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**„Factors Influencing Minimum Dietary Diversity
among Children Aged 6-23 Months in India: A Study of
Maternal Determinants and Child Health Status”**

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List of Abbreviations

BMI	Body Mass Index
DHS	Demographic Health Survey
FGscore	Food Group Score
GNMF	Global Nutrition Monitoring Framework
MDD	Minimum Dietary Diversity
MDD⁻	Not meeting the Minimum Dietary Diversity
MDD⁺	Meeting the Minimum Dietary Diversity
NFHS	National Family Health Survey
OR	Odds Ratio
PSU	Primary sampling units
SD	Standard Deviation
SDGs	Sustainable Development Goals
TEAM	Technical Expert Advisory group on nutrition
UN	United Nations
WHA	World Health Assembly
WHO	World Health Organization

Abstract

Introduction

Malnutrition continues to play a major role in many developing countries, but also in economically emerging countries. Inadequate feeding practices are a serious reason for the occurrence of malnutrition among young children, and its consequences are one of the big obstacles to sustainable socio-economic development and poverty reduction. Dietary diversity is one of the useful indicators for assessing nutrient intake among children. This study analyses the nutritional status of Indian children aged 6 - 23 months and examines possible factors influencing the improvement of the minimum dietary diversity of the children.

Methods

The study was based on nationally representative data from the National Family Health Survey of India 2019 - 21. The primary endpoint was Minimum Dietary Diversity (MDD) defined as reported consumption of a minimum of five out of eight indicator foods according to a 24-hour recall. A total of 64,725 children aged 6 - 23 months were included to estimate trends in MDD and identify factors associated with MDD. Multivariable linear and logistic regressions were performed to examine the association between potential determinants and MDD.

Results

The proportion of children, who achieved MDD, was at 22.9 %. Multivariable analyses indicated that children of older age, longer duration of breastfeeding, higher maternal education and higher maternal Body-Mass-Index (BMI) were associated with an increased likelihood of achieving MDD, with Odds Ratios (95 % Confidence Intervals) of age of child 18 - 23 months 3.01 (2.57 - 3.54) compared to 6 - 8 months, breastfeeding duration 18 - 23 months 1.82 (1.53 - 2.15) versus 6 - 8 months, higher maternal educational level 1.53 (1.36 - 1.7) in comparison with no education, overweight mother 1.2 (1.11 - 1.3) compared to normal weight. The models were adjusted for sex and age of the child, duration of breastfeeding, age, BMI, educational level and religion of the mother, household wealth, number of children in the household and type of place of residence. Also, the secondary analyses showed that higher maternal education had a strong influence on MDD achievement, as did higher BMI, but not wealth. Finally, certain food groups such as breastfeeding, cereals, roots and tubers, and dairy products were consumed more frequently by children who did not meet MDD, while consumption of vegetables, fruits, legumes, and nuts was insufficient.

Conclusion

The maternal educational level has a significant impact on the nutritional diversity of the child, highlighting the importance of targeted nutrition education and awareness programmes. Effective policies and counselling interventions are found to be effective as, maternal education shows positive impact on child nutrition irrespective of family wealth and type of residence. Interventions are needed to promote healthy eating habits and ensure a better future for Indian children.

Zusammenfassung

Einleitung

Unterernährung bleibt ein bedeutendes Problem in vielen Entwicklungsländern, einschließlich aufstrebender Wirtschaften, und hat weitreichende Auswirkungen auf die sozioökonomische Entwicklung und Armutsbekämpfung. Diese Studie analysiert den Ernährungszustand von indischen Kindern im Alter von 6 - 23 Monaten und untersucht Faktoren, die die Steigerung ihrer Ernährungsvielfalt beeinflussen können.

Methodik

Die Studie basiert auf landesweit repräsentativen Daten aus dem National Family Health Survey aus India 2019 - 21. Der primäre Endpunkt war die Mindestvielfalt in der Ernährung (Minimum Dietary Diversity, MDD), definiert als der berichtete Verzehr von mindestens fünf der acht Indikatorlebensmittel nach einem 24-Stunden-Protokoll. Insgesamt wurden 64.725 Kinder im Alter von 6 bis 23 Monaten eingeschlossen, um Trends bei MDD abzuschätzen und Faktoren zu identifizieren, die mit MDD in Verbindung stehen. Multivariable lineare und logistische Regressionen wurden durchgeführt, um den Zusammenhang zwischen potenziellen Determinanten und MDD zu untersuchen.

Ergebnisse

Der Anteil der Kinder, die MDD erreichten, lag bei 22,9 %. Multivariable Analysen ergaben, dass ein höheres Alter der Kinder, eine längere Stilldauer, eine höhere Bildung der Mutter und ein höherer mütterlicher Body-Mass-Index (BMI) mit einer erhöhten Wahrscheinlichkeit für das Auftreten von MDD verbunden waren, wobei die Odds Ratios (95 % Konfidenzintervalle) für das Alter des Kindes von 18 bis 23 Monaten 3,01 (2,57 - 3,54) im Vergleich zu 6-8 Monaten, Stilldauer 18-23 Monate 1,82 (1,53 - 2,15) im Vergleich zu 6-8 Monaten, höherer mütterlicher Bildungsstand 1,53 (1,36 - 1,7) im Vergleich zu keinem Bildungsstand, übergewichtige Mutter 1,2 (1,11 - 1,3) im Vergleich zu Normalgewicht. Die Modelle wurden für das Geschlecht und das Alter des Kindes, die Stilldauer, das Alter, den BMI, das Bildungsniveau und die Religion der Mutter, den Wohlstand des Haushalts, die Anzahl der Kinder im Haushalt und die Art des Wohnsitzes angepasst. Die Sekundäranalysen zeigten außerdem, dass ein höherer Bildungsgrad der Mutter einen starken Einfluss auf das Erreichen des MDD hatte, ebenso wie ein höherer BMI, nicht jedoch der Wohlstand. Schließlich wurden bestimmte Lebensmittelgruppen wie Stillen, Getreide, Wurzeln und Knollen sowie Milchprodukte häufiger von Kindern verzehrt, die den MDD nicht erreichten, während der Verzehr von Gemüse, Obst, Hülsenfrüchten und Nüssen unzureichend war.

Schlussfolgerung

Das Bildungsniveau der Mutter hat einen signifikanten Einfluss auf die Ernährungsvielfalt des Kindes, was die Bedeutung von gezielten Programmen zur Ernährungserziehung und -aufklärung unterstreicht. Es hat sich gezeigt, dass wirksame politische Maßnahmen und Beratungsinterventionen wirksam sind, da sich die Bildung der Mütter unabhängig vom Wohlstand der Familie und der Art des Wohnsitzes positiv auf die Ernährung der Kinder auswirkt. Es sind Maßnahmen erforderlich, um gesunde Ernährungsgewohnheiten zu fördern und eine bessere Zukunft für indische Kinder zu gewährleisten.

1 Introduction

Malnutrition continues to be a pressing challenge despite significant advancements across various facets of global development. Millions of individuals, especially infants and toddlers, still bear the devastating consequences of undernutrition. In a time when economic and technological progress define human development, the goal of "Zero Hunger," an integral component of the United Nations' (UN) Sustainable Development Agenda, remains a complex and unresolved issue [1].

1.1 Malnutrition: Definition and Terms

Malnutrition is a widespread global health issue that impacts the physical and cognitive development, growth, and survival of individuals worldwide. It covers both the lack of a balanced diet and imbalances or excesses in food intake [2]. It can manifest in several forms:

Overnutrition pertains to the intake of more calories and nutrients than the body requires, often in the form of high-calorie but nutrient-poor foods. This can lead to obesity, which, in turn, escalates the risk of heart diseases, diabetes, cancer, and other health issues. Overnutrition is an escalating problem globally, particularly in countries with increasing access to a Western-style diet [2].

Micronutrient deficiency occurs when the body does not receive sufficient essential vitamins and minerals, even when calorie intake is adequate, leading to potential health problems like anaemia and night blindness. [3]. Micronutrient deficiency is a prevalent concern in many developing nations and often affects children and pregnant women [3], [4].

The most commonly understood form of malnutrition is undernutrition and refers to a deficiency in adequate nutrients and calories. It results in stunted growth, muscle wasting, weakened immune systems, and an increased susceptibility to infections and diseases. Undernutrition often afflicts children in developing countries but is also a concern in developed nations, particularly among the elderly [2].

Malnutrition arises from a complex interplay of factors, often intertwined, spanning socioeconomic, cultural, and environmental dimensions. Socioeconomic factors, such as poverty, limited access to sufficient food, and inadequate educational opportunities, compounded by social disparities, stand as pivotal determinants driving malnutrition. Cultural and dietary habits profoundly influence nutrition, potentially resulting in either malnutrition or overnutrition. Environmental factors, including natural disasters, the impacts of climate change, conflicts, and contamination of water sources, contribute to the disruption of food availability and nutrition security [5].

1.1.1 Child Malnutrition

Malnutrition in children can take different forms. Stunting and wasting are two different manifestations of undernutrition in children that are associated with inadequate nutrition in different ways and then there is overnutrition [6]. The World Health Organization (WHO) uses anthropometric measurements such as height-for-age, weight-for-height and weight-for-age to assess and classify nutritional status to identify stunting, emaciation and underweight conditions [2]. These measurements are quantified and compared to the median of the reference population in terms of standard deviation units, often referred to as Z-scores. Figure 1 shows a visual representation of this concept [7].

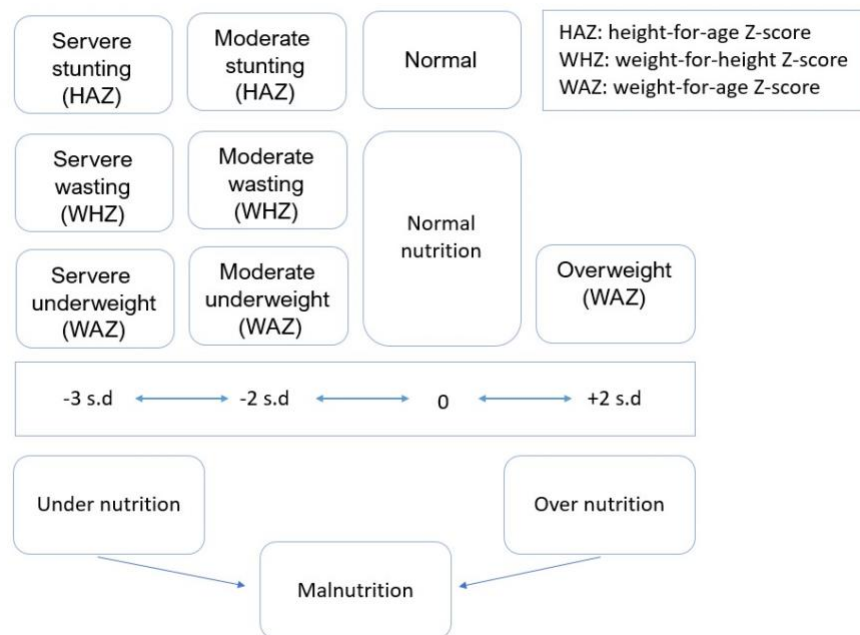


Figure 1 Pattern of malnutrition in children under the age of 5 years. Modified and adapted from Int J Environ Res Public Health - A scoping review of the risk factors associated with anaemia among children under five years in sub-Saharan African countries.

1.1.2 Overweight

Children under 5 are categorized as overweight if their weight-for-height Z-score is +2 standard deviations (s.d.) from the median of the reference population. Overweight in children is a growing health problem worldwide. This condition can have serious health consequences for young children. Factors contributing to childhood obesity include poor eating habits, lack of exercise and environmental factors. Childhood obesity not only increases the risk of immediate health problems such as diabetes and cardiovascular problems, but also sets the stage for long-term health problems in adulthood. Tackling childhood obesity requires a comprehensive approach that promotes healthy eating habits, regular physical activity, and a supportive environment to ensure the well-being of our youngest population [2], [7], [8].

1.1.3 Stunting

Stunting (height-for-age) in a child is defined as too short for his or her age with a height-for-age Z-score less than two standard deviations from the from the median of the reference population. It is a condition in which a child's height is below the expected range for his or her age. It is usually associated with poor living conditions, as low socio-economic status, poor maternal health, and results in inadequate nutrition during pregnancy and early childhood. Children affected by stunting can suffer profound and irreversible physical and cognitive impairments due to their stunted growth. The devastating effects of stunting can last a lifetime and even affect the well-being of the next generation [6], [7].

1.1.4 Wasting

Wasting is defined as low weight-for-height, where the Z-score is less than -2 s.d. from the median of the reference population. It is an extremely critical condition due to inadequate nutritional intake or recurrent illness. It is a child who is excessively thin in relation to their body size, often due to rapid weight loss or inability to gain weight. Children suffering from emaciation have weakened immune defences, making them vulnerable to prolonged developmental delays and an increased risk of death, especially in cases of severe emaciation. Timely identification and prompt treatment is critical for the survival of children with severe emaciation, although treatment is possible for moderately or severely emaciated children [6], [7].

Although childhood obesity is on the rise in the developing world, malnutrition remains the predominant problem for the time being which is why only child undernourishment is discussed in more detail below.

Stunting and wasting are different manifestations of malnutrition, they share the common denominator of inadequate nutrient intake. Children who are chronically malnourished can be both stunted (too short for their age) and wasted (too thin for their size), depending on how malnutrition affects their growth and condition.

It is important to emphasise that both conditions can have serious effects on children's health and long-term development. Therefore, the prevention and treatment of malnutrition in childhood is crucial to promote the health and well-being of the younger generation [2], [5].

1.1.5 Minimum Dietary Diversity for Children

One parameter to help identify malnutrition and nutritional deficiencies in children is Minimum Dietary Diversity (MDD). MDD refers to the diversity of food groups in a child's diet and plays a crucial role in ensuring a balanced diet and preventing malnutrition. This indicator was included

in the Global Nutrition Monitoring Framework (GNMF) in 2017, following a recommendation by the WHO-UNICEF Technical Expert Advisory group on nutrition Monitoring (TEAM) [9].

In general, the MDD records the diversity in the consumption of certain food groups by children aged 6 - 23 months within the last 24 hours. After the revision of the MDD definition in June 2017, an eighth food group was added to the original seven, namely breastfeeding. Thus, the eight food groups that are important for achieving minimum food diversity are:

- Food Group 1: Breastmilk
- Food Group 2: Grains, roots, and tubers
- Food Group 3: Legumes and nuts
- Food Group 4: Dairy products (milk, yogurt, cheese)
- Food Group 5: Flesh foods (meat, fish, poultry, liver, or other organs)
- Food Group 6: Eggs
- Food Group 7: Vitamin A-rich fruits and vegetables and
- Food Group 8: Other fruits and vegetables

One point is calculated per food group from which at least one food was consumed within the last 24 hours. The sum of the counted points gives the MDD score. Thus, if all foods were evaluated, the MDD score ranges from 0 to 8. The MDD itself is a dichotomous indicator that describes whether a diverse diet is present or not. The cut-off point for achieving MDD is an MDD score of ≥ 5 . A minimum level of dietary diversity is therefore achieved if foods from at least 5 of the 8 food groups have been consumed within the last 24 hours [3], [8].

Children aged 6-23 months are at a significant developmental stage, so malnutrition can have particularly critical effects for those of this age. The MDD can be used to better measure and document children's nutritional status and to target nutritional improvement. Achieving MDD requirements helps to reduce the likelihood of malnutrition in children. The MDD is therefore an important tool for assessing and improving children's food security and promoting their healthy development [1], [5].

1.2 „End hunger by 2030“ - Current status of malnutrition worldwide

In 2015, the UN and its member states set the goal of promoting sustainable development at the global level with the 2030 Agenda. To achieve this, 17 final main goals were set, which are to be reached by 2030 through smaller sub-goals. The second main goal of the Sustainable Development Goals (SDGs) stands for fighting hunger in the world, achieving food security and sustainable agriculture. Many positive developments have taken place worldwide in the last 15 years, but for the main goal "End hunger by 2030" it is already clear that this goal will not be achieved [10]–[12]. Figures 2 and 3 show the development of underweight in terms of prevalence at 5-year intervals since 2003. Figure 2 shows the total number of cases, whereas figure 3 the prevalence in percent illustrates.

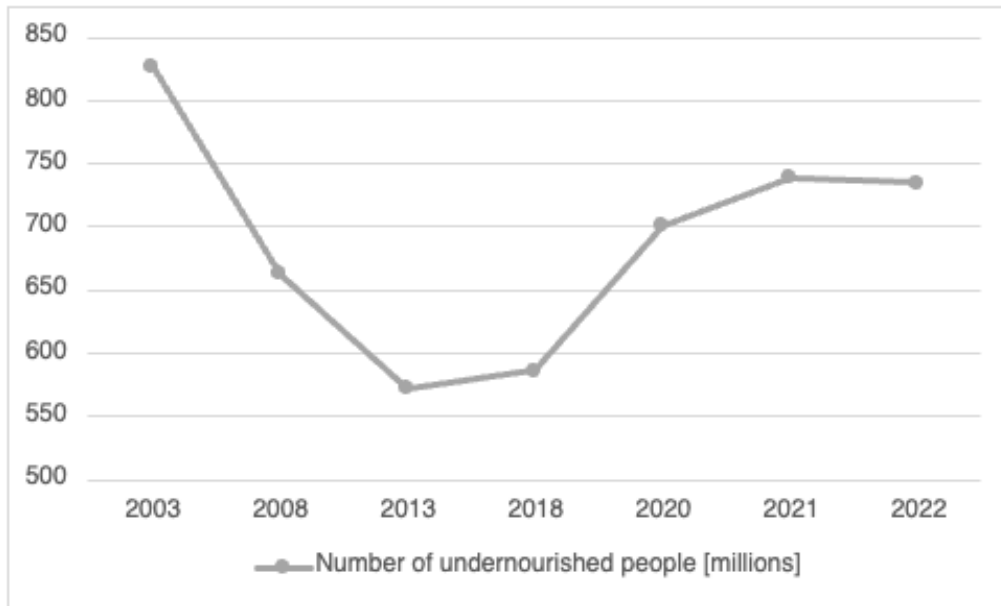


Figure 2 Trend in the total number of undernourished people worldwide 2003-2022. Modified and adapted from SDG Indicators Data Portal by the FAO.

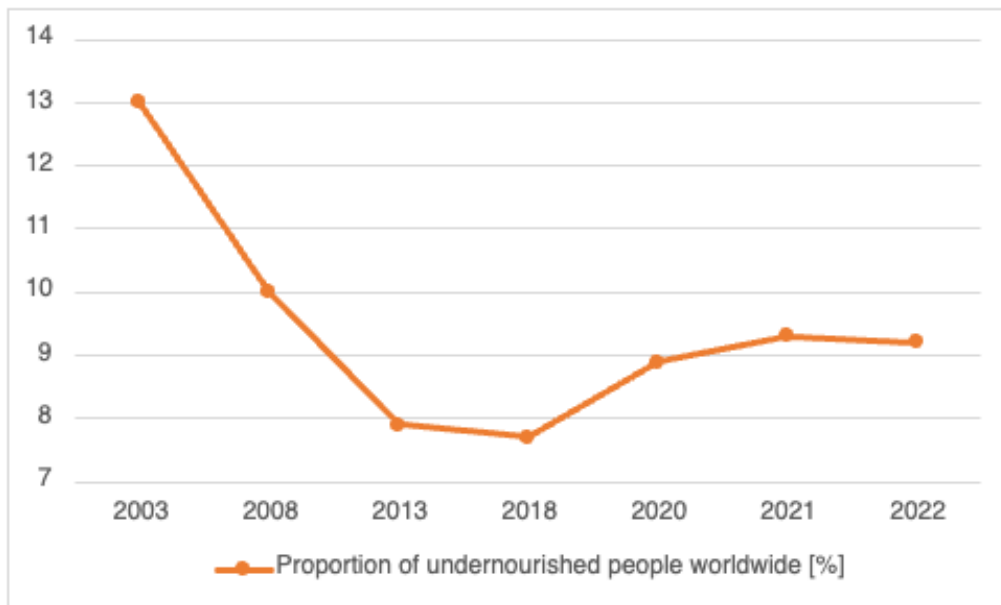


Figure 3 Trend in the proportion of undernourished people worldwide 2003-2022. Modified and adapted from SDG Indicators Data Portal by the FAO.

Since the turn of the millennium, the highest number of undernourished people was measured in 2002. With 827.8 million undernourished people, the prevalence in that year was 13.1 %. Since that year, there has been a downward trend worldwide. The lowest prevalence of was measured in 2017 (7.5 %) [13]. In the following years, the number of undernourished people has risen continuously. The last reported peak is from 2021 with 738.9 million undernourished people worldwide. This increase was particularly influenced by the Covid-19 pandemic. In addition to increasingly frequent climate-related disasters, such as storms, floods and droughts, the worsening situation and, ultimately, the war in Ukraine, also posed an additional threat to food

security. All of this, and the increasing social inequalities that accompany it, are affecting global food systems, with the poorest and most vulnerable in the system particularly struggling. In 2022, the number of underweight people fell slightly for the first time to 735.1 million, but is still far from the actual goal [11], [12], [14].

Child malnutrition

While undernutrition remains a global problem, it is especially troubling for the most vulnerable members of our population: children. Good nutrition is the basic need for children to thrive, grow, learn, play, and participate. Children are more vulnerable to macro- and micronutrient deficiencies caused by high demand for food during their years of growth. The effects of malnutrition in children under the age of 5 years include underweight, stunting, wasting and even death.

The goal of the SDGs to reduce child malnutrition and the global nutrition targets of the World Health Assembly (WHA) are not expected to be achieved by 2030. In 2022, 148.1 million children younger than 5 years old worldwide were stunted, 45 million were wasted and 37 million were overweight.

Looking at stunting and wasting over time, we see that since 2000, the overall proportion of children with both stunting and wasting has decreased. In 2000, the proportion of children suffering from stunting was 33 % and has decreased to 22.3 % by 2022. The proportion of wasted children has not been as dramatic as the proportion of stunted children from the beginning, which is why the proportion has only decreased to a lesser extent, from 8.7% to 6.8% (See Figure 4) [8], [15].

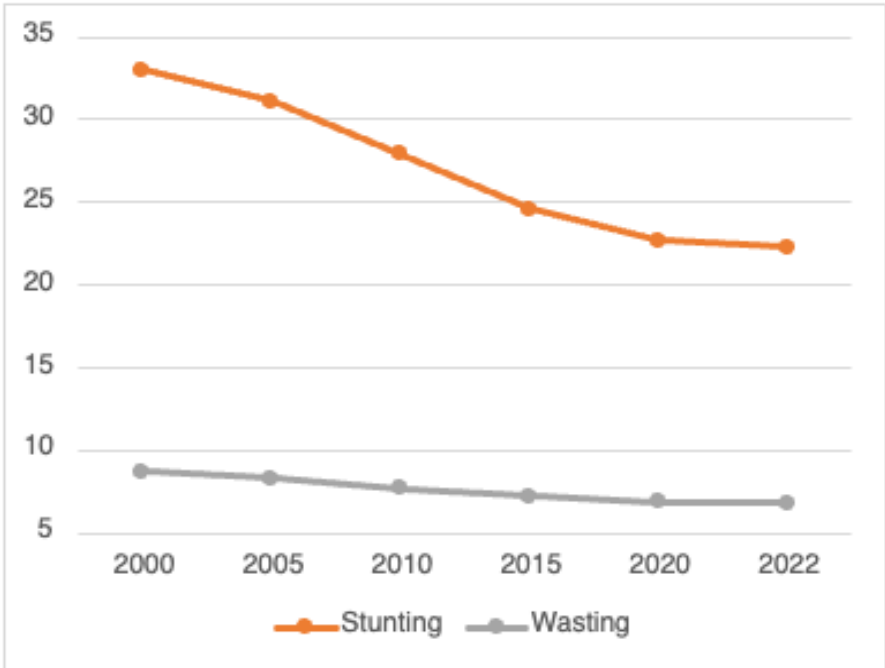


Figure 4 Percentage of children under 5 affected by stunting and wasting worldwide 2000-2022. Modified and adapted from UNICEF/WHO/The world Bank: Joint child malnutrition estimates (JME).

The proportion of stunting in children worldwide, but also in regional comparison, is strongly dependent on region. Most malnourished children come from South Asia and Sub-Saharan Africa. Figure 5 shows the global prevalence of stunted children in the time interval from 2010 to 2022, exemplified by a few years, compared to the prevalence broken down by region: Europe and Central Asia, South Asia, East Asia and Pacific, Middle East and North Africa, Sub-Saharan Africa and Latin America and Caribbean, as well as the SDG target (global): 50 % reduction 2012 – 2030 [16].

The prevalence of stunting in South Asia and Sub-Saharan Africa is significantly higher compared to the other regions. Two out of five children with stunting are from South Asia while another two of the five live in Sub-Saharan Africa [6], [15].

In 2022, about 6.8 % of children under 5 were affected by wasting, of which 2.1 % (13.6 million children) suffered from severe wasting. Over three-quarters of children affected by severe wasting are from South Asia, 22 % from Africa. This shows that South Asia has 2.5 times more wasted children than sub-Saharan Africa [16].

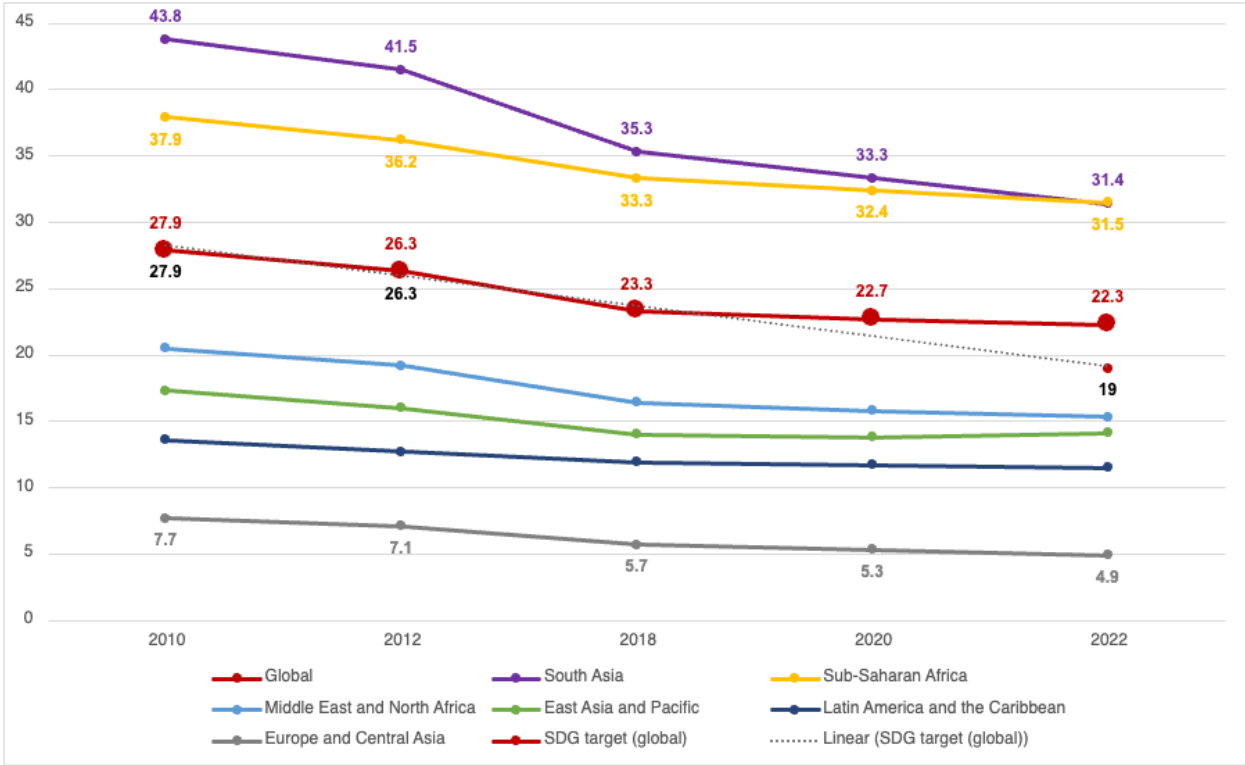


Figure 5 Global and Regional Prevalence for Stunting in Children. Estimates in % and global SDG target. Modified and adapted from worldbank blogs: new data expose alarming child malnutrition trends.

The Zero Hunger mission is not just a political statement, it is a community ethical principle and an issue of global concern [6], [17]. The challenges in achieving this goal, highlight that malnutrition, especially among young children, remains a major problem. In this context, understanding the importance of a diverse diet for young children's health is paramount.

1.3 Importance of dietary diversity for young children's health

Nutrition plays a crucial role in the physical and mental development of children. A balanced and varied diet is essential to ensure that children receive all the nutrients they need for healthy growth and optimal development [15].

A varied diet ensures that children receive a wide range of nutrients. Each group of nutrients has specific functions in the body, and a deficiency of any of these nutrients can lead to health problems. Studies have shown that children who do not eat a balanced diet often suffer from stunting and are associated with a double burden of malnutrition [18]. Stunting, in turn, is associated with an increased risk of infant mortality, increased susceptibility to infections, and poor cognitive and psychomotor development, which in turn can affect the child's performance at school and, later in life, their potential income [19]. Low dietary diversity is associated with increased cardiovascular risk [20], dyslipidemia and a higher likelihood of metabolic syndrome associated [21], [22]. The WHO report on stunting in childhood highlights the importance of the first 24 months in infant feeding, where the foundation is laid for a person's physical stature and physiological and intellectual abilities later in life [23].

Promoting dietary diversity in childhood can establish good eating habits in the long term and more potential can be fostered. When children are exposed to a variety of foods from an early age, they are more likely to make healthier choices later in life. This can help reduce the risk of diet-related diseases in adulthood [13], [15], [23].

Feeding practice

The WHO provides globally recognised and accepted guidelines for infant and young child feeding. The new-born should be breastfed immediately after birth and exclusively breastfed until 6 months of age. After that, the child needs more calories and nutrients than breast milk can provide. Therefore, a gradual introduction of solid and semi-solid foods is recommended from 6 months of age, in parallel with continued breastfeeding until 2 years of age [24].

Adequate complementary feeding of young children is known to be the most important factor in alleviating early childhood malnutrition [25]. To meet the needs of the growing infant, complementary foods should be varied, have sufficient energy density, and be introduced at the right time [26].

In 2010, the World Health Organization published a set of standardised indicators with minimum criteria for assessing the quality of complementary feeding. These include the timely introduction of complementary feeding, the minimum meal frequency, the minimum acceptable diets, and the minimum dietary diversity. This has allowed for a greater focus on complementary feeding, standardised cross-country comparisons, and assessments of predictors of poor practices [27].

Dietary diversity is a good predictor of micronutrient density in children's diets and has demonstrated its predictive value for child growth and development. It has been linked to various

factors, including aspects related to mothers and children, the resources available within households, and socio-cultural influences. Among these factors, the level of education, awareness, and knowledge that mothers possess regarding their children's eating habits is recognized as playing a significant role in determining the dietary diversity of these children [28].

1.4 Objectives

The aim of this master's thesis is to explore possible determinants of MDD achievement in children aged 6 - 23 months in India using the National Family Health Survey (NFHS-5) of 2019 - 21. Determinants of child, mother's area of influence and household circumstances will be explored.

Objective 1: To describe the potential determinants of MDD and its components among children aged 6 - 23 months in India.

Objective 2: To identify the socio-demographic determinants of MDD among children in India.

Objective 3: To further evaluate the determinants identified in Objective 2 to determine whether their associations with MDD vary in strength across different socioeconomic strata of the overall population.

These objectives collectively form the foundation of this research, allowing it to comprehensively examine the multifaceted factors influencing MDD in young children in India and provide valuable insights into the broader issue of child malnutrition.

2 Methods

2.1 The National Family Health Survey - Study Design

In this study, an empirical analysis was conducted using secondary data from the National Family Health Survey (NFHS-5) in India. The NFHS-5 survey was led and supervised by the Ministry of Health and Family Welfare, with coordination from the International Institute for Population Sciences (IIPS). Field agencies and research centres were part of the implementation process. The NFHS-5 is part of the Demographic Health Survey (DHS) Program [29]. Being included in this programme means receiving technical assistance in data collection and dissemination, strengthening local capacity in all areas of survey design, implementation, and data analysis, and improving access to and ease of use of survey results. The surveys cover health-related topics such as fertility, family planning, HIV, malaria, maternal and child health, and nutritional status of women and children [2, 3].

Access to the data was obtained by submitting a project description request on the DHS website. Upon approval of the application, the data was made available for download and usage.

2.2 Data Collection and Sample Design

The sample size for NFHS-5 was determined based on several considerations, with a focus on producing indicators at the district and state/union territory levels. A stratified, two-stage sample design was used for the survey, which is representative at the national, state and district levels. Stratification was done for urban and rural areas, with further sub-stratification in rural areas based on village population and percentage of population belonging to scheduled castes and scheduled tribes (SC/ST). Primary sampling units (PSUs) were selected within the explicit rural and urban sampling strata, with PSUs sorted by literacy rate and percentage of SC/ST population, respectively. The objective of the survey was to obtain information on various issues at the state and district levels [30].

The interviews were conducted with women aged 15 - 49 years, and children aged 0 - 59 months. In addition, men aged 15 - 54 were interviewed in a separate survey. Information was collected from 636.699 households, 724.115 women and 101.839 men during this survey [30].

Prior to participating in the survey, all participants were fully informed about the survey process and were given consent. Their participation in the survey was entirely voluntary and strict measures were taken to ensure the confidentiality and anonymity of the data collected. In addition, the protocol for the NFHS-5 survey, including the content of the questionnaires, was approved by the IIPS Institutional Review Board and the ICF Institutional Review Board. The protocol was also reviewed by the U.S. Centres for Disease Control and Prevention [2, 4].

The household visits and data collection through questionnaires for NFHS-5 in India was divided into two distinct phases. Phase one occurred from 17 June 2019 to 30 January 2020, while phase two took place from 2 January 2020 to 30 April 2021. A total of 17 field agencies were involved in carrying out the fieldwork and their coordinators were responsible for training the fieldworkers involved [30].

During the household visits, trained health assessors conducted blood pressure measurement, blood-based biomarker collection and anthropometric measurements. Height and weight were measured in children aged 0 - 59 months, women aged 15 - 49 years and men aged 15 - 54 years. The Seca 874 digital scale was used to measure the weight of children and adults. For adults and children aged 24-59 months, height was measured using the Seca 213 stadiometer. For children under two years of age or under 85 cm in length, the Seca 417 Infantometer was used to measure length while lying down. The measurements of length and height as well as the age of the child were used to calculate the variables height-for-age, weight-for-height and weight-for-age. These indices give information over the body composition of the child and provide information about their nutritional status [33].

During the NFHS-5 survey, several health assessments were conducted to gather crucial information. Anaemia testing involved collecting blood specimens from eligible women, men, and children to analyse their haemoglobin levels. Blood glucose testing involved measuring random blood glucose levels in women and men. Blood pressure measurements were taken for women and men to assess the prevalence of hypertension. Another aspect of the survey was the Dried Blood Spot (DBS) collection, which involved collecting samples for various biomarkers. This included malaria parasites and drug resistance testing, HbA1c testing to evaluate diabetes control at the population level and measuring Vitamin D3 levels to identify deficiencies. For malaria testing, DBS samples were collected to diagnose malaria and detect markers of antimalarial drug resistance. HbA1c testing utilized DBS samples to assess diabetes management strategies and guide policymakers in program planning. Furthermore, DBS collection facilitated the determination of Vitamin D3 levels, which is crucial due to the prevalence of deficiencies and their impact on the development of Osteopenia and osteoporosis [30].

Respondents with severe anaemia, high blood glucose levels, or elevated blood pressure readings were referred to health facilities for further evaluation and appropriate medical treatment. The analysis was mainly based on socio-economic data and demographic data requested in the survey. Further information regarding the methods of data collection can be found on the DHS website [34].

2.3 Data Preparation and Statistical Analysis

The statistical analyses were conducted using IBM SPSS Statistics for Mac, Version 29.0 (IBM Corp., Armonk, NY, U.S.). To examine the objectives of this dissertation, descriptive statistics

were applied, along with multivariable logistic and linear regression models. All computations were adapted to accommodate the cluster sample design and sample weights, ensuring that all presented results were fully survey-weighted, in accordance with the recommendations of the DHS program. For the graphical visualization of the results Microsoft Excel was used.

From the NFHS-5 in India, the Children's Recode (KR) was used for the analysis. This dataset contains information on 232,920 children under 5 years of age of an interviewed mother aged between 15 and 49 years. For calculating MDD in children, the unit of analysis is the youngest child in the age between 6 and 23 months, according to the DHS guidelines [35]. Consequently, data from children under the age of 6 months and older than 23 months were excluded from the analysis. In addition, all cases were removed from the dataset where the mothers did not provide any information on food given to the child in the last 24 h before the interview. The final sample size included 64,725 children.

To examine nutritional status in relation to MDD, the information provided in the questionnaire about food consumption in the 24 hours prior to the interview was categorized into respective food groups according to the Guide to DHS Statistics DHS-7 (see Table 1)[35].

Table 1 Food group classification

Food group [FG]	Food group name	Variable name	Variable label
FG1	Breastmilk	M4	Duration of breastfeeding
FG2	Grains, roots, tubers	V412A	Gave child fortified baby food (cerelac, etc)
		V414E	Gave child bread, noodles, other made from grains
		V414F	Gave child potatoes, cassava, or other tubers
FG3	Legumes and nuts	V414O	Gave child food made from beans, peas, lentils, nuts
FG4	Dairy products infant formula, milk, yogurt, cheese	V411	Gave child tinned, powdered or fresh milk
		V411A	Gave child baby formula
		V414V	Gave child yogurt
		V414P	Gave child cheese, yogurt, other milk products
FG5	Flesh foods meat, fish, poultry and liver/organ meats	V414M	Gave child liver, heart, other organs
		V414N	Gave child fish or shellfish
		V414T	Gave child other meat
FG6	Eggs	V414G	Gave child eggs
FG7	Vitamin A rich fruits and vegetables	V414I	Gave child pumpkin, carrots, squash (yellow or orange inside)
		V414J	Gave child any dark green leafy vegetables
		V414K	Gave child mangoes, papayas, other vitamin A fruits
FG8	Other fruits and vegetables	V414L	Gave child any other fruits

Each child was given a food group score (FGscore) ranging from 0 to 8, with 1 point awarded for each food group from which at least one food was consumed in the last 24 h. The FGscore was calculated from the number of food groups consumed. FGscore was divided into a binary variable

(FGscore_cat): MDD not reached (MDD⁻) if FGscore < 5 and MDD reached (MDD⁺) if FGscore ≥ 5.

The socio-economic and demographic data described in the following were used as covariates for the descriptive analysis and the multivariable regression models. Some of these variables had already been divided into predefined categories in the data collection and were used for this analysis without change. Sex of child was divided in male and female, type of place of residence in urban and rural.

Child's age in month was grouped into 6 - 8, 9 - 11, 12 - 17 and 18 - 23 months. The birth order number of the child was retained for the first-born children up to the third born and children born as the fourth child or later were combined as category 4+ due to the low number of cases. The variables height-at-age, weight-at-age and weight-at-age were categorised according to WHO guidelines to analyse the prevalence of stunting, wasting and underweight among children [33]. The duration of breastfeeding was grouped into 0 - 5, 6 - 8, 9 - 11, 12 - 17 and 18 - 23 months. The mother's age was divided into 5-year age groups: 15 - 19, 20 - 24, 25 - 29, 30 - 34 and 35+. BMI was categorised for descriptive statistics into underweight (< 18.5 kg/m²), normal weight (18.5 - 24.9 kg/m²) and overweight (≥ 25 kg/m²). Since the number of obese mothers is only a small part of the sample and thus does not make a meaningful subgroup, overweight and obesity were combined. The education level was divided into no education, primary, secondary, and higher as indicated and later simplified in the secondary analyses by combining no education and primary education to low education level, renaming secondary level to middle and higher to high education level. The religious affiliation of the mother was divided into three groups: the two predominant religions, Hindu and Muslim, and all other faiths were grouped together as "other", as they represent only a minor proportion in the survey. To allow comparisons of wealth's influence on health and nutrition indicators the wealth index is calculated by asking information about a household's ownership of certain assets in the questionnaire (e.g.: Ownership of televisions, bicycles, the type of water sources and sanitation facilities in the household). These data are then processed using principal component analysis to position each household on a continuous scale representing its relative wealth. In the DHS, all households surveyed are classified into five wealth categories. Wealth was examined in the descriptive statistics both with the original Wealth Index division into poorest, poorer, middle, richer, and richest and a simplified variable in which the two lowest categories were combined into poor and the two wealthier categories into rich. The initial nominal categorisation of the number of living children, ranging from 0 to 12, was subsequently restructured into discrete values of 0, 1, 2, 3, 4, and 5+.

Descriptive statistics were used to get an overview of the children's nutritional status and their socio-economic environment as well as to show trends in possible influencing factors. All descriptive evaluations were weighted in the survey, according to the DHS guidelines [35]. The

frequency distributions of the variables of interest were looked at and possible relationships and trends between two variables were examined with the help of cross-classification. Possible determinants were considered both gender-specifically and their proportions for MDD⁻ and MDD⁺ were examined (see results).

In the primary model, all important determinants, like gender, age and duration of breastfeeding of the child, age BMI, education level and religion of the mother, as well as household characteristics, such as, wealth, type of place of residence and number of living children, were examined for possible associations and confounding factors using logistic regression. The determinants were tested for the achievement of the MDD, and their odds ratios were shown within the main model.

As a secondary analysis, determinants identified in Objective 2 were examined if they show differential associations with MDD by socioeconomic factors. BMI was cross-classified with the maternal education level to examine a possible difference between obesity in poorer families versus obesity in wealthier families. For this the BMI was divided into low and high BMI with a cut-off point of $25 \text{ kg/m}^2 < \text{BMI} \leq 30 \text{ kg/m}^2$ to generate bigger sub-sample groups. Subgroups of this model were then analysed for trends in child MDD achievement. These pre-specified secondary analyses were carried out against the background of the Obesity Transition and the trend of increasing BMIs in India [36]. Similarly, the variables education and wealth were combined to investigate whether meeting the MDD might show differences between poor educated and rich educated or poor uneducated and richer uneducated mothers. In addition, it was investigated whether the determinants from the main analysis could also be used to predict the prevalence of the consumption of individual food groups. As well as whether different patterns of consumption are evident according to the religion of the mother. The logistic regression model was also used for this purpose. All logistic regression models were adjusted by age and sex of child, breastfeeding duration and the age, BMI, religion and education level of the mother, number of living children in the household, type of place of residence, and wealth.

3 Results

3.1 General Study Characteristics

3.1.1 Study Population

The sample was defined after data preparation as the youngest child aged between 6 and 23 months of an interviewed mother and consists of n = 64.725 children. Summary Table 2 and 3 show all relevant socio-economic and demographic background characteristics of the study sample and their gender proportions.

Table 2 Background child characteristics of children aged 6-23 months of the NFHS-5 (gender-specific), India (N= 64.725). Values are survey weighted.

Background characteristics	Count [%]	Male	Female
Child characteristics			
Sex of child		33.469 (51.7 %)	31.256 (48.3 %)
Age [months]			
6-8	14.447 (22.4 %)	7.411 (22.1 %)	7.036 (22.7 %)
9-11	11.088 (17.2 %)	5.738 (17.2 %)	5.350 (17.2 %)
12-17	22.116 (33.7 %)	11.473 (33.8 %)	10.643 (33.6 %)
18-23	17.074 (26.7 %)	8.847 (26.9 %)	8.227 (26.5 %)
Breastfeeding status			
Still breastfeeding	55.389 (84.9 %)	28.810 (85.6 %)	26.579 (84.2 %)
Not breastfeeding	9.336 (15.1 %)	4.659 (14.4 %)	4.677 (15.8 %)
Still breastfeeding [months]*			
6-8	13.526 (24.7 %)	6.926 (24.1 %)	6.600 (25.2 %)
9-11	10.062 (18.3 %)	5.214 (18.3 %)	4.848 (18.4 %)
12-17	18.694 (33.1 %)	9.760 (33.3 %)	8.934 (32.9 %)
18-23	13.107 (23.9 %)	6.910 (24.3 %)	6.197 (23.4 %)
Dietary diversity score			
0	1.059 (1.6 %)	535 (1.5 %)	524 (1.7 %)
1	13.434 (20.8 %)	6.824 (20.2 %)	6.610 (21.4 %)
2	12.152 (19.2 %)	6.302 (19.2 %)	5.850 (19.2 %)
3	12.647 (19.9 %)	6.626 (20.3 %)	6.021 (19.4 %)
4	9.881 (15.6 %)	5.137 (15.6 %)	4.744 (15.5 %)
5	6.811 (10.5 %)	3.551 (10.6 %)	3.260 (10.3 %)
6	4.014 (5.9 %)	2.052 (5.9 %)	1.962 (5.9 %)
7	2.601 (3.6 %)	1.306 (3.7 %)	1.295 (3.5 %)
8	2.126 (2.9 %)	1.136 (3.0 %)	990 (2.9 %)

*N(still breastfeeding) = 55.389 [28.810/26.579]

Table 3 Background maternal and household characteristics of children aged 6-23 months of the NFHS-5 (gender-specific), India (N= 64.725). Values are survey weighted.

Background characteristics	Count [%]	Male	Female
Maternal characteristics			
BMI**			
Underweight	15.537 (25.5 %)	8.156 (26.2 %)	7.381 (24.9 %)
Normal weight	39.399 (58.7 %)	20.278 (58.4 %)	19.121 (59.1 %)
Overweight	9.756 (15.7 %)	5.018 (15.4 %)	4.738 (16.0 %)
Age [years]			
15-19	2.582 (4.5 %)	1.301 (4.3 %)	1.281 (4.7 %)
20-24	23.742 (38.4 %)	12.130 (37.8 %)	11.612 (39.0 %)
25-29	23.903 (37.0 %)	12.505 (37.5 %)	11.398 (36.5 %)
30-34	10.177 (14.6 %)	5.326 (15.0 %)	4.851 (14.1 %)
35+	4.321 (5.5 %)	2.207 (5.3 %)	2.114 (5.7 %)
Highest education level			
No education	12.509 (18.7 %)	6.419 (18.6 %)	6.090 (18.9 %)
Primary	7.621 (11.2 %)	3.915 (11.1 %)	3.706 (11.2 %)
Secondary	34.586 (52.4 %)	17.898 (52.5 %)	16.688 (52.4 %)
Higher	10.009 (17.7 %)	5.237 (17.9 %)	4.772 (17.5 %)
Talked about Nutrition/Health Education in last 3 months			
no	62.529 (96.5 %)	32.313 (96.5 %)	30.216 (96.6 %)
yes	2.196 (3.5 %)	1.156 (3.5 %)	1.040 (3.4 %)
Religion			
Hindu	47.909 (79.4 %)	24.858 (79.6 %)	23.051 (79.2 %)
Muslim	91.85 (16.3 %)	4.727 (16.1 %)	4.458 (16.6 %)
Other	7.631 (4.3 %)	3.884 (4.3 %)	3.747 (4.2 %)
Household characteristics			
Wealth (simple)			
Poor	31.957 (45.1 %)	16.383 (44.8 %)	15.574 (45.6 %)
Middle	12.792 (20.0 %)	6.658 (20.2 %)	6.134 (19.7 %)
Rich	19.976 (34.9 %)	10.428 (35 %)	9.548 (34.8 %)
Wealth			
Poorest	16.988 (23.8 %)	8.711 (23.6 %)	8.277 (23.9 %)
Poorer	14.969 (21.4 %)	7.672 (21.1 %)	7.297 (21.6 %)
Middle	12.792 (20.0 %)	6.658 (20.2 %)	6.134 (19.7 %)
Richer	11.067 (18.6 %)	5.764 (18.5 %)	5.303 (18.8 %)
Richest	8.909 (16.2 %)	4.664 (16.5 %)	4.245 (16.0 %)
Type of residence			
Urban	13.086 (26.5 %)	6.730 (26.3 %)	6.356 (26.7 %)
Rural	51.639 (73.5 %)	26.739 (73.7 %)	24.900 (73.3 %)
Number of living children			
1	24.892 (39.1 %)	12.825 (39.2 %)	12.067 (38.9 %)
2	22.984 (36.4 %)	11.802 (35.9 %)	11.182 (37.0 %)
3	9.879 (14.9 %)	5.228 (15.2 %)	4.651 (14.6 %)
4+	6.970 (9.6 %)	3.614 (9.7 %)	3.356 (9.5 %)

**N(BMI) = 64.692 [33.452/31.240]

Child characteristics

The genders are relatively evenly represented in the unit of analysis. 51.7 % are boys, 48.3 % girls. The age categories of the children are also roughly equal and there are no differences between the genders.

The breastfeeding status for both boys and girls at the time of the survey is currently breastfeeding for the majority of children at around 85 %. Only 15.1 % of the children are breastfed for less than the 6 months recommended by the WHO [37]. The duration of breastfeeding at the time of the survey was also looked at for the currently breastfed children. More than half (57 %) of the currently breastfed children were between 12 and 23 months old at the time of the survey. Only 22.9 % of children reached the recommended MDD, with slightly fewer girls (22.7 %) than boys (23.2 %). Over a third (41.6 %) of the children even consumed only ≤ 2 food groups. Here, the difference between the genders is somewhat more noticeable: while 40.9 % of the boys ate ≤ 2 food groups, the rate for girls was 42.3 %.

Maternal characteristics

The mother's BMI was divided into three categories: underweight ($< 18.5 \text{ kg/m}^2$), normal weight ($18.5 - 24.9 \text{ kg/m}^2$) and overweight ($\geq 25 \text{ kg/m}^2$). The largest group represented is normal weight (58.7 %). In this sample, there are more underweight mothers (25.5 %) than overweight mothers (15.7 %).

Three quarters of the mothers are between 20 and 29 years old. Only a few are younger (15 - 19 years = 4.5 %) and about 20 % are 30 years and older.

Half of the mothers have secondary school as their highest education level. One third are below that with no education or primary school and 17.7 % have a higher level of education. The mothers were also asked if they had talked about nutrition or health education in the last 3 months, with almost all (96.5 %) answering "no".

Most mothers are Hindu with 79.4 %, 16.3 % are Muslim and 4.3 % belong to other faiths.

Household characteristics

The more detailed Wealth Index is relatively evenly distributed, although it is already clear that the poorest group is the largest with 23.8 %. This becomes clearer when the two poorer groups and the two wealthier groups are combined. 45.1 % belong to the poorest households and 34.9 % to the wealthiest.

About two-thirds of households live in rural areas and slightly less than one-third in urban areas. Most households have one or two children, about one third have three children or more (24.5 %).

Gender differences

The descriptive analysis of the sample shows no differences between the genders of the children.

3.1.2 Minimum Dietary Diversity

In the following chapter, the relevant socio-economic and demographic background characteristics from the previous chapter are presented across MDD categories: not meeting MDD (MDD⁻) and meeting the MDD (MDD⁺) (Table 4, 5 and 6).

Table 4 Background child characteristics of children aged 6-23 months from NFHS-5, India, divided into MDD⁻ and MDD⁺. The values are survey weighted.

Background characteristics	Count [%]	MDD ⁻	MDD ⁺
Child characteristics			
Sex of child	64.725	49.173	15.552
Male	33.469 (51.7 %)	25.424 (51.6 %)	8.045 (52.3 %)
Female	31.256 (48.3 %)	23.749 (48.4 %)	7.507 (47.7 %)
Age [months]	64.725	49.173	15.552
6-8	14.447 (22.4 %)	12.908 (26.0 %)	1.539 (10.2 %)
9-11	11.088 (17.2 %)	8.708 (17.8 %)	2.380 (15.2 %)
12-17	22.116 (33.7 %)	15.854 (32.2 %)	6.262 (39.0 %)
18-23	17.074 (26.7 %)	11.703 (24.0 %)	5.371 (35.6 %)
Breastfeeding status	64.725	49.173	15.552
Still breastfeeding	55.389 (84.9 %)	41.694 (83.8 %)	13.695 (88.6 %)
Not breastfeeding	9.336 (15.1 %)	7.479 (16.2 %)	1.857 (11.4 %)
Still breastfeeding [months]	55.389	41.694	13.695
6-8	13.526 (24.7 %)	12.055 (28.9 %)	1.471 (11.1 %)
9-11	10.062 (18.3 %)	7.805 (19.0 %)	2.257 (16.3 %)
12-17	18.694 (33.1 %)	13.137 (31.2 %)	5.557 (39.3 %)
18-23	13.107 (23.9 %)	8.697 (20.9 %)	4.410 (33.3 %)
Stunting	62.099	47.124	14.975
Yes	18.607 (30.1 %)	13.918 (29.7 %)	4.689 (31.6 %)
Normal weight	38.266 (62.0 %)	29.206 (62.3 %)	9.060 (60.7 %)
Missing value	5.226 (7.9 %)	4.000 (8.0 %)	1.226 (7.7 %)
Wasting	62.118	47.141	14.977
Wasted	11.421 (18.9 %)	8.615 (18.3 %)	2.806 (19.7 %)
Normal weight	43.683 (70.7 %)	33.145 (70.3 %)	10.538 (70.2 %)
Overweight	1.787 (2.5 %)	1.381 (2.9 %)	406 (2.4 %)
Missing value	5.227 (7.9 %)	4.000 (8.5 %)	1.227 (7.7 %)
Dietary diversity score	64.725		
Not meeting MDD		49.173	15.552
0	1.059 (1.6 %)	1.059 (2.1 %)	-
1	13.434 (20.8 %)	13.434 (27.0 %)	-
2	12.152 (19.2 %)	12.152 (24.9 %)	-
3	12.647 (19.9 %)	12.647 (25.8 %)	-
4	9.881 (15.6 %)	9.881 (20.2 %)	-
Total	49.173 (77.1 %)	-	-
Meeting MDD			
5	6.811 (10.5 %)	-	6.811 (45.6 %)
6	4.014 (5.9 %)	-	4.014 (25.8 %)
7	2.601 (3.6 %)	-	2.601 (15.8 %)
8	2.126 (2.9 %)	-	2.126 (12.8 %)
Total	15.552 (22.9 %)	-	-

Table 5 Background characteristics including child's food group consumption, maternal and household characteristics from NFHS-5, India, divided into MDD⁻ and MDD⁺. The values are survey weighted.

Background characteristics	Count [%]	MDD ⁻	MDD ⁺
Child characteristics			
Food group consumption			
Breastfeeding	-	41.694 (83.8 %)	13.695 (88.6 %)
Grains, roots, tubers	-	27.603 (56.4 %)	15.023 (96.6 %)
Legumes and nuts	-	2.922 (5.8 %)	8.894 (56.6 %)
Dairy products	-	20.288 (43.5 %)	12.668 (82.7 %)
Flesh foods	-	1.322 (2.3 %)	7.175 (42.3 %)
Eggs	-	2.773 (6.1 %)	8.730 (55.4 %)
Vitamin A rich fruits and vegetables	-	12.780 (25.4 %)	14.416 (91.9 %)
Other fruits and vegetables	-	5.821 (11.8 %)	12.753 (81.6 %)
Maternal characteristics			
BMI	64.692	49.173	15.552
Underweight	15.537 (25.5 %)	12.096 (26.1 %)	3.441 (23.7 %)
Normal weight	39.399 (58.7 %)	29.988 (58.9 %)	9.411 (58.0 %)
Overweight	9.756 (15.7 %)	7.064 (14.9 %)	2.692 (18.3 %)
Age [years]	64.725	49.173	15.552
15-19	2.582 (4.5 %)	2.029 (4.4 %)	553 (4.7 %)
20-24	23.742 (38.4 %)	18.591 (39.0 %)	5.151 (36.5 %)
25-29	23.903 (37.0 %)	18.094 (37.1 %)	5.809 (37.0 %)
30-34	10.177 (14.6 %)	7.393 (14.3 %)	2.784 (15.6 %)
35+	4.321 (5.5 %)	3.066 (5.3 %)	1.255 (6.2 %)
Highest education level	64.725	49.173	15.552
No education	12.509 (18.7 %)	9.867 (19.7 %)	2.642 (15.5 %)
Primary	7.621 (11.2 %)	5.825 (11.3 %)	1.796 (10.6 %)
Secondary	34.586 (52.4 %)	26.069 (51.8 %)	8.517 (54.5 %)
Higher	10.009 (17.7 %)	7.412 (17.2 %)	2.597 (19.4 %)
Talked about Nutrition/Health Education in last 3 months	64.725	49.173	15.552
No	62.529 (96.5 %)	47.644 (96.9 %)	14.885 (95.4 %)
Yes	2.196 (3.5 %)	1.529 (3.1 %)	667 (4.6 %)
Religion	64.725	49.173	15.552
Hindu	47.909 (79.4 %)	37.466 (80.5 %)	10.443 (75.7 %)
Muslim	91.85 (16.3 %)	6.754 (15.6 %)	2.431 (18.8 %)
Other	7.631 (4.3 %)	4.953 (3.9 %)	2.678 (5.5 %)
Household characteristics			
Wealth (simple)	64.725	49.173	15.552
Poor	31.957 (45.1 %)	24.525 (45.8 %)	7.432 (43.0 %)
Middle	12.792 (20.0 %)	9.707 (19.9 %)	3.085 (20.3 %)
Rich	19.976 (34.9 %)	14.941 (34.4 %)	5.035 (36.6 %)
Wealth	64.725	49.173	15.552
Poorest	16.988 (23.8 %)	13.033 (24.1 %)	3.955 (22.7 %)
Poorer	14.969 (21.4 %)	11.492 (21.7 %)	3.477 (20.4 %)
Middle	12.792 (20.0 %)	9.707 (19.9 %)	3.085 (20.3 %)
Richer	11.067 (18.6 %)	8.289 (18.3 %)	2.778 (19.7 %)
Richest	8.909 (16.2 %)	6.652 (16.0 %)	2.257 (16.9 %)
Type of residence	64.725	49.173	15.552
Urban	13.086 (26.5 %)	9.773 (26.0 %)	3.313 (28.1 %)
Rural	51.639 (73.5 %)	39.400 (74.0 %)	12.239 (71.9 %)

Table 6 Background household characteristic number of living children from NFHS-5, India, divided into MDD⁻ and MDD⁺. The values are survey weighted.

Background characteristics	Count [%]	MDD ⁻	MDD ⁺
Number of living children	64.725	49.173	15.552
1	24.892 (39.1 %)	19.108 (39.0 %)	5.784 (39.3 %)
2	22.984 (36.4 %)	17.177 (35.8 %)	5.807 (38.7 %)
3	9.879 (14.9 %)	7.641 (15.4 %)	2.238 (13.4 %)
4+	6.970 (9.6 %)	5.247 (9.9 %)	1.723 (8.6 %)

Child characteristics

Examining the gender distribution with regarding to the achievement of MDD, there are no differences between boys and girls. While the overall percentage of boys stands at 51.7 %, the MDD+ group's percentage of boys increases marginal to 52.3 %, whereas for girls, it slightly decreases from 48.3 % to 47.7 %. There are no changes for MDD⁻ group in the distribution of gender observed.

The breakdown by age indicates that a larger percentage of younger children (6 - 8 months) fall short of meeting the MDD criteria. Moreover, the proportion of children older than 12 months who fulfill the MDD standards is clearly higher than for those who do not. While there are 22.4 % 6 – 8-month-old children, the proportion of this age group increases to 26.0 % when children who do not reach MDD are considered separately. The prevalence for children in this age range for MDD+ is significantly lower (10.2 %). In the oldest age group, children between 18 and 23 months, the trend is reversed: the proportion of children meeting MDD is higher (35.6 %) than the general proportion of children of this age (26.7 %).

The majority of children are still breastfed at the time of the study (84.9 %). Within the MDD group, the percentage of children who are currently breastfeeding and those who are no longer breastfeeding is about the same, whereas the percentage of children who are currently breastfeeding is even higher in the MDD+ group (88.6 %) than in the general comparison. Looking at the duration of breastfeeding, the proportions within the MDD children remain equally distributed. For MDD+, the distribution shifts to more children breastfed for longer, compared to the general proportion. Almost three quarters of children who reach MDD are breastfed for 12 months or longer.

For stunting and wasting, there are no significant deviations from the baseline when divided into MDD+ and MDD⁻. In general, the proportion of normal-weight children is highest. Overweight is still very rare with 2.5 % of children aged 6-23 months, whereas 30.1 % of children are Stunted and 18.9 % Wasted.

The Dietary Diversity Score shows that half of the children who do not reach MDD even eat only ≤ 2 food groups. Within the MDD+ cohort, it shows that almost half of the children only reach the threshold of 5 food groups to be consumed, which is considered the minimum score for reaching MDD.

Next, the study looked at which food groups were consumed by children based on whether they reached MDD or not. Breastfeeding was the most frequently mentioned food group among children who did not reach MDD, at 83.8 %. The majority of children who achieve MDD are also breastfed (88.9 %). Otherwise, in the MDD⁻ group, food group 2 (grains, roots, tubers) was consumed by 56.4 % and food group 4 (dairy products) by 43.5 % of the children in the last 24 h before the interview. Only a few reported food groups 3 (legumes and nuts), 5 (flesh foods) and 6 (eggs) as consumed.

Among the children who reached MDD, food group 2 (grains, roots tubers) was most frequently reported (96.6 %). Significantly more percentages than in MDD⁻ indicated food group 7 (Vitamin A rich fruits and vegetables = 91.9 %) and food group 8 (other fruits and vegetables = 81.6 %). As with MDD⁻, the proportion of dairy products was also high (82.7 %).

Maternal characteristics

The BMI for more than half of the mothers is normal weight, even when divided into mothers with MDD⁻ and MDD⁺ children, the proportion remains roughly the same. The underweight category is less frequent among mothers whose children reach MDD, at 23.7 %, compared to the MDD group (26.1 %). The proportion of overweight mothers is with 18.3 % notably higher in the MDD⁺ group compared to the MDD⁻ group with 14.9 %.

The age distribution of the mothers is relatively similar between the MDD⁻ and MDD⁺ groups. Generally, the youngest age group, between 15 and 19 years, is the smallest group of mothers (4.5 %). Most mothers are between 20 and 29 years old (75.4 %). In the 20 – 24 age group the MDD⁺ group has a lower percentage (36.5 %) compared to the MDD⁻ group (39.0 %). Additionally, in the age group (30-34 years), the MDD⁺ mothers have a slightly higher percentage (15.6 %) compared to 14.3 % in the MDD⁻ group.

The education level of the mothers shows a predominant proportion with secondary education (52.4 %), followed by those with tertiary education (17.7 %), primary education (11.2 %) and the lowest proportion with no education (18.7 %). There are noticeable differences in the education level distribution between the MDD⁻ and MDD⁺ groups: MDD⁺ mothers have a lower percentage of “no education” compared to MDD⁻ mothers (15.5 % vs. 19.7 %). In the "secondary education" level, more mothers have children who meet the MDD (54.5 %) than children who do not (51.8 %). The predominant religious affiliation of the mothers is Hinduism (79.4 %), followed by Muslim mothers (16.3 %). Comparing the religions within the MDD groups shows that a slightly lower proportion of Hindu mothers reach the MDD compared to the overall percentage (75.7 % vs. 79.4 %). Whereas slightly more children of mothers belonging to the Muslim faith reach MDD (18.8 %) compared to the overall percentage of 16.3 %.

Household characteristics

The overall distribution of the wealth index in the more detailed breakdown shows a relatively even distribution within the 5 groups with a slight tendency towards more poor and poorer households than rich and richer. The simplified wealth index shows this a little more clearly: 45.1% belong to the poorer and 34.9% to the richer part of the population. If the proportions of children divided into MDD⁻ and MDD⁺ are compared with each other, it becomes apparent that children of a poorer household are somewhat more strongly represented in the MDD⁻ group (MDD⁻ = 45.8 % vs. MDD⁺ = 43.0 %), whereas children in wealthier households are somewhat more likely to reach MDD (MDD⁺ = 36.6 % vs. MDD⁻ = 34.4 %).

Most of the households are located in rural areas (73.5 %), while slightly less than a third resides in urban areas (26.5 %). While the percentage of MDD⁻ (73.5 %) in rural located households is slightly higher than the percentage for MDD⁺ (71.9 %), this trend is also reversed in urban located households: here the percentage of MDD⁺ with 28.1 % is slightly higher than the percentage of MDD⁻ with 26.0 %.

The number of living children in a household show that a noticeable proportion have either one (39.1 %) or two (36.4 %) living children. A smaller portion of households have three living children (14.9 %), while an even smaller percentage have 4 or more children (9.6 %). The proportion of households with one child between MDD⁻ and MDD⁺ is hardly different from the overall proportion. While the few percent of MDD⁺ households tend more towards two living children in the household, compared to the overall share, these percentages shift more towards 3 and 4+ children in the MDD⁻ group.

3.1.2.1 Types of food groups consumed by children according to MDD status

The predominant dietary patterns among children not meeting MDD are breast milk (83.8 %), grains, roots, and tubers (56.4 %), and dairy (43.5 %) (Figure 6). Smaller proportions of these children consumed vitamin A-rich fruits and vegetables (25.4 %) and other fruits and vegetables (11.8 %), with minimal intake of eggs (6.1 %), legumes and nuts (5.8 %) and flesh foods (2.3 %). Conversely, among children meeting MDD, the most consumed foods were grains, roots, and tubers (96.6 %), vitamin A-rich fruits and vegetables (91.9 %), breast milk (88.6 %), dairy (82.7 %), and other fruits and vegetables (81.6 %) (Figure 6). Consumption of the remaining food groups was notably lower among children meeting MDD: legumes and nuts (56.6 %), eggs (55.4 %) and flesh foods (42.3 %).

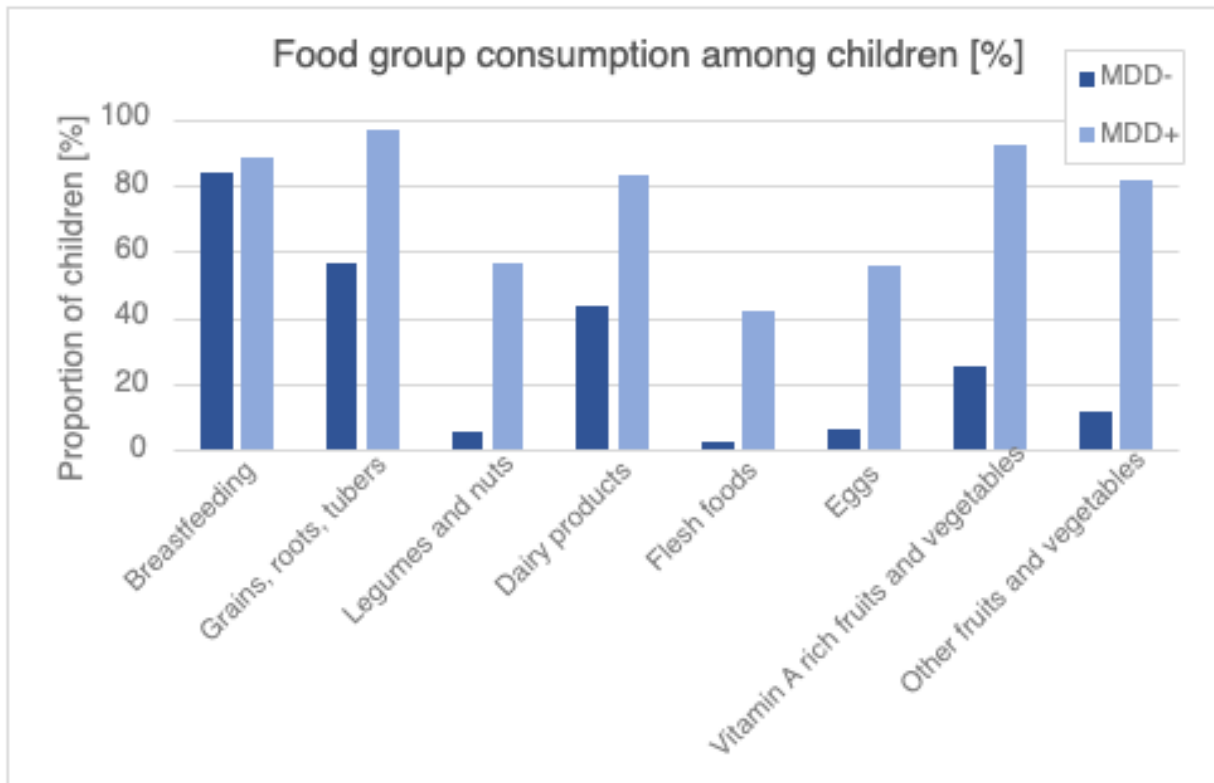


Figure 6 Food group consumption among children 6–23 months old not meeting MDD (MDD-, n = 49.173) and meeting MDD (MDD+, n = 15.552) in India in the 2019–2021 National Family Health Survey. All percentages are weighted to be nationally representative.

3.1.2.2 Food group patterns by dietary diversity score

Although many unique combinations of the eight food groups were consumed, certain general trends emerged based on the dietary diversity score (Figure 7). In all groups (dietary diversity score > 0), the proportion of children who received breast milk was above 80 %. Among children with a dietary diversity score above 1, primarily the consumption of grains, roots and legumes increased strongly. This food group, with a dietary diversity score greater than 2, is even higher than the proportion of children who received breast milk. Likewise, the proportion of dairy products increases strongly in children with a dietary diversity score above 1 and ranges between 48 % and 100 %. From a dietary diversity score of 3 and 4, the proportion of vitamin A rich fruits and vegetables and other fruits and vegetables in particular increases sharply. The food groups with the lowest consumption across the range of dietary diversity score were eggs, legumes and nuts and flesh foods. With a dietary diversity score between 1 and 5, the consumption of these food groups ranges from 0.1 % to 32.1 %, 0.1 % to 33.9 % and 0.0 % to 17.0 %.

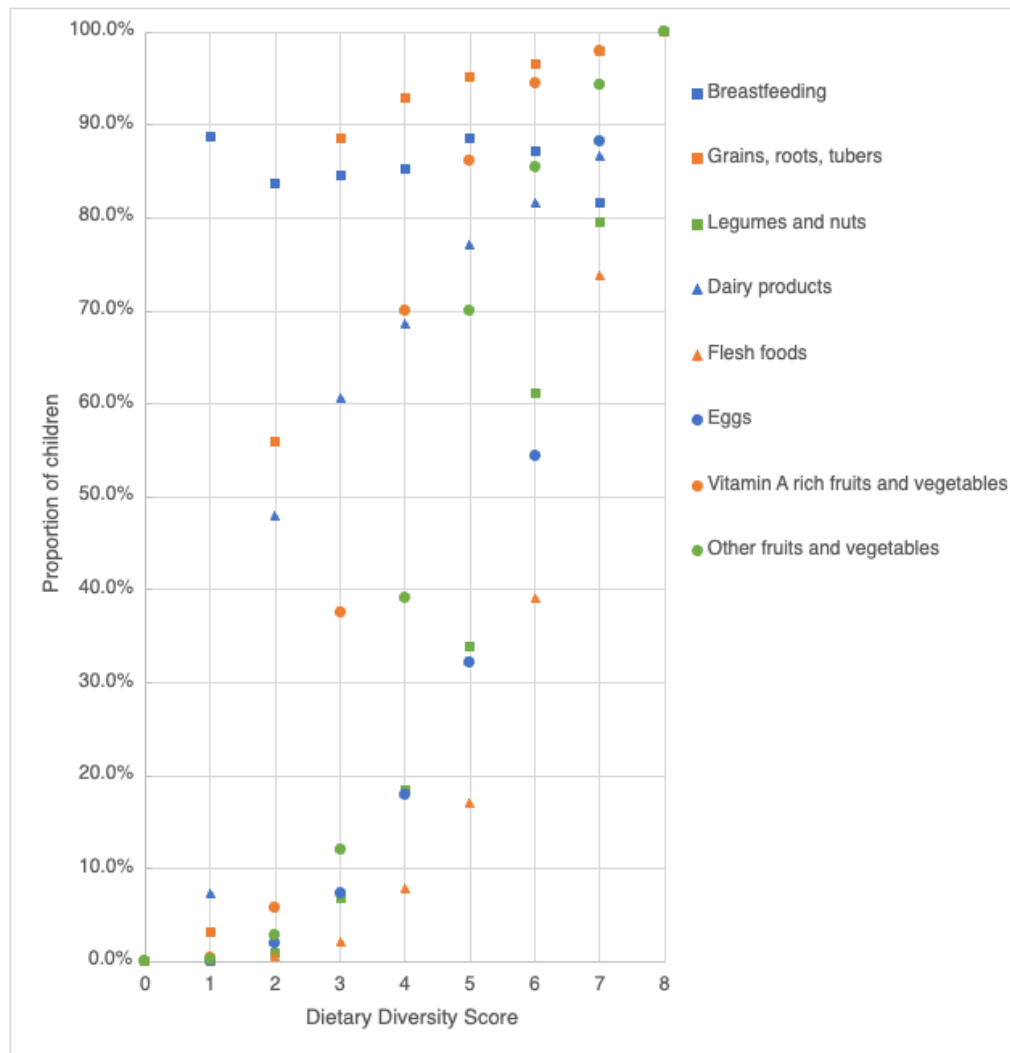


Figure 7 Food group consumption by dietary diversity score among children 6-23 months old in India in NFHS-5.

3.2 Determinants of Minimum Dietary Diversity

3.2.1 Main Model

The following chapter presents the results of the multivariable logistic regression model of this analysis, which examined the determinants that may have an impact on the child's MDD-status. Table 7 shows the odds ratios (OR) and corresponding 95 %-confidence intervals (CI) for meeting and not meeting minimum dietary diversity in relation to various potential determinants. The odds ratios provide information about the strength and direction of the association between MDD and each determinant, while the 95%-CIs provide a measure of the precision of these estimates. MDD is dichotomously coded as "yes" (meeting) or "no" (not meeting), and the determinants represent factors of interest in understanding its occurrence. Not meeting MDD was set as the reference category of dependent variable. Table 7 shows the odds ratios for meeting MDD.

In the following, only the statistically significant results from Table 7 are described. It is shown that the chance of meeting the MDD rises continuously as the age of the child increases. The odds ratio of meeting the MDD increases to 1.69 for 9 - 11-month-old children, to 2.1 for 12 – 17-month-old children and even to 3.01 for 18 - 23-month-old children, compared to 6 - 8-month-old children.

Moreover, the logistic regression model shows that breastfed children have a higher chance (OR = 1.75) of meeting the MDD compared to children who have already been weaned or children who have never been breastfed. Looking at the duration of breastfeeding in months - compared to 6 - 8 months of breastfeeding - the OR increases with longer breastfeeding duration of the child to reach MDD. However, the OR is also 1.26 higher for the comparison group of children breastfed for 0 - 5 months, as well as for the children who were never breastfed.

Mothers aged 20 - 24 were chosen as the reference category, as this was the most prevalent. Comparing this age group with middle-aged mothers (25 - 29 and 30 - 34 years), there are no significant differences for the MDD achievement of their children. However, children with younger (15 - 19 years) and older (35+ years) mothers had a higher chance of reaching MDD with an OR of 1.28 and 1.22, respectively.

Another factor that has been examined is the mother's BMI. It was analysed to what extent the chance of the child reaching MDD changes depending on whether the mother is underweighting or overweight compared to normal-weight mothers. Children of underweight mothers have a lower chance of meeting MDD (OR = 0.91). Children with overweight mothers are more likely to reach MDD (OR = 1.20).

When examining the educational level of the mother (reference category = no education), a linear trend in the OR is evident from primary education upwards to higher education: OR(primary) = 1.18, OR(secondary) = 1.36 and OR(higher) = 1.53. For all categories of the maternal education level significant differences to the reference category (low education) are observed.

With an odds ratio of 1.37, children of Muslim mothers have a higher chance of being fed diversely enough compared to Hindu mothers. Children of other faiths are also more likely to reach MDD (OR = 1.47).

The number of children in the household also appears to have an impact on the youngest child's attainment of MDD, aged 6 - 23 months. However, no linear trend is found here when households with one child are taken as a reference. While the number of two children in the household indicates a better chance of reaching MDD (OR = 1.10), the chance is lower for 3 children with an OR of 0.88. For more than 4 children, the results are no longer significant.

For the determinants sex of the child, type of place of residence and wealth, there are no significant associations regarding the achievement of MDD of the youngest child, aged 6 - 23 months.

Table 7 Odds Ratios (95% confidence intervals) for meeting MDD for Determinants of Minimum Dietary Diversity of children aged 6-23 months from NFHS-5, India (N= 64.725).

Determinants for MDD	Reference of Factors and Covariates	MDD	Odds Ratio	95 %-Confidence Interval
Sex of child	Male			
Female		Yes	1.01	0.96-1.07
Child's age in months	6-8			
9-11		Yes	1.69	1.48-1.92
12-17		Yes	2.10	2.10-2.81
18-23		Yes	3.01	2.57-3.54
Currently breastfeeding	No			
Yes		Yes	1.75	1.58-1.94
Months of breastfeeding	6-8			
0-5		Yes	1.26	1.02-1.56
9-11		Yes	1.49	1.29-1.71
12-17		Yes	1.58	1.36-1.84
18-23		Yes	1.82	1.53-2.15
Never breastfed		Yes	1.45	1.15-1.84
Don't know		Yes	0.55	0.17-1.76
Mother's age in years	20-24			
15-19		Yes	1.28	1.11-1.48
25-29		Yes	1.01	0.95-1.08
30-34		Yes	1.09	1.00-1.20
35+		Yes	1.22	1.07-1.39
Mother's BMI	Normal weight			
Underweight		Yes	0.91	0.86-0.97
Overweight		Yes	1.20	1.11-1.30
Missing value		Yes	0.72	0.27-1.92
Mother's highest education level	No education			
Primary		Yes	1.18	1.07-1.31
Secondary		Yes	1.36	1.26-1.48
Higher		Yes	1.53	1.36-1.70
Religion	Hindu			
Muslim		Yes	1.37	1.26-1.49
Other		Yes	1.47	1.31-1.65
Type of place of residence	Urban			
Rural		Yes	0.97	0.89-1.05
Wealth Index	Middle			
Poorest		Yes	1.03	0.94-1.12
Poorer		Yes	0.95	0.87-1.04
Richer		Yes	0.99	0.91-1.08
Richest		Yes	0.90	0.81-1.00
Number of living children	1			
2		Yes	1.10	1.04-1.18
3		Yes	0.88	0.80-0.96
4		Yes	0.89	0.76-1.03
5+		Yes	0.90	0.77-1.07

Dependent Variable: MDD (reference category = No)

From a multivariable logistic regression model adjusted for sex, child's age in months, duration of breastfeeding, Mother's age, BMI, education level, Religion, type of place of residence, wealth index and number of living children.

3.2.2 Secondary analyses for promising determinants from main model

3.2.2.1 Participation of mothers in additional nutrition and health education offers

The main model has shown that the mother's level of education has an influence on the diversity of her child's diet. As the level of education increases, the chance of the child meeting MDD becomes more likely. There is a linear significant trend, which is why this variable was used for further subgroup analyses to identify possible correlations.

First, another variable of the questionnaire was analysed descriptively. It was asked whether the mothers had received a service related to nutrition and health education in the last three months. 96.5 % of the mothers stated that they had not received a service of this kind within the last three months. Only 3.5 % answered 'yes' to this question (Table 8).

Table 8 Proportion of mothers who accessed a Nutrition/Health education service in the last 3 months from NFHS-5, India, divided by sex of the child. (N= 64.725).

Services/matters talked about in last 3 months	Count (%)	Male	Female
Nutrition/Health Education			
No	62.529 (96.5 %)	32.313 (96.5 %)	30.216 (96.6 %)
Yes	2.196 (3.5 %)	1.156 (3.5 %)	1.040 (3.4 %)

Examining the proportions of participating in the Nutrition and Health Education Service broken down by education level, the participation increases as the level of education rises (Table 9). The share increases from 2.0 % for No education to about double that for the higher education levels. The trend is linear up to the secondary education level, from secondary to higher the percentage for participating in the service decreases slightly to 3.7 % (Figure 8).

Table 9 Proportion of mothers who accessed Nutrition/Health education services in the last 3 months from NFHS-5, India, by education level.

Services/matters talked about in last 3 months:	No [%]	Yes [%]
Nutrition/Health Education		
Education level		
No education	98.0	2.0
Primary	97.0	3.0
Secondary	96.0	4.0
Higher	96.3	3.7

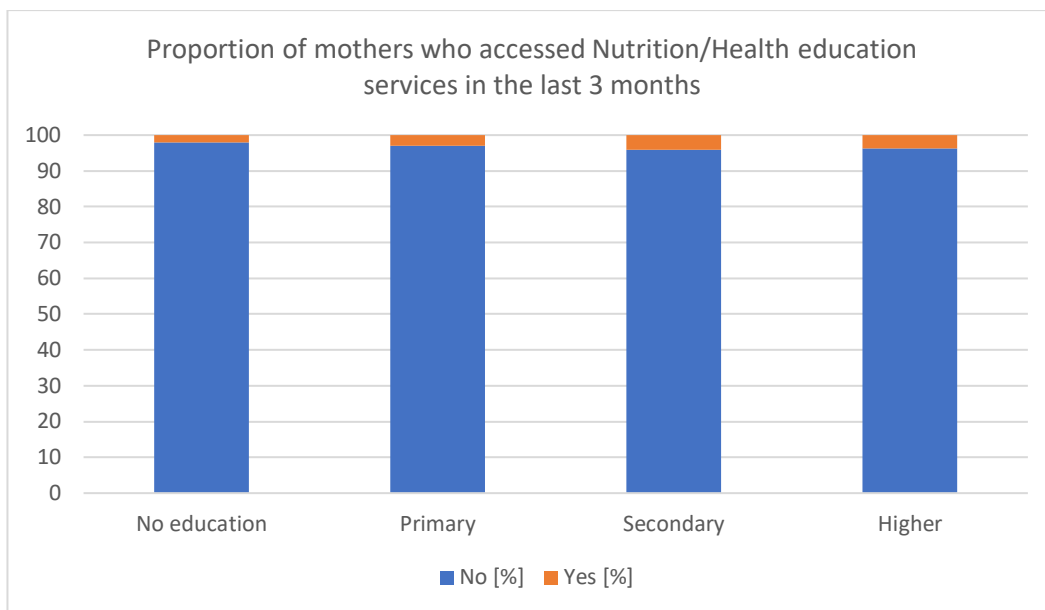


Figure 8 Proportion of mothers who accessed Nutrition/Health education services in the last 3 months from NFHS-5, India, by education level.

As a trend within the education levels for participation in the service could be seen, it was further examined how the OR for participation in the service behaves according to the education level (Table 10). It can also be seen that the chance of participating in the service is higher for all education levels compared to No education. Secondary education level had the highest OR with 2.04, and similarly for Higher education, with OR=1.86 (Figure 9).

Table 10 Odds ratios (95% confidence intervals) for mother's participation in Nutrition/Health Service by mother's educational level from NFHS-5, India (N= 64,725).

Highest educational level	Nutrition/Health Education-Service	Odds Ratio	95 %-Confidence Interval
Primary vs. No education	Yes	1.53	1.22-1.93
Secondary vs. No education	Yes	2.04	1.72-2.43
Higher vs. No education	Yes	1.86	1.51-2.29

Dependent Variable: Services/matters talked about in last 3 months: Nutrition/Health Education (reference category = No)

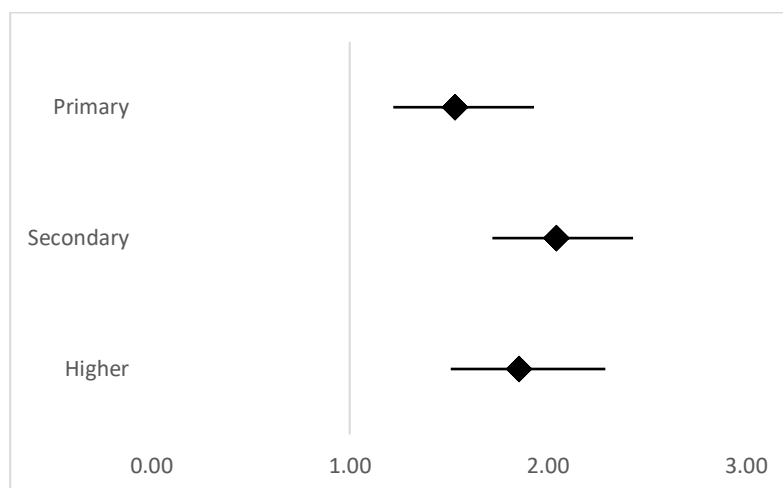


Figure 9 Odds ratios (95% CI) for mother's participation in Nutrition/Health Service by mother's educational level. (Reference category = No education)

Next, the OR for the influence of the MDD was calculated in Model 1 exclusively for this service. This showed that the use of such a service significantly increases the chance of meeting MDD (OR = 1.48). Subsequently, the confounder was included in the multivariable model (Model 2) to examine it in a reciprocally adjusted model. Here, too, the result is significant with an OR of 1.45 (Table 11).

Table 11 Odds ratios (95% confidence intervals) for meeting MDD by mother's participation in Nutrition/Health Service from NFHS-5, India (N= 64,725) for both crude and multivariable model.

Services/matters talked about in last 3 months	MDD	Odds Ratio	95 %-Confidence Interval
Nutrition/Health Education			
Model 1 (crude)			
Yes vs. No	Yes	1.48	1.30-1.69
Nutrition/Health Education			
Model 2 (multivariable)			
Yes vs. No	Yes	1.45	1.27-1.66

Dependent Variable: MDD (reference category = No)

Model 2 (multivariable): adjusted for sex, child's age in months, duration of breastfeeding, Mother's age, BMI, education level, Religion, type of place of residence, wealth index and number of living children.

Finally, by analysing the variables of participation in Nutrition/Health education service and education level as a subpopulation, it was analysed whether the MDD is more likely to be achieved with participation in the service if the mother also has a higher education. The results for No education and Primary education are not significant, but for Secondary and Higher education a higher OR for achieving MDD is shown. For service participation and secondary education with an OR of 1.41 and for service participation and higher education the OR is as high as 1.89 (Table 12 and Figure 10).

Table 12 Influence of mother's education level when participating in Nutrition/Health Education Service on the chance to reach MDD.

Nutrition/Health Education-Service	Subpopulation: Educational level	MDD	Odds Ratio	95 %-Confidence Interval
Yes vs. No	No education	Yes	1.12	0.77-1.64
Yes vs. No	Primary	Yes	1.22	0.80-1.86
Yes vs. No	Secondary	Yes	1.41	1.20-1.67
Yes vs. No	Higher	Yes	1.89	1.40-2.54

Dependent Variable: MDD (reference category = No)

Multivariable model adjusted for sex, child's age in months, duration of breastfeeding, Mother's age, BMI, education level, Religion, type of place of residence, wealth index and number of living children.

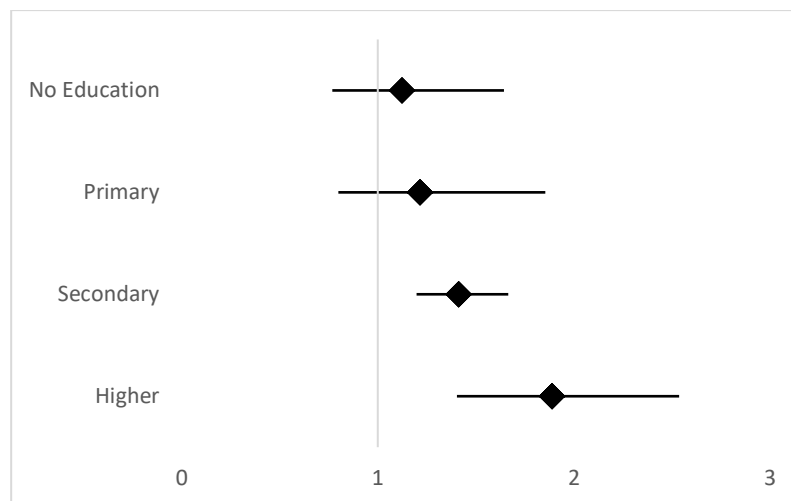


Figure 10 OR (95%-CI) for meeting MDD with mother's participation in Nutrition/Health Service by mother's educational level.

3.2.2.2 Maternal Education Level, BMI, and Wealth

For maternal BMI, the main model found that being underweight was more likely to be associated with the child not reaching MDD, whereas children with an overweight mother had a higher chance of reaching MDD. To find out if there are trends between different levels of education or wealth and the BMI categories, new combined variables were created (see methods) and examined in a further logistic regression for the chance of meeting the MDD. Table 13 presents the OR for the BMI and education and Table 14 for BMI and wealth for meeting MDD.

There were no significant differences between the group with low BMI and high education, and high BMI and low education, compared to low BMI and medium education (Table 13). However, when looking at mothers with low BMI and low education level, the chance of the child reaching MDD decreases significantly (OR = 0.82). For children with a mother with a high BMI, a positive correlation for achieving the MDD is shown for both mothers with a medium (OR = 1.25) and high level of education (OR = 1.27).

Table 13 Odds ratios (95% confidence intervals) for meeting MDD by mother's education level and BMI from NFHS-5, India (N= 64,725).

Combined Variable for BMI and Education level		Reference Category	MDD	Odds Ratio	95 %-Confidence Interval
BMI	Education level				
Low	Low	Low BMI and Middle Education	Yes	0.82	0.76-0.87
Low	High		Yes	1.05	0.96-1.15
High	Low		Yes	0.97	0.82-1.15
High	Middle		Yes	1.25	1.13-1.38
High	High		Yes	1.27	1.13-1.44

Dependent Variable: MDD (reference category = No)

Multivariable model adjusted for sex, child's age in months, duration of breastfeeding, Mother's age, BMI, education level, Religion, type of place of residence, wealth index and number of living children.

As a control, it was examined whether the level of education is related to wealth and thus has an influence on the achievement of the MDD (Table 14). It becomes clear that the OR for meeting the MDD increases significantly when the education level changes from low to higher. This is the case both for lower wealth (OR=1.24) and for higher wealth (OR=1.29). The chance of achieving the MDD when wealth changes from low to higher instead of education does not have a statistical effect.

Table 14 Odds ratios (95% confidence intervals) for meeting MDD by mother's education level and household wealth from NFHS-5, India (N= 64,725).

Combined Variable for Education and Wealth		Reference Category	MDD	Odds Ratio	95 %-Confidence Interval
Education	Wealth				
Low	Higher	Low Education	Yes	1.01	0.90-1.13
Higher	Low	and	Yes	1.24	1.15-1.34
Higher	Higher	Low Wealth	Yes	1.29	1.21-1.39

Dependent Variable: MDD (reference category = No)

Multivariable model adjusted for sex, child's age in months, duration of breastfeeding, Mother's age, BMI, education level, Religion, type of place of residence, wealth index and number of living children.

3.2.2.3 Dietary Diversity Score by MDD status of children

Nearly 80 % of children aged 6 - 23 months in India are not meeting the MDD. Among these children, half consumed ≤ 2 food groups. Of the children who did achieve the MDD, 45.6 % just barely reached the dietary diversity score cut-off point of 5.

Table 15 Dietary diversity score by MDD status among children aged 6-23 in India in the NFHS-5. The values are survey weighted.

Dietary diversity score	n	%	
Not meeting MDD			% within MDD ⁻
0	1.059	1.6	2.1
1	13.434	20.8	27.0
2	12.152	19.2	24.9
3	12.647	19.9	25.8
4	9.881	15.6	20.2
Total	49.173	77.1	100
Meeting MDD			% within MDD ⁺
5	6.811	10.5	45.6
6	4.014	5.9	25.8
7	2.601	3.6	15.8
8	2.126	2.9	12.8
Total	15.552	22.9	100

3.2.2.4 Child food group consumption patterns according to the mother's religion and the child's MDD status

The analysis of the consumption of food groups depending on the religion of the mothers and the achievement of MDD shows noticeable differences between Hindus, Muslims, and other religious groups (Figure 11).

Among children who reach the MDD, it is noticeable that more mothers of other religions have already weaned, whereas around 90 % of Hindu and Muslim mothers are still breastfeeding. In fact, a higher proportion of children who do not meet the MDD are still breastfed by Hindu mothers (84.4 %) than children of other religions who reach MDD (82.7 %).

The consumption of grains, roots and tubers is highest among Hindus (97.0 %) and lowest among Muslims (94.9 %) for children who reach MDD. For children who do not reach MDD, the difference is even more pronounced for Muslims as opposed to Hindus and other religions. Moreover, the proportion of Other Religions is higher than that of Hindus (Muslim: 53.2 %, Hindu: 56.9 % and Others: 58.2 %).

The distribution of proportions between religions remains the same for legumes and nuts at MDD⁺ and MDD⁻, although the general consumption of this food group increases sharply for all three religions when the child reaches MDD: from 5.8 % (Hindu and Muslim) to 56.6 % (Hindu) and 56.9 % (Muslim) and from 5.0 % to 55.5 % (Other).

The consumption of dairy products is relatively high among MDD⁻ children. Almost half of the Hindus (44.6 %) who do not reach MDD report dairy products as a food consumed. The proportion is slightly lower among Muslims and the other religions. Even among children who achieve the MDD, dairy products are still listed in the top 5 most consumed food groups.

For flesh foods, the difference between MDD achieved and not achieved is very clear. While less than 6 % of the children who do not meet MDD are fed flesh foods, among the MDD⁺ children it is over 50 % for Muslim and other religions. Hindus have the lowest proportion in both groups with 1.7 % (MDD⁻) and 38.4 % (MDD⁺).

Eggs were most often given by Muslims to their children. 11.3 % for children not meeting MDD and 71 %, of children meeting MDD. However, tends to increase similarly in all religions when MDD is reached.

The trend for vegetables and fruit looks similar for the respective religions. The proportion increases significantly for children who reach MDD compared to those who do not. For both vitamin A rich fruits and vegetables and the other fruits and vegetables category, Hindus and the other religions have a similar incidence, whereas Muslims are slightly below in both categories, for both MDD⁻ and MDD⁺. Vitamin A rich fruits and vegetables are the second most frequently reported food group among MDD⁺ children in all three religions (Hindu = 92.3 %, Muslim = 90.0 %, Other = 92.9 %).

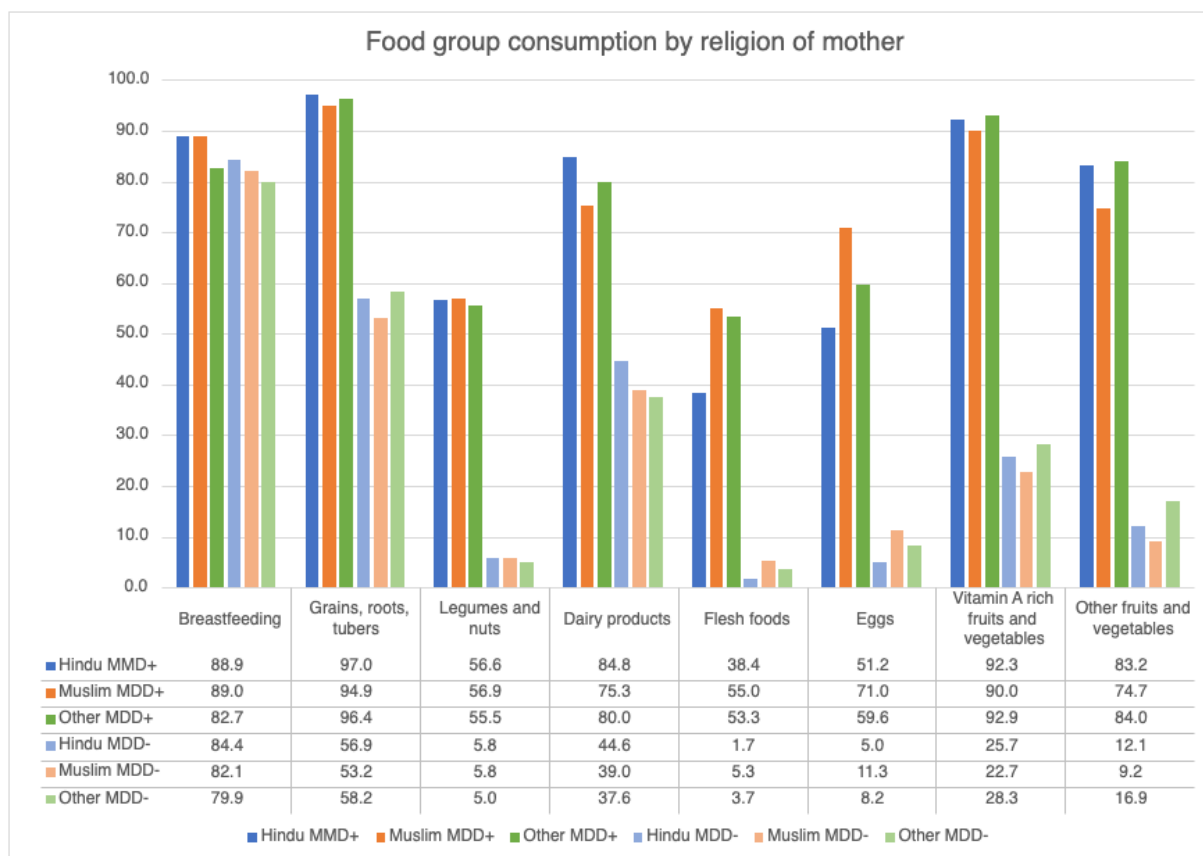


Figure 11 Food group consumption by religion of mother with youngest child aged 6 - 23 months not meeting MDD and meeting MDD in India in the 2019 – 2021 National Family Health Survey. All percentages are weighted to be nationally representative.

4 Discussion

4.1 Summary of the present findings

The study examined potential socio-demographic determinants that might influence whether children meet the Minimum Dietary Diversity. The Breastfeeding duration had a significant impact on whether the child was meeting the MDD or not. Children who were breastfed for longer were more likely to reach MDD than children who were breastfed for shorter periods. Looking at the results of the maternal influencing factors, for BMI it was found that overweight mothers had a slightly higher chance of their children meeting MDD compared to mothers with normal BMI. Underweight mothers had a lower chance. The maternal education level analyses show that mothers with secondary education were more likely to have their children meet the MDD criteria than mothers with no education or primary education. Mothers who reported having talked about nutrition or health education in the past three months were significantly more likely to have their children meet the MDD than mothers who did not use this service of health education. Furthermore, a trend was found that mothers with secondary education level and higher were more likely to use the service than mothers without education or primary level. In general, too few mothers have used the health service at all. The factors sex of child, household wealth and type of place of residence were not associated with MDD.

When looking at the likelihood of the child reaching MDD, children of mothers with higher levels of education are more likely to do so when BMI and education, as well as wealth and education of the mother, are examined in combination. For mothers with a low BMI and a low level of education, the likelihood of the child reaching MDD decreases. For children whose mother has a high BMI, both mothers with medium and high education levels show a positive correlation for achieving MDD.

It is concerning that almost 80 % of children in India do not meet the MDD. Of these children, half consume less than or equal to two food groups. Even of the children who reach MDD, almost half barely reach the minimum of 5 food groups. The predominant dietary patterns among children who do not meet MDD include a high intake of breastmilk, grains, roots and tubers and dairy products. In contrast, intake of vitamin A-rich fruits and vegetables, other fruits and vegetables, eggs, legumes and nuts and meat-containing foods is much lower to minimal. Children who meet the MDD have a much more varied diet. In particular, the consumption of roots and tubers, vitamin A-rich fruits and vegetables, and other fruits and vegetables is significantly higher here than on average and among children who do not meet the MDD. On the other hand, eggs, legumes and nuts, as well as flesh foods, are consumed the least. The study finds differences in food group consumption according to mothers' religion and their children's MDD status. While the proportions increase from MDD⁻ to MDD⁺ for all food groups, the distribution of religions within a food group

remains similar. The most striking difference between the religions is that the proportion of flesh foods is significantly lower among Hindus than among Muslims and other religions.

4.2 Interpretation of the present findings in context of existing literature

This paper illustrates the status of Minimum Dietary Diversity of children aged 6 - 23 months in India and the associated determinants, using a nationally representative cross-sectional study (NFHS-5). The results show that over two-thirds (77.1 %) of children aged 6 - 23 months in India will not achieve MDD in 2020 - 2021. This provides a possible explanation for the high prevalence of micronutrient deficiencies and anthropometric failure observed among children in India. Over the last few years, there has been a declining trend for not reaching MDD. From 87.4 % in 2005 - 2006 to 80.6 % in 2015 - 2016 and to 77.1 % in the current survey from 2020 - 2021 [38]. Comparing the 22.9 % of children achieving MDD in India with other countries, India continues to perform worse. In Myanmar, 24.6 % meet the MDD, in Cambodia 47.7 % and Indonesia even more than half of the children with 58.2 % [39]. The proportion of stunted children in India has fallen to 30.1 % from 38 % in 2015 - 16 [40], but is well above the global average of 22 % in 2020 [15] and Wasting is also above the global average of 6.7 % at 18.9 % [15].

In this research, an examination was conducted to analyse the patterns of Minimum Dietary Diversity (MDD) among infants and young children in India, while also exploring potential influencing factors across various levels, including the child, mother, and household.

Factors associated with minimum dietary diversity

The age of the child is one of the factors that plays a role in the diversity of the child's diet. This determinant has already been shown to influence the achievement of MDD in other studies from Sri Lanka and Ethiopia [41], [42]. One possible explanation for the fact that the likelihood of a more varied diet also increases with the age of the child is the introduction of complementary foods from the 6th month. According to the infant and young child feeding recommendations of the WHO, a staggered increase in solid, semi-solid and soft foods is recommended between 6-8 months and 9-23 months [24]. Furthermore, the acceptance of new tastes and textures increases with trying different foods, which is accompanied by an increased acceptance of new foods over the course of the first two years of life [43].

The achievement of MDD is also influenced by breastfeeding and the duration of breastfeeding. The longer breastfeeding, the higher the chance of achieving MDD. On the one hand, this can be explained by the fact that since 2017 breastfeeding represents a separate food group within the MDD score, which accordingly favours the achievement of the 5 food groups if breastfeeding continues. Secondly, the WHO recommends breastfeeding alongside the introduction of complementary foods until the child is at least 23 months old. Accordingly, all children in this

sample should still be breastfed if this recommendation is followed. However, the prevalence of current breastfeeding of 84.9 % shows that some mothers have already stopped breastfeeding before the recommended duration [30]. In terms of breastfeeding duration, it is also noticeable that the chance of reaching MDD is higher for children who have only been breastfed for 5 months or less than for children who have been breastfed for between 6 - 8 months. The WHO recommends that children should be exclusively breastfed until the age of 6 months [24]. Accordingly, it would have been expected that the group of children breastfed for 0 - 5 months would only consume one food group, namely breastmilk, and thus have a lower chance of reaching MDD. However, the proportion of children who are exclusively breastfed up to 6 months of age is only 64 % in the most recent DHS (2019 - 21) from India. This is already an upward trend compared to the 2015 - 2016 DHS, where the proportion was 55 %. Despite the recommendation for exclusive breastfeeding for children under the age of six months, a notable proportion within this age group incorporate additional liquids like plain water, other milk, or complementary foods into their diet, alongside breastmilk [30].

Maternal age shows a higher probability of achieving MDD for younger mothers (15 - 19 years) and older mothers (35 years and older) compared to the reference age of 20 - 24 years. Older mothers may have had more children and more experience with child feeding, which would explain the improved chance for meeting MDD. The youngest age group, however, would be expected to predict a lower chance due to lack of life experience. It would be possible to assume that in recent years, trainings for expectant mothers have been better implemented and are also more established and accepted by the younger generation. However, as the age categories are only 5 years apart, it remains an assumption that cannot be substantiated, as no further literature was found in which the determinate "age of the mother" played a significant role in meeting the MDD. Here, more in-depth studies can be sought to show possible reasons for this trend.

Looking at the influence of maternal BMI, the chance of a balanced diet is lower for children of underweight mothers than for children of normal-weight mothers. It is likely that children whose mothers are already underweight do not have the appropriate variety of foods available to them. Other studies have also shown that the BMI of the mother has a strong influence on the nutritional status of the child [44]–[47]. In addition to malnutrition, maternal obesity also affects MDD status. Dual burden of malnutrition (DBM) is now also considered a major health problem among adult men and women in India [48]. This describes the co-occurrence of underweight and overweight and their both negative health effects on the population [49]. It outlines the trend that even in families where the mothers are overweight, the children continue to be malnourished. This trend is called the intra-household dual burden of malnutrition and is becoming an increasing problem in low- and middle-income countries [50]. Based on these trends, one might expect that the child of an overweight mother in India would continue to suffer from malnutrition. However, contrary to

this assumption, this study actually found a positive trend with the association of maternal overweight on child nutrition. Children of overweight mothers have a higher chance of reaching MDD and thus have a more diverse nutrient intake than children of underweight and normal weight mothers.

Another determinant that influences the child's MDD status is the mother's education level. Children whose mothers reported no education as the level of education have a higher proportion in the MDD than in the MDD⁺ group. Similarly, mothers with higher education are more likely to have children who achieve MDD and less likely to have children who do not achieve MDD. The OR shows a significant linear trend from primary upwards to higher education. The study found that children of well-educated mothers with secondary education had a 36 % higher and with higher education a 53 % higher chance to eat varied foods. Accordingly, the likelihood of the child achieving minimum dietary diversity increases with higher maternal education. These results are consistent with other studies in low- and middle-income countries. Many other studies show that maternal education is a major determinant of appropriate and varied infant feeding. Several Asian countries have been studied in terms of adequate and varied infant feeding, as have some African countries, all of which have described maternal education as an important determinant [39], [41], [51]–[55]. Similarly, these trends have been found in previous studies of MDD in children in India [51].

Mothers who have completed higher levels of schooling may be better able to understand educational materials and information and may also be better able to educate themselves on the topic. To further investigate the influence of maternal education on the child's nutritional status, the extent to which participation in a nutrition/health education service depends on the mother's level of education and whether participation has a positive effect on the child's MDD status was examined. Participation in this service was very low, at 3.5% of mothers. However, the proportion increased with the mother's level of education. Thus, more educated mothers were more likely to participate in the service than mothers with less or no schooling. The OR to participate in the service is higher for all education levels compared to no education. Participation in the service is also significantly associated with an improved chance of meeting the MDD for the child for secondary and higher education levels. For the less educated groups, there is no significant trend. Accordingly, it can be concluded that participation in a service that educates on health and nutrition topics is generally higher among better educated mothers and has an influence on the child's nutrition. In general, participation in the service is too low and mothers of all educational levels should be given the opportunity and motivated to make use of such a counselling service. A Study from Malawi has shown that supplementary nutrition education and counselling led to significant improvements in nutrition knowledge, dietary diversity and nutrition behavior of pregnant women [56]. A study in Northern Ghana revealed that almost half of pregnant mothers are unaware of their potential risk of having a low-birth-weight child. After consultation on the topic

and awareness of the severity of the health consequences for the unborn child, healthy behaviors were adopted, making awareness raising during antenatal care crucial for balanced nutrition and healthy child development [57]. If the number of participants in health and nutrition consultations increases in the future, this factor can be further analysed and may provide insightful results for public health interventions for mothers in India, which could subsequently improve the nutritional status of the child.

Comparing the predominant religions Hindu and Muslims and other religions in India, it is clear that more Muslims children achieve MDD than Hindus. The chance for MDD⁺ is higher for both Muslims with 37 % and other religions with 47 % than the chance for Hindus. This may be due to the fact that a large proportion of Hindus abstain from eating meat, fish and eggs, as living beings are all considered equal, cows even as sacred, and thus for a part of the population two food groups are already omitted that are counted towards achieving MDD [58].

It would be expected that as the number of children in the household increases, the opportunity for a diverse diet decrease. However, the results of this study deviate from this expectation as they are not linear. The chances of having a diverse diet increase when there are two living children in the household compared to only one child. However, the chances of meeting the MDD are 12 % lower if there are three children in the household than if there is only one. There are no longer significant differences when there are four or more children. These findings could possibly be explained by the fact that with the first child, the mother's knowledge of child nutrition is less pronounced, as she still has less experience. In contrast, with the second child she has already gained experience by raising the older child. The lower chance of a varied diet for the third child could be due to the fact that there may not be enough resources to feed all the children adequately. Therefore, solid foods might be given to the older children rather than the youngest child.

Factors not associated with minimum dietary diversity

In this study there were several factors not significantly associated with meeting the minimum dietary diversity criteria for children. These factors include the sex of the child, the type of place of residence, and household wealth. The gender of the child did not appear to influence their likelihood of achieving MDD, suggesting that both boys and girls had similar dietary diversity. No other studies were found in the literature that found a gender difference in the achievement of minimal dietary diversity. However, gender differences were explored in the research question as boys in general [59]–[61] but also specifically in India [62] are worse than girls in terms of prevalence of underweight and hence a difference in achieving MDD status was hypothesized. Further studies can be conducted to examine the dietary diversity of children for gender differences in more detail.

The place of residence, whether urban or rural, was also not found to be a significant factor influencing MDD status in this sample, although in studies in other countries, MDD was less likely to be achieved if the child came from a household in a rural area [53], [54].

In addition, household wealth, which is considered a key predictor of dietary diversity in numerous studies [52], [53], [63], [64], did not show a clear association with MDD compliance among children in this study population. However, in other studies, wealth is sometimes not identified as a determinant for the achievement of MDD. According to a study based on NFHS-4 data from India, household wealth was primarily associated with higher consumption of milk and dairy products, but not staple foods [65]. This suggests that cultural factors may be more important than economic status in determining the dietary habits of children in India. Other socioeconomic factors, as well as education and possibly associated lack of knowledge about appropriate feeding practices, may play a greater role in the child's food intake and the mother's feeding practices [66]. Further research can be conducted to identify possible trends and correlations.

These findings highlight the complex interplay of various factors that influence children's dietary diversity and underscore the need for a holistic approach to addressing nutritional challenges.

Trends in the consumption of food groups by MDD-status

It is evident that breast milk is a predominant dietary component in the first 23 months of life for both children who reach MDD and those who do not. This is in line with established recommendations on early childhood nutrition, such as those of the WHO.

Besides breast milk, cereals, roots and tubers and dairy products constitute a significant part of infant feeding in India. The high proportion of cereal consumption, with 96.6 % of MDD⁺ and 56.4% of MDD⁻ children, underscores the continued reliance on carbohydrate-rich foods in the diets of young children, regardless of MDD status. Similarly high proportions of grains, roots and tuber consumption are also documented in Ethiopia [52], as well as in Pakistan [67] and Bangladesh [68]. At 32.2 %, the proportion of dairy products consumed in Bangladesh is significantly lower than in India (MDD⁻: 43.5 %; MDD⁺: 82.7 %). At first glance, the consumption of meat and fish looks significantly higher in Bangladesh (67.2 %) [68], but here the food groups Flesh Foods and Eggs were combined, which were considered in separate groups in the DHS from India.

Among children who were fed at least 5 food groups in the last 24 h, i.e., have a more varied diet, vegetables and fruits were also important. than half of them consumed these foods.

Dairy products are another important component of children's diets, especially among children with MDD. While more than 80 % of MDD⁺ children consume dairy products, about 43 % of MDD⁻ children also include dairy products in their diet. This indicates that dairy products are an important source of nutrition even for children who do not meet the minimum diversity requirements.

Consumption of nutrient-rich foods such as vitamin A-rich fruits and vegetables, eggs, legumes, and nuts, as well as meat-containing foods, is significantly lower among children who do not meet

the MDD. These findings raise concerns about the limited variety of nutrient-rich foods in their diets. In contrast, when children meet the MDD, consumption of these nutrient-rich foods increases significantly, which has also been surveyed in studies in other countries [52], [67]. Flesh foods, legumes and nuts and eggs are the least frequently consumed. This has also been documented in other studies from low- and middle-income countries [52], [54], [67], [68]. This could be due to the religious dietary practices in India, as a large part of the population follows the Hindu faith, in which vegetarianism is often practiced or at least a significantly lower proportion of meat is on the menu [58], [69]. If we look at the consumption patterns within the religions, we can clearly see the above-mentioned trend of less meat and fish consumed in the Hindu population. Especially when the minimum dietary diversity is achieved, the difference between Hindu and Muslim and other religion becomes even more apparent.

4.3 Study limitations

The aim of this study was to highlight the current situation of child malnutrition in India and to examine dietary diversity and its possible determinants and to highlight trends. Although the study aims to provide valuable insights into this critical issue, it is important to acknowledge the limitations that may affect the interpretation and generalisation of the findings.

In order to assess dietary diversity in children, the indicator Minimum Dietary Diversity was examined in more detail in this thesis. However, there are others that are important to consider for the holistic analysis of the child's nutritional status, such as the Minimum Acceptable Diet (MAD) and Minimum Meal Frequency (MMF) used. These can be included in further analyses. The MDD itself also has a number of limitations. Some items are not taken into account, such as portion size and frequency of consumption of a food. The MDD indicator, which focuses on food consumed within the last 24 hours, may not properly capture the diversity of dietary habits in India. Indian dietary habits can vary from one day to the next, with people eating a monotonous diet between meals. This day-to-day variability is not fully captured by a 24-hour recall, which may lead to an incomplete assessment of dietary diversity. In addition, the potential of household-level dietary diversity indicators to reflect household food security and socioeconomic status needs to be confirmed.

Another limitation arises from the fact that the study relies on mothers' recollection of their children's food consumption in the last 24 hours. This raises the possibility of recall bias, as recall is not always accurate. It is possible that mothers do not accurately remember all the foods their children have consumed, leading to possible errors in the data collected. In addition, the cross-sectional survey is inherently limited in its ability to establish a causal link. Associations between dietary diversity and nutritional status variables can be established, but causality cannot be definitively demonstrated.

It is important to recognise that reported cases of child malnutrition may not reflect the true extent of the problem. Many cases may go unreported due to various social, economic and cultural factors. In addition, this study did not take into account child mortality, which is an important consequence of malnutrition. The impact of child malnutrition on mortality rates was not included in this study.

The findings of this study are specific to the sample population and may not be generalisable to all regions and states of India. The diversity within India, both in terms of socio-economic factors and dietary habits, limits the ability to draw sweeping conclusions for the country as a whole. Regional differences need to be taken into account when interpreting the results.

In summary, while this study provides valuable insights into the relationship between dietary diversity and its determinants, its limitations should also be noted. These limitations include problems with measurement, the possibility of recall error, the cross-sectional design, limited assessment of dietary diversity, factors not taken into account and limited generalisability. Acknowledging these limitations is critical to a nuanced understanding of the implications of the study and to informing future research in this important area of public health.

5 Conclusion

The results of this master's thesis highlight the issue of Minimum Dietary Diversity (MDD) among children aged 6 - 23 months in India. They point out that the mother's education plays a key role in achieving MDD, regardless of her economic status. In particular, the findings revealed that higher maternal education increases the child's chances of meeting MDD. At the same time, nutrition education interventions for mothers were found to have positive effects but were predominantly effective for women with higher levels of education. However, it also became clear that only a very small proportion of mothers made use of education and health services that could have helped them improve their children's nutrition. Here it is important to determine whether the low participation is due to a lack of provision in certain regions or insufficient communication about the availability of these services.

These findings are of great importance as they show that better general education of mothers is a crucial factor for improving the nutritional situation of their children. The goal of improving women's education is important in many ways and has been addressed in the SDGs at various points. Goal 4 "Quality Education" generally pursues ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for everyone. Some of the targets explicitly focus on improving adult education with emphasis on addressing gender inequalities in education. The last is additionally addressed in Goal 5 "Gender Equality" and underlines its importance.

Higher general education seems to be a promising factor for adequate nutritional status and should therefore be targeted through interventions. In addition, there is a need for nutrition education programmes to raise awareness among mothers and families in India. These measures should be implemented in a low-threshold manner at all levels and be directed at the children themselves, but also at expectant parents up to health services, households, and communities. Socio-economically and geographically disadvantaged groups in particular must be included in these programs. The materials and information should be provided in a way that is understandable for all levels of education. Policymakers and program managers should prioritize the improvement of nutritional counselling for pregnant women, expectant mothers, and lactating mothers. Raising public awareness of the importance of best infant and young child feeding practices and of balanced and appropriate diets is crucial. Education and counselling interventions can help improve the feeding practices of mothers and their children. Finally, these interventions should consider not only dietary diversity but also nutrient density to promote healthy child growth and development.

Overall, the findings of this master's thesis highlight the close link between education and food security. They highlight the need for educational initiatives aimed at improving the general education of mothers to promote the nutritional diversity of their children. These findings can help

support the implementation of the SDGs related to education and gender equality, while improving the nutritional situation of the young generation in India in a sustainable way.

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