wasting was relatively uncommon in the study population, limiting the variability necessary to observe stronger educational gradients. The low prevalence of wasting despite high levels of stunting may also reflect the chronic nature of malnutrition in Guatemala, where children may experience long-term growth retardation while still maintaining weight levels proportionate to their reduced stature.

The relationship between maternal education and overweight/obesity followed a different pattern compared to undernutrition outcomes and therefore did not fully confirm the first hypothesis. In the initial models, higher levels of maternal education appeared to be associated with increased risks of childhood overweight and obesity, suggesting that educational attainment may also be linked to emerging nutritional risks related to overnutrition and nutritional transition processes. In Model 2, the relationship remained similar, as secondary and higher education continued to show lower odds of being in the normal nutritional category, although the coefficients lost statistical significance after controlling for confounding variables.

However, once mediating variables were introduced in Model 3, the direction of the association reversed: all educational categories presented odds ratios above 1, although none of these coefficients remained statistically significant. This suggests that the initial association between maternal education and childhood overweight was partly related to broader socioeconomic and maternal characteristics related with education rather than to education itself. More educated mothers tend to belong to wealthier households and to have higher BMI, both of which are associated with greater risks of child overweight and obesity. Once these mediating pathways were considered, the residual direct effect of maternal education was no longer evident, and the coefficients became unstable and statistically non-significant. This finding is consistent with the proposed mediation framework and suggests that the relationship between maternal education and childhood overnutrition may operate through broader socioeconomic and maternal nutritional mechanisms rather than only through education directly.

Given the lack of statistical significance across wealth categories, these findings further suggest that overweight and obesity may be more strongly influenced by broader behavioural and environmental transformations associated with urbanization and nutritional transition processes, including dietary changes, greater availability of processed and energy-dense foods, reduced physical activity, and increasingly sedentary lifestyles. Overall, the results support the idea that undernutrition and overnutrition coexist within the same population but are shaped by different socioeconomic and educational dynamics.

A crucial finding of this study concerns the existence of a clear educational threshold. Across most analyses, the transition from primary to secondary maternal education was associated with the most substantial improvements in children's nutritional outcomes, especially regarding chronic malnutrition. This suggests that basic levels of schooling alone may not be sufficient to fully translate into meaningful nutritional advantages, particularly in structurally disadvantaged contexts. Instead, secondary education appears to provide women with a broader set of cognitive, economic, and social resources that more effectively contribute to improved childcare practices.

The second hypothesis **(H2)**, concerning ethnic inequalities in the protective role of maternal education, was also supported. Although maternal education improved nutritional outcomes among both Ladina and Indigenous children, Maya children consistently experienced higher levels of stunting at nearly all educational levels, even after controlling for confounding factors. A particularly important reduction in stunting among the Maya population was observed between primary and secondary education, whereas among Ladino children even primary education already appeared to exert a strong protective effect. These findings indicate that maternal education plays a crucial role in improving child nutritional outcomes, but remains insufficient to fully overcome the structural disadvantages affecting chronic malnutrition among Indigenous populations. By contrast, ethnicity did not present statistically significant differences for underweight and overweight conditions.

The third hypothesis **(H3)**, which expected regional inequalities and rural residence to shape the relationship between maternal education and child nutritional outcomes, was also partially confirmed. Children living in rural areas and historically disadvantaged western regions such as Noroccidente and Suroccidente consistently displayed worse stunting outcomes compared to children living in more urbanized and economically advantaged regions. Underweight and overweight conditions, however, did not show equally strong or consistent territorial differences.

Furthermore, regional disparities persisted even among children whose mothers had relatively high levels of education, although improvements in nutritional outcomes were still observable. In the most disadvantaged regions, substantial improvements in child nutritional status often became visible only at secondary levels of maternal education, suggesting that lower levels of schooling may not be sufficient to overcome structural territorial disadvantages. At the same time, Noroccidente recorded one of the largest reductions in stunting prevalence between children of non-educated and highly educated mothers, highlighting the particularly strong protective role that maternal education may play in more vulnerable contexts.

The weaker association between maternal education and stunting observed in Model 2 compared to Model 1 further suggests that part of the crude educational gradient reflects broader social and spatial inequalities. The benefits associated with maternal education therefore appear strongly conditioned by contextual factors such as regional disparities in healthcare access, sanitation, infrastructure, economic opportunities, and potentially differences in educational quality across regions.

The fourth hypothesis **(H4)**, which proposed that maternal education influences child nutrition both directly and indirectly through mediating factors, also received strong empirical support, with particular regard to stunting. The regression analyses showed that the effect of maternal education became substantially attenuated once mediating variables such as household wealth, maternal BMI, number of children, and occupation were introduced in Model 3. This attenuation suggests that part of the educational gradient operates through broader socioeconomic and household mechanisms. At the same time, the persistence of significant effects for secondary education in the stunting models indicates that maternal education retains an independent protective role beyond material household conditions alone. Education therefore appears not only to shape the socioeconomic environment in which children grow up, but also to influence health-related behaviours, nutritional awareness, healthcare utilization, and childcare practices.

These findings are consistent with the existing literature linking maternal education to improved child health and nutritional outcomes. Previous studies have emphasized that maternal education influences child nutrition through both direct and indirect mechanisms. On the one hand, education increases women's economic opportunities and household socioeconomic resources, thereby improving access to food, healthcare, sanitation, and other essential living conditions that contribute to better child nutrition (G. S. Becker, 1964; Fuchs et al., 2010; Schultz, 1961). This interpretation is also supported by the attenuation of educational coefficients observed in Model 3 after controlling for household wealth and occupation.

At the same time, the persistence of significant associations for stunting even after controlling for these mediators suggests that maternal education exerts an influence beyond economic resources alone. As highlighted in the literature, education contributes to the development of cognitive skills, health literacy, and the ability to process and apply health-related information

(Baker et al., 2011; Herd, 2010; Mirowsky & Ross, 2003). Although schooling does not necessarily directly teach childcare practices, it equips women with reasoning abilities and greater capacity to understand, evaluate, and respond to health-related situations. Caldwell and collegues (2005), for example, argue that education strengthens confidence in modern medicine and promotes more effective use of healthcare services, ultimately benefiting both maternal and child health outcomes.

Education is also closely related to women's autonomy and decision-making power within the household. More educated women are generally more aware of the importance of preventive healthcare, nutrition, and child wellbeing, and are therefore more likely to make independent decisions concerning childcare practices and healthier diets (Caldwell, 1986; Frost et al., 2005; Gewa, 2010; Pratley, 2016; van Ansem et al., 2014)

Previous studies on Latin America and Guatemala have consistently shown that Indigenous populations and rural communities experience higher levels of poverty, food insecurity, limited healthcare access, and poorer living conditions, all of which contribute to persistent nutritional inequalities (Orozco & Valdivia, 2017; Pons, 2012; Szekely & Adelman, 2016; UNHCR, 2018). The findings of these studies strongly reflect these patterns, as Maya children and children living in rural and western regions consistently displayed worse stunting outcomes even at similar educational levels. At the same time, the strongest reductions in stunting prevalence were often observed among Indigenous and rural populations when mothers attained secondary education, highlighting how education can partially mitigate structural vulnerabilities. These findings therefore support intersectional approaches within the literature, which argue that child malnutrition cannot be explained by a single factor alone, but rather emerges from the interaction between educational, social, economic, geographic, and demographic disadvantages.

Finally, the coexistence of persistent undernutrition and emerging overweight/obesity patterns reflects the presence of the double burden of malnutrition in Guatemala. While improvements in education and socioeconomic conditions may reduce traditional forms of deprivation, they may simultaneously increase exposure to new nutritional risks associated with dietary change, urbanization, and sedentary lifestyles (Jaacks et al., 2019; Monteiro et al., 2004). Importantly, these two dimensions are not independent phenomena, but are closely interconnected. As highlighted in the literature review, early-life chronic undernutrition may increase the risk of overweight and obesity later in life through long-term metabolic and physiological adaptations (Adair et al., 2013; Shrimpton & Rokx, 2012). In fact, prolonged nutritional deprivation during critical stages of development can alter energy metabolism, fat storage, and growth regulation, predisposing individuals to excessive weight gain when exposed to improved food availability or energy-dense diets later in life. Consequently, childhood stunting, and adult overweight should not be viewed as separate phenomena, but rather as interconnected manifestations of nutritional inequality and nutritional transition.

6.1 STRENGTHS AND LIMITATIONS

This study has several important strengths. It relies on objectively measured anthropometric information collected using standardized procedures, reducing the risk of measurement error associated with self-reported data. By examining multiple forms of malnutrition—including stunting, underweight, wasting, and overweight/obesity—it provides a comprehensive assessment of child nutritional outcomes and captures the multiple burden of malnutrition in Guatemala. The analysis also explores heterogeneity across regions, place of residence, and ethnicity, offering insights into how contextual factors shape the relationship between maternal education and child nutrition. Furthermore, the use of ordinal regression models allows nutritional status severity to be analysed in greater detail than binary classifications, while controlling for a broad range of socioeconomic, demographic, and household characteristics. The sequential modelling strategy also makes it possible to examine how the association between maternal education and child nutritional outcomes changes after the inclusion of potential mediating factors, thereby providing insights into both the direct and indirect pathways through which maternal education may influence child nutrition.

Several limitations should also be acknowledged. First, the cross-sectional nature of the data prevents causal inference, and the observed associations should not be interpreted as definitive evidence of causality. Second, the relatively low prevalence of wasting and obesity reduces statistical power for these outcomes and may partly explain the absence of statistically significant associations in some subgroup analyses. Third, because some mothers contributed more than one child to the sample, a multilevel sensitivity analysis was performed to account for potential within-mother clustering. Although the results remained broadly consistent with the main analyses, survey weights could not be incorporated into the multilevel specification, and the model was therefore estimated as an unweighted robustness check. Finally, the analysis does not take into consideration information on dietary practices, breastfeeding behaviours, physical activity, or other lifestyle factors that may influence child nutritional outcomes.

7. CONCLUSION

This study demonstrates that maternal education plays a crucial role in shaping child nutritional outcomes in Guatemala, particularly with regard to chronic undernutrition. Higher levels of maternal education were consistently associated with lower risks of stunting and underweight, with secondary education emerging as the level of schooling most strongly linked to improved nutritional outcomes. However, the findings also show that the benefits of maternal education are not distributed equally across the population. Children with Indigenous background, living in rural areas, and those residing in historically disadvantaged regions continue to face substantially worse nutritional outcomes, even when maternal educational attainment is similar. Furthermore, the results suggest that maternal education influences child nutrition both directly and indirectly through household socioeconomic conditions, maternal characteristics, and family resources, highlighting the complex mechanisms through which educational attainment affects child well-being. At the same time, the findings point to the emergence of overweight and obesity alongside persistent undernutrition, reflecting the ongoing nutritional transition in Guatemala and the coexistence of multiple forms of malnutrition within the same population.

From a policy perspective, these results suggest that expanding access to maternal education, particularly secondary education, should remain a central priority for reducing child malnutrition in Guatemala. Nevertheless, educational policies need to be accompanied by broader interventions aimed at addressing the structural disadvantages that continue to characterize the Guatemalan context. Policies targeting poverty reduction, ethnic inequalities, food security, reproductive health services, sanitation, healthcare access, and regional disparities would likely strengthen the protective effect of education on child nutrition. Particular attention should be directed toward Indigenous and rural populations, where structural disadvantages remain especially severe and where improvements in nutritional outcomes often become visible only at higher levels of maternal education.

At the same time, the findings also highlight the importance of adopting a broader perspective on malnutrition that considers both undernutrition and the emerging rise of overweight and obesity. Addressing chronic forms of child malnutrition, particularly stunting, may not only improve children's immediate health and developmental outcomes, but could also represent an important preventive strategy contributing to the reduction of overnutrition and non-communicable diseases later in life. Reducing child malnutrition in Guatemala therefore requires a multidimensional strategy that improves women's educational opportunities while also tackling broader socioeconomic, territorial, and ethnic inequalities.

Future research could further expand the understanding of child malnutrition in Guatemala by using longitudinal data for a more robust assessment of causal relationships between maternal education and child nutritional outcomes, as well as the observation of nutritional trajectories over time.

In addition, future studies could incorporate more detailed information on dietary patterns, physical activity, food consumption, and broader lifestyle behaviours in order to better explain differences in both undernutrition and overweight conditions. In particular, analysing the role of the food environment—including access to nutritious foods, exposure to processed and energy-dense products, and local food availability—could provide important insights into the ongoing nutritional transition in Guatemala.

Finally, future analyses would benefit from the use of more recent and updated datasets. Given the rapid socioeconomic, dietary, and demographic changes occurring in Guatemala, newer data could help assess whether the patterns observed in this study have persisted or evolved over time, particularly with regard to the coexistence of undernutrition and overnutrition within the population.

8. APPENDIX

Table 19: Prevalence of stunting condition according to region

	Metropolitana % (n)			Nororiente % (n)		
	Severe	**Moderate**	**Normal**	**Severe**	**Moderate**	**Normal**
No education	6.4% (7)	44.5% (52)	49.1% (57)	27.6% (61)	33.2% (74)	39.2% (87)
Primary	7.2% (50)	26.1% (184)	66.7% (469)	15.4% (84)	29.1% (159)	55.5% (304)
Secondary	3.2% (27)	15.6% (132)	81.2% (690)	4.1% (11)	14.1% (37)	81.7% (216)
Higher	1.8% (3)	12.9% (19)	85.3% (123)	0.0% (0)	15.5% (6)	84.5% (31)
	F = 7.2256, p-value < 0.001			F = 19.974, p-value < 0.001		

	Central % (n)			Suroriente % (n)		
	Severe	**Moderate**	**Normal**	**Severe**	**Moderate**	**Normal**
No education	25.2% (37)	33.0% (48)	41.8% (61)	27.7% (43)	33.6% (52)	38.7% (60)
Primary	15.9% (115)	31.0% (225)	53.1% (386)	15.6% (94)	29.7% (178)	54.6% (328)
Secondary	6.3% (22)	22.0% (77)	71.8% (252)	5.6% (15)	18.0% (47)	76.4% (200)
Higher	5.2% (2)	15.4% (6)	79.4% (33)	3.1% (1)	18.9% (7)	78.0% (29)
	F = 8.5824, p-value = < 0.001			F = 11.144, p-value = < 0.001		

	Suroccidente % (n)			Noroccidente % (n)		
	Severe	**Moderate**	**Normal**	**Severe**	**Moderate**	**Normal**
No education	29.1% (123)	40.9% (174)	30.0% (127)	40.9% (264)	39.5% (255)	19.7% (127)
Primary	20.2% (323)	34.6% (555)	45.2% (725)	31.1% (321)	39.7% (409)	29.2% (301)
Secondary	8.2% (55)	28.6% (192)	63.2% (423)	10.4% (29)	25.8% (72)	63.8% (177)
Higher	6.2% (6)	22.7% (21)	71.0% (66)	0.0% (0)	24.4% (7)	75.6% (21)
	F = 21.151, p-value < 0.001			F = 15.647, p-value < 0.001		

	Norte % (n)			Petén % (n)		
	Severe	**Moderate**	**Normal**	**Severe**	**Moderate**	**Normal**
No education	24.0% (98)	36.3% (148)	39.7% (161)	15.2% (12)	40.1% (33)	44.7% (36)
Primary	16.8% (123)	32.5% (238)	50.6% (370)	9.5% (25)	32.5% (87)	58.0% (154)
Secondary	7.1% (13)	26.3% (49)	66.6% (125)	4.3% (5)	12.5% (16)	83.1% (105)
Higher	2.0% (0)	11.6% (3)	86.5% (21)	0.0% (0)	0.0% (0)	100.0% (9)
	F = 5.5433, p-value = < 0.001			F = 5.5721, p-value < 0.001		

***Note**: Percentages were measured within each maternal education level for each region.*

Table 20: Prevalence of underweight condition according to region

	Metropolitana % (n)			**Nororiente** % (n)		
	Severe	**Moderate**	**Normal**	**Severe**	**Moderate**	**Normal**
No education	0.0% (0)	21.2% (25)	78.8% (92)	5.5% (12)	16.4% (36)	78.1% (174)
Primary	1.2% (8)	6.4% (45)	92.4% (647)	2.2% (12)	10.9% (60)	86.9% (472)
Secondary	0.8% (7)	5.5% (46)	93.7% (777)	1.0% (3)	5.1% (13)	93.9% (239)
Higher	1.8% (3)	4.8% (7)	93.4% (123)	0.0% (0)	4.7% (2)	95.3% (33)
	F = 3.0631, p-value = 0.01094			F = 5.4802, p-value = 9.296e-05		

	Central % (n)			**Suroriente** % (n)		
	Severe	**Moderate**	**Normal**	**Severe**	**Moderate**	**Normal**
No education	2.7% (4)	17.5% (25)	79.8% (116)	4.1% (6)	15.0% (23)	80.8% (125)
Primary	0.7% (5)	9.4% (68)	89.9% (651)	1.7% (10)	10.4% (62)	87.9% (526)
Secondary	1.9% (6)	4.8% (17)	93.3% (324)	1.0% (3)	5.0% (13)	94.0% (242)
Higher	1.9% (6)	4.8% (17)	93.3% (324)	0.8% (0)	3.7% (1)	95.5% (35)
	F = 3.8583, p-value = 0.001345			F = 4.0769, p-value = 0.00194		

	Suroccidente % (n)			**Noroccidente** % (n)		
	Severe	**Moderate**	**Normal**	**Severe**	**Moderate**	**Normal**
No education	4.8% (20)	15.8% (67)	79.4% (335)	5.1% (33)	21.8% (141)	73.1% (472)
Primary	2.1% (33)	12.7% (203)	85.3% (1366)	3.7% (38)	15.5% (160)	80.9% (833)
Secondary	1.2% (8)	7.4% (50)	91.3% (610)	1.2% (3)	6.4% (18)	92.4% (257)
Higher	0.0% (0)	4.4% (4)	95.6% (86)	0.0% (0)	0.0% (0)	100.0% (28)
	F = 6.182, p-value = 3.667e-06			F = 5.0835, p-value = 0.0001675		

	Norte % (n)			**Petén** % (n)		
	Severe	**Moderate**	**Normal**	**Severe**	**Moderate**	**Normal**
No education	3.4% (14)	9.9% (40)	86.8% (353)	3.3% (3)	8.0% (6)	88.7% (72)
Primary	1.5% (11)	9.1% (66)	89.4% (652)	0.0% (0)	8.7% (23)	91.3% (242)
Secondary	0.5% (1)	7.0% (13)	92.5% (172)	0.7% (1)	4.2% (5)	95.0% (119)
Higher	0.0% (0)	1.1% (0)	98.9% (24)	0.0% (0)	0.0% (0)	100.0% (9)
	F = 1.4235, p-value = 0.2221			F = 2.2294, p-value = 0.05444		

Note*: Percentages were measured within each maternal education level for each region.*

Table 21: Prevalence of wasting condition according to region

	Metropolitana % (n)			**Nororiente** % (n)		
	Severe	**Moderate**	**Normal**	**Severe**	**Moderate**	**Normal**
No education	0.0% (0)	0.9% (1)	99.1% (114)	0.0% (0)	0.8% (2)	99.2% (215)
Primary	0.5% (3)	0.7% (5)	98.8% (668)	0.0% (0)	1.0% (5)	99.0% (515)
Secondary	0.0% (0)	1.3% (10)	98.7% (781)	0.0% (0)	0.8% (2)	99.2% (242)
Higher	0.0% (0)	0.0% (0)	100.0% (134)	0.0% (0)	2.2% (1)	97.8% (31)
	F = 0.47745, p-value = 0.7945			F = NaN, p-value = NA		

	Central % (n)			**Suroriente** % (n)		
	Severe	**Moderate**	**Normal**	**Severe**	**Moderate**	**Normal**
No education	0.0% (0)	0.6% (1)	99.4% (139)	0.5% (1)	0.0% (0)	99.5% (146)
Primary	0.0% (0)	1.0% (7)	99.0% (684)	0.4% (2)	0.4% (2)	99.2% (569)
Secondary	0.3% (1)	0.7% (2)	99.0% (328)	0.5% (1)	0.7% (2)	98.9% (238)
Higher	0.0% (0)	0.0% (0)	100.0% (40)	0.0% (0)	0.0% (0)	100.0% (36)
	F = 0.37939, p-value = 0.8559			F = 0.26465, p-value = 0.9295		

	Suroccidente % (n)			**Noroccidente** % (n)		
	Severe	**Moderate**	**Normal**	**Severe**	**Moderate**	**Normal**
No education	0.0% (0)	0.3% (1)	99.7% (406)	0.0% (0)	0.7% (4)	99.3% (604)
Primary	0.1% (1)	1.0% (15)	98.9% (1530)	0.0% (0)	0.2% (2)	99.8% (982)
Secondary	0.2% (1)	0.6% (4)	99.2% (631)	0.0% (0)	0.0% (0)	100.0% (268)
Higher	0.0% (0)	0.0% (0)	100.0% (83)	0.0% (0)	0.0% (0)	100.0% (28)
	F = 0.52234, p-value = 0.7519			F = NaN, p-value = NA		

	Norte % (n)			**Petén** % (n)		
	Severe	**Moderate**	**Normal**	**Severe**	**Moderate**	**Normal**
No education	0.0% (0)	1.6% (6)	98.4% (383)	0.0% (0)	2.1% (2)	97.9% (79)
Primary	0.4% (3)	0.0% (0)	99.5% (703)	0.0% (0)	0.3% (1)	99.7% (259)
Secondary	0.0% (0)	0.3% (1)	99.7% (182)	0.0% (0)	0.0% (0)	100.0% (122)
Higher	0.0% (0)	0.0% (0)	100.0% (23)	0.0% (0)	3.1% (0)	96.9% (8)
	F = 1.2001, p-value = 0.3113			F = NaN, p-value = NA		

Note: *Percentages were measured within each maternal education level for each region.*

Table 22: Comparison between survey-weighted and multilevel ordered logistic models for child stunting – Model 2

Variable	**Odd Ratios**	
	Original Model 2	**Multilevel Model 2**
Primary	1.38***	1.48***
Secondary	2.39***	2.82***
Higher	2.66***	2.99***
Mother-level variance	–	0.85
ICC	–	0.21
Observations	10,868	10,868
Number of mothers	8472	8472

Note*: Odds ratios (OR) are reported. The *** indicates p-value <0.001. The multilevel specification includes a random intercept at the mother level ((1|caseid)) in order to account for within-mother clustering among siblings. The mother-level variance captures unobserved heterogeneity shared among children belonging to the same mother, including common household, environmental, and maternal characteristics. The Intraclass Correlation Coefficient (ICC) indicates the proportion of the total variance in child stunting attributable to differences between mothers and households.*

Table 23: Ordered logistic regression estimates for child stunting— Model 2

Model 2 - Stunting						
Reference categories: No education, Male Child, Ethnicity Ladina, Religion Catholic, Rural Residence, Region Metropolitana						
(Intercept):1: OR = 1.34e-07 | SE = 0.819 | p < 0.001 (Intercept):2: OR = 2.18e-08 | SE = 0.824 | p < 0.001						
Variable	**Coef**	**SE**	**OR**	**Lower OR**	**Upper OR**	**P-value**
Primary	0,32	0,07	1,38	1,20	1,58	p < 0.001
Secondary	0,87	0,08	2,39	2,01	2,84	p < 0. 001
Higher	0,97	0,17	2,66	1,89	3,74	p < 0. 001
Age Child	-0,01	0,00	0,98	0,98	0,99	p < 0. 001
Female Child	0,15	0,04	1,16	1,06	1,27	p < 0.01
Age Mother	-0,00	0,00	0,99	0,99	1,00	ns
Ethnicity Maya	-0,46	0,08	0,62	0,53	0,74	p < 0. 001
Ethnicity Other	-0,54	0,17	0,58	0,41	0,81	p < 0.01
Religion Evangelical	0,11	0,05	1,11	1,00	1,24	p < 0.05
Religion No Religion	0,19	0,10	1,21	0,99	1,47	ns
Religion Other	-0,12	0,20	0,88	0,58	1,33	ns
Urban	0,22	0,07	1,24	1,08	1,43	p < 0.01
Region Norte	-0,07	0,15	0,92	0,68	1,24	ns
Region Nororiente	-0,33	0,14	0,71	0,53	0,95	p < 0.05
Region Suroriente	-0,53	0,13	0,58	0,45	0,75	p < 0. 001
Region Central	-0,28	0,12	0,75	0,58	0,96	p < 0.05
Region Suroccidente	-0,54	0,11	0,58	0,46	0,73	p < 0. 001
Region Noroccidente	-0,83	0,14	0,43	0,32	0,57	p < 0. 001
Region Petén	-0,01	0,14	0,98	0,73	1,32	ns
Height Mother	0,12	0,00	1,12	1,11	1,14	p < 0. 001

Table 24: Ordered logistic regression estimates for child underweight— Model 2

Model 2 - Underweight						
Reference categories: No education, Male Child, Ethnicity Ladina, Religion Catholic, Rural Residence, Region Metropolitana						
(Intercept):1: OR = 1.39e-04 | SE = 1.079 | p < 0.001 (Intercept):2: OR = 1.87e-05 | SE = 1.069 | p < 0.001						
Variable	**Coef**	**SE**	**OR**	**Lower OR**	**Upper OR**	**P-value**
Primary	0,29	0,09	1,33	1,11	1,60	p < 0. 01
Secondary	0,60	0,11	1,82	1,44	2,29	p < 0. 001
Higher	0,83	0,26	2,29	1,36	3,88	p < 0.01
Age Child	-0,00	0,00	0,99	0,99	1,00	ns
Female Child	0,16	0,07	1,17	1,02	1,35	p < 0.05
Age Mother	-0,01	0,00	0,98	0,97	0,99	p < 0.01
Ethnicity Maya	0,16	0,09	1,18	0,97	1,42	ns
Ethnicity Other	-0,47	0,26	0,61	0,36	1,03	ns
Religion Evangelical	0,03	0,08	1,03	0,87	1,21	ns
Religion No Religion	-0,16	0,13	0,85	0,65	1,11	ns
Religion Other	-0,06	0,25	0,93	0,57	1,52	ns
Urban	0,14	0,10	1,15	0,94	1,41	ns
Region Norte	0,01	0,22	1,01	0,65	1,57	ns
Region Nororiente	-0,26	0,18	0,77	0,53	1,10	ns
Region Suroriente	-0,10	0,20	0,90	0,60	1,34	ns
Region Central	-0,06	0,17	0,94	0,67	1,32	ns
Region Suroccidente	-0,27	0,16	0,75	0,55	1,04	ns
Region Noroccidente	-0,57	0,18	0,56	0,38	0,81	p < 0.01
Region Petén	0,28	0,22	1,33	0,85	2,08	ns
Height Mother	0,08	0,00	1,09	1,07	1,10	p < 0. 001

Table 25: Ordered logistic regression estimates for child wasting— Model 2

Model 2 - Wasting						
Reference categories: No education, Male Child, Ethnicity Ladina, Religion Catholic, Rural Residence, Region Metropolitana						
(Intercept):1: OR = 1.14e+02 | SE = 3.69 | p = 0.2 Intercept):2: OR = 1.89e+01 | SE = 3.753 | p = 0.434						
Variable	**Coef**	**SE**	**OR**	**Lower OR**	**Upper OR**	**P-value**
Primary	0,30	0,35	1,35	0,68	2,70	ns
Secondary	0,47	0,39	1,60	0,74	3,46	ns
Higher	1,71	0,73	5,53	1,31	23,26	p < 0.05
Age Child	0,02	0,00	1,02	1,00	1,03	p < 0.05
Female Child	0,71	0,30	2,05	1,12	3,75	p < 0.05
Age Mother	-0,01	0,02	0,98	0,94	1,02	ns
Ethnicity Maya	0,39	0,34	1,48	0,75	2,93	ns
Ethnicity Other	-0,23	0,97	0,79	0,11	5,31	ns
Religion Evangelical	-0,09	0,28	0,91	0,52	1,58	ns
Religion No Religion	-0,04	0,46	0,95	0,38	2,38	ns
Religion Other	0,82	1,04	2,27	0,29	17,68	ns
Urban	0,06	0,29	1,06	0,59	1,90	ns
Region Norte	0,37	0,59	1,46	0,45	4,73	ns
Region Nororiente	0,40	0,48	1,50	0,58	3,87	ns
Region Suroriente	0,58	0,51	1,79	0,65	4,93	ns
Region Central	0,70	0,53	2,02	0,70	5,82	ns
Region Suroccidente	0,45	0,47	1,57	0,62	3,96	ns
Region Noroccidente	1,23	0,69	3,44	0,88	13,43	ns
Region Petén	0,75	0,74	2,12	0,49	9,15	ns
Height Mother	0,00	0,02	1,00	0,95	1,05	ns

Table 26: Ordered logistic regression estimates for child overweight and obesity — Model 2

Model 2 - Overweight/Obesity						
Reference categories: No education, Male Child, Ethnicity Ladina, Religion Catholic, Rural Residence, Region Metropolitana						
(Intercept):1: OR = 1.43e+02 | SE = 1.454 | p < 0.001 (Intercept):2: OR = 2.56e+01 | SE = 1.449 | p < 0.05						
Variable	**Coef**	**SE**	**OR**	**Lower OR**	**Upper OR**	**P-value**
Primary	0,09	0,16	1,10	0,80	1,50	ns
Secondary	-0,09	0,18	0,91	0,63	1,31	ns
Higher	-0,18	0,25	0,82	0,49	1,37	ns
Age Child	0,03	0,00	1,03	1,02	1,04	p < 0.001
Female Child	0,10	0,10	1,11	0,91	1,35	ns
Age Mother	-0,00	0,00	0,99	0,98	1,01	ns
Ethnicity Maya	0,13	0,13	1,14	0,87	1,49	ns
Ethnicity Other	-0,44	0,26	0,64	0,37	1,08	ns
Religion Evangelical	0,25	0,10	1,28	1,04	1,59	p < 0.05
Religion No Religion	0,11	0,15	1,11	0,81	1,52	ns
Religion Other	-0,37	0,34	0,68	0,34	1,36	ns
Urban	-0,04	0,13	0,95	0,73	1,24	ns
Region Norte	0,19	0,26	1,22	0,72	2,05	ns
Region Nororiente	-0,03	0,21	0,96	0,62	1,48	ns
Region Suroriente	0,03	0,22	1,03	0,66	1,61	ns
Region Central	-0,09	0,21	0,91	0,60	1,38	ns
Region Suroccidente	0,17	0,21	1,18	0,77	1,80	ns
Region Noroccidente	-0,01	0,25	0,98	0,60	1,62	ns
Region Petén	0,71	0,32	2,04	1,07	3,90	p < 0.05
Height Mother	-0,00	0,00	0,99	0,97	1,00	ns

Table 27: Ordered logistic regression estimates for child stunting — Model 3

Model 3 – Stunting						
Reference categories: No education, Male Child, Ethnicity Ladina, Religion Catholic, Rural Residence, Region Metropolitana, Wealth Poorest, BMI Normal, Currently Not Working						
(Intercept):1: OR = 2.23e-07 | SE = 0.833 | p < 0.001 (Intercept):2: OR = 3.40e-08 | SE = 0.837 | p < 0.001						
Variable	**Coef**	**SE**	**OR**	**Lower OR**	**Upper OR**	**P-value**
Primary	0,14	0,07	1,15	1,00	1,32	p < 0.05
Secondary	0,37	0,09	1,45	1,21	1,73	p < 0.001
Higher	0,11	0,19	1,11	0,76	1,62	ns
Age Child	-0,01	0,00	0,98	0,98	0,99	p < 0.001
Female Child	0,17	0,04	1,19	1,09	1,31	p < 0.001
Age Mother	0,01	0,00	1,01	1,00	1,03	p < 0.01
Ethnicity Maya	-0,35	0,08	0,70	0,59	0,82	p < 0.001
Ethnicity Other	-0,37	0,16	0,68	0,49	0,95	p < 0.05
Religion Evangelical	0,08	0,05	1,08	0,97	1,20	ns
Religion No Religion	0,16	0,10	1,18	0,97	1,44	ns
Religion Other	-0,17	0,20	0,83	0,56	1,24	ns
Urban	-0,05	0,06	0,95	0,83	1,08	ns
Region Norte	0,26	0,15	1,30	0,97	1,76	ns
Region Nororiente	-0,00	0,14	0,99	0,74	1,33	ns
Region Suroriente	-0,22	0,13	0,80	0,61	1,03	ns
Region Central	-0,20	0,12	0,81	0,63	1,03	ns
Region Suroccidente	-0,34	0,11	0,70	0,56	0,89	p < 0.01
Region Noroccidente	-0,57	0,14	0,56	0,42	0,74	p < 0.001
Region Petén	0,29	0,16	1,34	0,98	1,84	ns
Height Mother	0,11	0,00	1,12	1,10	1,13	p < 0.001
Wealth Poorer	0,20	0,07	1,22	1,06	1,41	p < 0.01
Wealth Middle	0,49	0,07	1,64	1,40	1,91	p < 0.001
Wealth Richer	0,77	0,10	2,18	1,79	2,65	p < 0.001
Wealth Richest	1,12	0,14	3,08	2,34	4,07	p < 0.001
Number of Children	-0,12	0,01	0,88	0,84	0,91	p < 0.001
BMI Underweight	-0,65	0,21	0,51	0,33	0,79	p < 0.01
BMI Overweight	0,34	0,05	1,41	1,26	1,57	p < 0. 001
BMI Obese	0,54	0,08	1,71	1,46	2,01	p < 0.001
Currently Working	-0,00	0,05	0,99	0,88	1,10	ns

Table 28: Ordered logistic regression estimates for child underweight — Model 3

Model 3 - Underweight						
Reference categories: No education, Male Child, Ethnicity Ladina, Religion Catholic, Rural Residence, Region Metropolitana, Wealth Poorest, BMI Normal, Currently Not Working						
(Intercept):1: OR = 2.48e-04 | SE = 1.107 | p < 0.001 (Intercept):2: OR = 3.24e-05 | SE = 1.1 | p < 0.001						
Variable	**Coef**	**SE**	**OR**	**Lower OR**	**Upper OR**	**P-value**
Primary	0,15	0,09	1,17	0,97	1,40	ns
Secondary	0,22	0,13	1,25	0,96	1,62	ns
Higher	0,10	0,29	1,10	0,61	1,97	ns
Age Child	-0,00	0,00	0,99	0,99	0,99	p < 0.05
Female Child	0,19	0,07	1,20	1,05	1,39	p < 0.01
Age Mother	-0,00	0,00	0,99	0,97	1,01	ns
Ethnicity Maya	0,28	0,09	1,32	1,09	1,60	p < 0.01
Ethnicity Other	-0,41	0,26	0,65	0,39	1,09	ns
Religion Evangelical	0,00	0,08	1,00	0,85	1,17	ns
Religion No Religion	-0,18	0,13	0,83	0,63	1,09	ns
Religion Other	-0,10	0,23	0,89	0,56	1,43	ns
Urban	-0,07	0,10	0,92	0,75	1,13	ns
Region Norte	0,25	0,24	1,28	0,79	2,08	ns
Region Nororiente	0,00	0,21	1,00	0,65	1,51	ns
Region Suroriente	0,17	0,22	1,19	0,76	1,85	ns
Region Central	-0,00	0,20	0,99	0,66	1,46	ns
Region Suroccidente	-0,12	0,19	0,88	0,60	1,28	ns
Region Noroccidente	-0,37	0,21	0,68	0,45	1,04	ns
Region Petén	0,46	0,25	1,59	0,96	2,63	ns
Height Mother	0,08	0,00	1,08	1,07	1,10	p < 0.001
Wealth Poorer	0,18	0,09	1,19	0,99	1,44	ns
Wealth Middle	0,37	0,12	1,45	1,13	1,87	p < 0.01
Wealth Richer	0,52	0,15	1,69	1,26	2,27	p < 0.001
Wealth Richest	0,97	0,20	2,66	1,78	3,98	p < 0.001
Number of Children	-0,08	0,02	0,92	0,87	0,96	p < 0.01
BMI Underweight	-0,82	0,26	0,43	0,25	0,74	p < 0.01
BMI Overweight	0,50	0,08	1,66	1,41	1,95	p < 0.001
BMI Obese	0,74	0,13	2,10	1,63	2,72	p < 0.001
Currently Working	-0,06	0,08	0,93	0,79	1,09	ns

Table 29: Ordered logistic regression estimates for child wasting — Model 3

Model 3 - Wasting						
Reference categories: No education, Male Child, Ethnicity Ladina, Religion Catholic, Rural Residence, Region Metropolitana, Wealth Poorest, BMI Normal, Currently Not Working						
(Intercept):1: OR = 1110| SE = 1.461 | p = 1.6e-06 (Intercept):2: OR = 185 | SE = 1.443 | p = 2.96e-04						
Variable	**Coef**	**SE**	**OR**	**Lower OR**	**Upper OR**	**P-value**
Primary	-0,10	0,14	0,89	0,67	1,18	ns
Secondary	-0,00	0,17	0,99	0,70	1,40	ns
Higher	-0,01	0,26	0,98	0,59	1,64	ns
Age Child	-0,02	0,00	0,97	0,96	0,97	p < 0.001
Female Child	0,01	0,09	1,01	0,84	1,22	ns
Age Mother	0,00	0,01	1,00	0,98	1,02	ns
Ethnicity Maya	-0,00	0,12	0,99	0,78	1,26	ns
Ethnicity Other	0,44	0,24	1,56	0,96	2,53	ns
Religion Evangelical	-0,23	0,10	0,79	0,64	0,97	p < 0.05
Religion No Religion	-0,12	0,15	0,87	0,65	1,18	ns
Religion Other	0,32	0,33	1,38	0,71	2,68	ns
Urban	-0,06	0,12	0,93	0,73	1,20	ns
Region Norte	-0,07	0,24	0,92	0,56	1,51	ns
Region Nororiente	0,16	0,22	1,18	0,75	1,84	ns
Region Suroriente	0,15	0,23	1,17	0,74	1,84	ns
Region Central	0,22	0,20	1,25	0,83	1,87	ns
Region Suroccidente	-0,00	0,20	0,99	0,66	1,50	ns
Region Noroccidente	0,22	0,23	1,25	0,78	1,98	ns
Region Pet√©n	-0,45	0,27	0,63	0,36	1,08	ns
Height Mother	0,00	0,00	1,00	0,98	1,02	ns
Wealth Poorer	-0,12	0,13	0,88	0,68	1,14	ns
Wealth Middle	-0,13	0,15	0,87	0,65	1,18	ns
Wealth Richer	-0,21	0,18	0,80	0,56	1,15	ns
Wealth Richest	0,15	0,21	1,16	0,75	1,79	ns
Number of Children	-0,07	0,03	0,92	0,86	0,98	p < 0.05
BMI Underweight	-0,72	0,35	0,48	0,23	0,97	p < 0.05
BMI Overweight	0,38	0,11	1,47	1,18	1,83	p < 0.001
BMI Obese	0,83	0,12	2,29	1,78	2,95	p < 0.001
Currently Working	0,01	0,10	1,01	0,82	1,24	ns

Table 30: Ordered logistic regression estimates for child overweight and obesity— Model 3

Model 3 - Overweight/Obesity						
Reference categories: No education, Male Child, Ethnicity Ladina, Religion Catholic, Rural Residence, Region Metropolitana, Wealth Poorest, BMI Normal, Currently Not Working						
(Intercept):1: OR = 7.27e+01 | SE = 1.481 | p = 0.004 (Intercept):2: OR = 1.30e+01 | SE = 1.473 | p = 0.082						
Variable	**Coef**	**SE**	**OR**	**Lower OR**	**Upper OR**	**P-value**
Primary	0,18	0,15	1,20	0,89	1,62	ns
Secondary	0,13	0,18	1,14	0,79	1,65	ns
Higher	0,32	0,27	1,38	0,80	2,37	ns
Age Child	0,03	0,00	1,03	1,02	1,04	p < 0.001
Female Child	0,10	0,10	1,11	0,91	1,35	ns
Age Mother	-0,01	0,01	0,98	0,96	1,01	ns
Ethnicity Maya	0,07	0,13	1,07	0,83	1,39	ns
Ethnicity Other	-0,49	0,27	0,60	0,35	1,03	ns
Religion Evangelical	0,26	0,10	1,29	1,04	1,60	p < 0.5
Religion No Religion	0,12	0,15	1,13	0,82	1,54	ns
Religion Other	-0,29	0,36	0,74	0,36	1,51	ns
Urban	0,10	0,14	1,11	0,84	1,47	ns
Region Norte	0,16	0,27	1,18	0,68	2,03	ns
Region Nororiente	-0,11	0,22	0,89	0,57	1,38	ns
Region Suroriente	-0,08	0,23	0,91	0,58	1,45	ns
Region Central	-0,14	0,21	0,86	0,56	1,31	ns
Region Suroccidente	0,07	0,21	1,07	0,70	1,64	ns
Region Noroccidente	-0,09	0,25	0,90	0,55	1,49	ns
Region Petén	0,71	0,34	2,05	1,03	4,06	p < 0.5
Height Mother	-0,00	0,00	0,99	0,97	1,01	ns
Wealth Poorer	0,22	0,15	1,25	0,92	1,69	ns
Wealth Middle	0,21	0,16	1,23	0,90	1,70	ns
Wealth Richer	0,27	0,20	1,31	0,89	1,95	ns
Wealth Richest	-0,16	0,23	0,84	0,53	1,34	ns
Number of Children	0,11	0,04	1,12	1,03	1,22	P < 0.01
BMI Underweight	0,78	0,49	2,19	0,83	5,80	ns
BMI Overweight	-0,41	0,12	0,66	0,51	0,84	p < 0.001
BMI Obese	-0,90	0,13	0,40	0,31	0,52	p < 0.001
Currently Working	-0,12	0,11	0,88	0,70	1,10	ns

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