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Infant and Young Child Feeding Practices in Southeast Asia: associations with socioeconomic status, child nutrition and longer-term growth trajectories

by

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Abstract

Despite a breadth of research evidencing the association between exclusive breastfeeding and child growth, little is known about infant feeding practices and diet diversity in low- and middle-income countries. In these settings, the weaning transition offers a critical window in which nutritional inputs can help establish the path to lifelong health, yet only one in six young children receives an adequate diet necessary for optimal growth and development. A distinctive nutrition transition in Southeast Asia has coincided with significant economic growth, with the emergence of a double burden of malnutrition. Chronic and persistent undernutrition in young Southeast Asian children is increasingly coupled with rising prevalence of malnutrition, as diets rapidly "westernize" in line with GDP growth and increasing socioeconomic inequalities. This thesis aimed to examine the role of early feeding practices on child nutritional status and growth in light of this nutrition transition, in three economically and culturally diverse Southeast Asian countries (Cambodia, Myanmar and Indonesia). Given the rapid economic and socio-cultural shifts in this region, the role of socioeconomic status on early life feeding practices and dietary diversity is a focus throughout the thesis. Using the most recent DHS data from all three countries, the first analysis in this thesis presents a sub-regional snapshot of the socioeconomic factors associated with exclusive breastfeeding in children aged 0 to <6 months and minimum dietary diversity in children aged 6 to <24 months. The second analysis used structural path analysis to examine the role of continued breastfeeding and dietary diversity in pathways to stunting in Cambodia and how these varied according to contextually relevant, underlying socioeconomic factors. The final analysis in this thesis applied group-based trajectory modelling to longitudinal data from the Indonesian Family Life Survey, to identify BMI growth trajectories and examine early life feeding practices associated with BMI trajectory membership. Overall, evidence from Cambodia, Myanmar and Indonesia demonstrates that exclusive and continued breastfeeding and dietary diversity in young children are clearly defined by socioeconomic conditions. The research presented in this thesis further suggests that feeding practices during the first two years of life play significant mediating roles in the complex pathways between underlying socioeconomic factors and short-term nutritional status in young children, however these associations are harder to identify over longer periods of study, due to the limitations of observational studies.

Keywords: Dietary diversity; breastfeeding; Southeast Asia; child nutrition; nutrition transition

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Research Thesis: Declaration of Authorship

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Definitions and Abbreviations

ANC	Antenatal care
AOR	Adjusted odds ratio
ARI	Acute Respiratory Infection
ASEAN	Association of Southeast Asian Nations
BCC	Behaviour Change Communication
BIC	Bayesian Information Criteria
BMI	Body mass index
COMBI	Communication for Behavioural Impact
DBM	Double burden of malnutrition
DHS	Demographic and Health Survey
DOHaD	Developmental Origins of Health and Disease
EA	Enumeration areas
ESPGHAN	European Society for Paediatric, Gastroenterology, Hepatology and Nutrition
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GNI	Gross National Income
GTBM	Group-based trajectory modelling
HAZ	Height-for-age Z-scores
IFLS	Indonesian Family Life Survey
ILO	International Labour Organization
IQ	Intelligence Quotient
IYCF	Infant and Young Child Feeding
LMIC	Low- and middle-income countries
MAD	Minimum acceptable diet
MDD	Minimum dietary diversity
MGRS	Multicentre Growth Reference Study
MICS	Multiple Indicator Cluster Surveys
MMF	Minimum meal frequency
OECD	Organization for Economic Cooperation and Development
ORS	Oral rehydration salts

PCA	Principle component analysis
PNC	Postnatal care
PSU	Primary sampling unit
RTI	Respiratory tract infection
SD	Standard deviation
SDG	Sustainable Development Goal
SEM	Structural Equation Modelling
UN	United Nations
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNICEF	United Nations Children's Fund
UOR	Unadjusted odds ratio
USAID	United States Agency for International Development
WASH	Water, Sanitation and Hygiene
WAZ	Weight-for-age Z-scores
WFP	World Food Programme
WHO	World Health Organization
WHZ	Weight-for-height Z-scores

Chapter 1 Introduction

Optimal infant and young child feeding practices (Figure 1.1) are key to nurturing healthy growth and development of young children, supporting not only their survival, but also encouraging them to thrive. The trajectories of health that are shaped during this early life period can predict an individual's exposure to later health and wellbeing. Ultimately, the *Convention on the Rights of the Child* recognizes this as a human rights issue, noting that children should be free of 'disease and malnutrition…. through the provision of adequate nutritious foods' (UN General Assembly, 1989, Art.4, p.7). Although there is no explicit reference to infant and young child feeding practices in the United Nations 2030 Sustainable Development Agenda, optimal nutrition in early life is key to achieving Sustainable Development Goal (SDG) 2 on ending hunger and all forms of malnutrition (UNICEF, 2016). Furthermore, prioritising infant and young child feeding practices is also central to the progress of other SDGs which focus on improving health, enhancing educational achievement, preventing poverty, encouraging economic growth, narrowing inequalities and promoting gender equality.

Figure 1.1 WHO Infant and Young Child Feeding Recommendations, 2018

- Initiation of breastfeeding within the first hour of life.
- Exclusive breastfeeding for the first 6 months (no additional food, drink or water).
- Complementary foods should be introduced alongside continued breastfeeding from 6 months and these foods should be of the appropriate frequency, consistency and nutritional quality.
- From six months onwards, the consistency and variety of foods should be gradually increased.
- Breastfeeding should be continued, on-demand until 2 years of age or beyond.

Despite overall reductions in global malnutrition estimates in the past decade, in 2018 there were still 149 million stunted children under the age of five, and 40 million overweight and obesity globally (UNICEF, WHO and World Bank, 2019). The emergence of a double burden of malnutrition (DBM) in young children, characterised by the co-existence of persisting undernutrition[1] and increasing overnutrition[2], disproportionately affects low- and middle-income countries (LMICs).   Recent estimates have suggested that 65% of stunted children and 36% of overweight children reside in lower-middle-income countries (UNICEF, WHO and World Bank, 2019), indicating an evolving and challenging nutrition landscape in these geographical contexts. The first 1000 days of life offer a critical window in which optimal nutritional inputs can help prevent both forms of malnutrition, but families experience multiple 'economic, political, social and cultural barriers to providing children with adequate quantities of safe, nutritious and age-appropriate foods' (UNICEF, 2016, p.13). In response to the growing prevalence of contrasting and confounding forms of malnutrition, the WHO conceptualised five double-duty actions that aimed to tackle malnutrition on both ends of the spectrum (WHO, 2017), by identifying the shared drivers of both undernutrition and overnutrition. Two of these double-duty actions relate directly to encouraging optimal infant and young child feeding practices in the first two years of life:

1. ***Initiatives to promote and protect exclusive breastfeeding in the first 6 months, and beyond***
2. ***Promotion of appropriate early and complementary feeding in infants***
   (Source: WHO, 'Double-duty actions for nutrition', 2017)

Although research has provided a wealth of evidence on the potential benefits of exclusive breastfeeding in reducing child morbidity and mortality, and supporting neurocognitive function (Victora et al., 2016; Horta, de Sousa and de Mola 2018), less is known about complementary feeding practices that ensue alongside, or after, breastfeeding in LMICs. The weaning transition offers a window of opportunity in which nutritional inputs can help establish the path to lifelong health, yet figures show that only one in six of these children receives an adequate diet[3] that is necessary for optimal growth and development (UNICEF, 2016). Furthermore, between the ages of 6 and <24 months is the period in which the most growth faltering occurs (Marriott et al. 2012), and inadequate[3] diets can exacerbate the risk of stunting, micronutrient deficiencies and

[1] Defined by stunting, wasting, underweight and micronutrient deficiencies.
[2] Defined by overweight and obesity
[3] Adequacy of diet is defined by WHO (2010) as a diet which meets both the minimum dietary diversity and the minimum meal frequency, also known as 'minimum acceptable diet'.

consequent rapid 'catch-up' growth, with associated risks of overweight (Lampl et al. 2016). The importance and complexity of a child's first feeds of complementary foods is reflected in the multiple dimensions of infant and young child feeding guidelines, which specify that the introduction of foods should be timely, of adequate amounts and frequency, and provide a diverse and nutritious range of food groups. In spite of these multifaceted recommendations for complementary feeding, the guidelines fail to account for the heterogeneity of complementary feeding practices and availability of different food types between and within countries. This phenomenon is known as the 'weanling's dilemma' (Rowland, 1986), highlighting the diversity of supplementary feeding practices due to the variety of traditional weaning foods and practices, food availability and hygiene circumstances. Nevertheless, despite the vulnerability of children during this critical window, the weaning transition has received little attention, especially in the context of LMICs.

Although there has been a global increase in the proportion of children under-5 years of age who are overweight and obese, Southeast Asia has experienced the fastest growth of 128%, from 3.2% in 2000 to 7.3% in 2017 (FAO, 2018). Significant gains have been made in the region to reduce undernutrition, with a decrease in stunting prevalence from 46.9% in 1990 to 25.0% in 2018 (UNICEF, 2018), but undernutrition remains a problem in most Southeast Asian countries. Furthermore, the speed at which the nutrition transition is occurring in the region, following rapid economic growth, is particularly concerning for health systems in countries which must now manage the increasing burden of non-communicable disease associated with nutrition, whilst still tackling communicable diseases and conditions associated with undernutrition. However, substantial economic growth, which has triggered this shift in dietary patterns within Southeast Asia, has not benefited all socioeconomic groups. In fact, it is estimated that income inequality increased by 20% in the past two decades in Southeast Asia (UNESCAP, 2018), and in recent years, the number of people considered severely food insecure has risen from 48 million in 2015 to 71 million in 2016 (FAO, 2018).

Rising incomes and socio-cultural changes within countries of Southeast Asia have had divergent effects on different aspects of infant and young child feeding. Recent estimates suggest that rates of exclusive breastfeeding reported for children aged 0 to <6 months within Southeast Asia, range from 23.1% in Thailand (2015), to 65.2% in Cambodia (2014) (UNICEF, 2018). Barriers to exclusive breastfeeding in this region include high rates of female labour-force participation, especially for those working in the informal and agricultural sector, aggressive marketing of breast milk substitutes in health care settings, and, alongside possibly attributed to increased rates of caesarean sections amongst the rising middle and upper class in urban and peri-urban areas

(UNICEF, 2016). Despite national-level economic growth in Southeast Asian countries, the diets of children transitioning to complementary foods at six months are also of a particular concern with less than half of children meeting the requirements for a minimum acceptable diet[4]. For children not meeting this target, inadequate dietary diversity[5] seems to be the main factor, with estimates of minimum dietary diversity achievement ranging from 21.3% in Myanmar to 58.9% in Vietnam (UNICEF, 2018). Globally, it is also true that dietary diversity is a greater challenge than meal frequency, with an estimated 52% of children aged 6-23 months meeting the minimum meal frequency, and only 29% meeting the minimum dietary diversity (White et al., 2017). Among poorer, rural families in low- and middle-income countries, children transition onto the household diet usually consisting of a cereal, starch or grain which, whilst staving off hunger, lacks nutrient quality. Therefore, whilst young children may be receiving the minimum meal frequency, their diets are often devoid in the diversity necessary for promoting optimal growth such as essential proteins, nutrients and vitamins. Furthermore, insufficient dietary diversity not only has implications for under- and over-nutrition, but it is also a contributing factor to other conditions such as childhood anaemia and vitamin-A, iron and zinc deficiencies (Malako et al., 2018; Kennedy et al., 2007).

With just under half of the total population living in urban areas (48.9%) (UNESCAP, 2019), accelerated urbanisation poses an additional paradoxical factor to consider in the dietary quality of young children in Southeast Asia. Although urban settings may offer advantage in terms of better access to a diverse range of foods types, there is an increased consumption of processed, convenience foods for those who are time poor (Kelly, 2016). In summary, the multiple socioeconomic shifts that have taken place alongside a rapid economic transition in Southeast Asia have resulted in marked differentials in infant and young child feeding practices and nutritional outcomes. The changing nutrition landscape in this region, which is being increasingly characterised by steep increases in the prevalence of overweight and associated non-

[4] Minimum acceptable diet is a composite indicator, defined by the WHO as the proportion of children aged 6 to <24 months who receive both the minimum dietary diversity and minimum meal frequency and is calculated separately for breastfed and non-breastfed children (WHO, 2008).

[5] Inadequate dietary diversity is used here to define those children not meeting the WHO (2010) recommendations for receiving food from four or more food groups. This is based on the hypothesis that in most populations, children who receive four or more food groups daily, have an increased likelihood of consuming an animal-source protein which is crucial for optimal linear growth and fruit or vegetables which can prevent micronutrient deficiencies.

communicable diseases, calls for an in-depth study of the nutritional factors in early life that are malleable to change such as infant and young child feeding practices.

1.1 Problem Statement

In light of the increasing double burden of malnutrition in low- and middle-income countries, the motivation behind this research is to understand the trajectories of optimal feeding practices in early life as a cost-effective and valuable health intervention to improve health outcomes and protect against morbidity and mortality throughout the life course. Although the preconception and pregnancy periods are vital for maternal nutrition interventions, the weaning period, which occurs towards the end of the critical 1000 days window, warrants further study, since this may offer a final window of opportunity to shape an infant's path to long-life health.

Southeast Asia represents an important geographical context for this research as strong economic growth over previous decades has given rise to a distinctive nutrition transition and a resultant double burden of malnutrition, with growth rates of overweight and obesity in children under five years of age over the past two decades the highest in the world (FAO, 2018). GDP growth within the region is expected to accelerate between 2019-23, to an average of 5.2% annual growth (OECD, 2018), which is likely to further propel rates of overweight and widen child nutrition inequalities. At the same time, the region is still tackling undernutrition in young children, with 25.0% of children under five years of age currently stunted (UNICEF, 2019), putting significant strain on health systems to tackle forms of malnutrition on both ends of the spectrum. Furthermore, estimates from the 2017 Asia and Pacific SDG report (UNESCAP, 2017) stated that Southeast Asia was the only sub-region within the region in which progress regressed on SDG2, which focuses on eradicating hunger and reducing malnutrition in all its forms, highlighting the need to reverse progress in this area in Southeast Asia, in order to meet the 2030 Sustainable Development Goal.

Although there has been some improvement in rates of exclusive breastfeeding in some countries of the region, such as Cambodia, the proportion of children exclusively breastfed requires further progress. Moreover, the diet of children from age six months presents a particular concern for the region as more than 70% of children do not meet the minimum acceptable diet (UNICEF, 2018), and of these children the main factor is a lack of dietary diversity. Stark socioeconomic disparities, rapid urbanisation and high female labour force participation rates across Southeast Asia further complicate the nutrition situation of young children and pose serious implications for infant and young child feeding practices.

Cambodia, Myanmar and Indonesia were selected for study in this thesis as they represent three economically and culturally diverse countries, and combined account for just over half of the total population of Southeast Asia (51%) in 2017 (UNESCAP, 2018). Cambodia remains predominately burdened with issues related to undernutrition, with 32% of children under five stunted (UNICEF, 2018) and stark inequalities between urban and rural areas exacerbated by the rapid rate of urbanisation between 1990 and 2010. Myanmar is considered to be on the cusp of the double burden of malnutrition (Haddad et al., 2015), with 29% of children under the age of five stunted (UNICEF, 2018) and 40% of children above 15 years overweight or obese. Indonesia is already confronted with the double burden of malnutrition as prevalence of overweight in children under five is 11.5%, whilst at the same time 36.4% of children are stunted (UNICEF, 2018). These three countries also have relatively recent data available, suitable for addressing the research questions proposed.

Cambodia, Myanmar and Indonesia clearly face unique health challenges, in terms of the extent and type of burden of child malnutrition and the associated morbidities, which make them interesting case studies when examining the role of infant and young child feeding practices.

1.2 Research Objectives and Questions

This PhD research examines the role of infant and young child feeding practices on child nutritional status and growth, in light of the nutrition transition in three economically and culturally diverse Southeast Asian countries: Cambodia, Myanmar and Indonesia. Taking into consideration the rapid economic and socio-cultural shifts in this region, the role of socioeconomic status on early feeding practices and child nutrition is a particular theme addressed throughout the thesis.

The overarching aim of this PhD research is to contribute to an understanding of the importance of early life feeding practices, particularly the transition from exclusive breastfeeding, in their potential role of optimising the healthy physical growth of infants and subsequent later life in the context of low- and middle-income countries. This thesis will identify the similarities and differences in the factors associated with exclusive breastfeeding and minimum dietary diversity across all three countries, paying particular attention to the socioeconomic differentials in achievement of these. With use of nationally representative cross-sectional and longitudinal data, this research intends to shed light on the intricate paths and associations between selected infant and young child feeding practices and short-term child nutrition outcomes and longer-term growth throughout childhood and adolescence.

This research employs a quantitative approach structured around three related analysis chapters, employing a variety of statistical methods. Each objective and underlying research questions below pertain to the three analysis chapters presented in this thesis:

Objective 1 - (Analysis 1): To examine demographic and socioeconomic factors associated with two important infant and young child feeding (IYCF) practices: exclusive breastfeeding in 0 to <6 month olds and minimum dietary diversity in 6 to < 24 month olds in three economically and culturally diverse countries of Southeast Asia (Cambodia, Myanmar and Indonesia).

1) *Are there clear socioeconomic differentials in achievement of the WHO recommendation of exclusive breastfeeding status and do these associations vary by country?*
2) *Are there clear socioeconomic differentials in achievement of the WHO recommendation for minimum dietary diversity and do these associations vary by country?*
3) *What conclusions can be drawn about the effect of overall improvements in socioeconomic conditions on exclusive breastfeeding and dietary diversity in Southeast Asia?*

Objective 2 – (Analysis 2): To explore pathways to predicting height-for-age (HAZ) Z-scores among children aged 6 to <24 months in Cambodia, and determine the role of dietary diversity, continued breastfeeding and underlying socioeconomic factors.

1) *Is maternal education, household wealth and maternal employment associated with dietary diversity and continued breastfeeding?*
2) *To what extent (if at all) do dietary diversity and continued breastfeeding mediating the association between socioeconomic factors and children's height-for-age Z-scores?*
3) *Are these aforementioned associations moderated by urban/rural residence?*

Objective 3 – (Analysis 3): To identify distinct BMI growth trajectories in a cohort of Indonesian children using longitudinal data and assess whether the early life environment (including feeding practices) explains variability in growth throughout childhood and adolescence.

1) Can a distinctive BMI growth trajectory be identified in these Indonesian children (aged between 0 to <36 months in the first wave of the Indonesian family life survey and followed through to 14 to 17 years in wave four) that would indicate the development of overweight and obesity?

2) *Does the early life environment – including early infant feeding practices – explain variability in child growth outcomes?*

1.3 Policy and Scientific Contribution to Knowledge

The study of infant and young child feeding practices and associated nutritional outcomes in Southeast Asia is relevant from both the perspective of academic research and the international policy arena. This thesis aims to contribute to the knowledge of infant and young child feeding practices in light of the nutrition transition which is occurring in many low- and middle-income countries. The research attempts to challenge the theories and evidence that equate improvements in socio-economic status to reductions in malnutrition (Preston 1975; Pritchett & Summers 1996; Smith & Haddad 2002), by systematically exploring the role of socio-economic status in countries which have experienced rapid economic growth over recent decades, and the actual associations with infant and young child feeding practices and child nutrition. This part of the research is aimed at understanding how feeding practices during this early stage of life may be determined by structural conditions within the economy, society and evolving gender norms, such as high rates of female labour-force participation. Developed countries in which economic growth and epidemiological transitions have occurred more steadily are the current basis for evidence that increases in national income have contributed to a decline in the adequacy of infant and young child feeding practices and an increase in diets containing processed foods, high in saturated fats (Popkin, Adair and Ng, 2012). However, less is known about the effects of rapid economic growth on infant and young child feeding practices in low- and middle-income countries, currently undergoing these transitions at a much faster pace than previously industrialised, now high-income countries. Southeast Asia also represents a relatively understudied region in terms of this weaning transition and complementary feeding practices, despite some existing research on breastfeeding practices and child malnutrition. The importance of studying these three Southeast Asian countries is further evidenced by the fact that together these countries account for 51% of the total population of Southeast Asia, and that therefore the overall results from this thesis are likely relevant to the rest of the region and other LMICs. The second study in this thesis proposes a theoretical structural path model that explains pathways to stunting in the context of Cambodia, however there is potential for this model to be applied in other study contexts. The final analysis presented in this thesis, which uses longitudinal data from Indonesia to model children's BMI trajectories, supports existing research on the shape of BMI growth trajectories in young children through to adolescence, using a statistical method which allows for the identification of growth trajectories indicative of overweight and obesity in later life. This study is one of the first to model BMI growth trajectories from an LMIC using longitudinal data, and proposes a method of identifying populations at risk from developing an adverse health outcome, which has value for population health.

In terms of the potential for informing policy-making, this research sheds light on the heterogeneity in the socioeconomic factors associated with early feeding practices, both between and within countries in Southeast Asia. In the context of the 2030 Sustainable Development Agenda (UN General Assembly, 2015), this research aims to highlight the importance of improving infant and young child feeding practices for accelerating progress towards SDG2[6] and SDG3[7] in particular. Current guidelines for complementary feeding practices are relatively broad and do not account for variation between population sub-groups or for country-specific, traditional weaning practices that are often commonplace. In this geographical context where a high proportion of women actively participate in the labour force, it is also important to consider the implications of that for both infant and young child feeding practices and child nutrition, to ensure that maternity legislation is adequate. This research also contributes in terms of a novel approach to measuring female labour force participation, with the creation of a composite indicator which considers different aspects of female employment, especially important in a context where the majority of women are employed in the informal labour market.

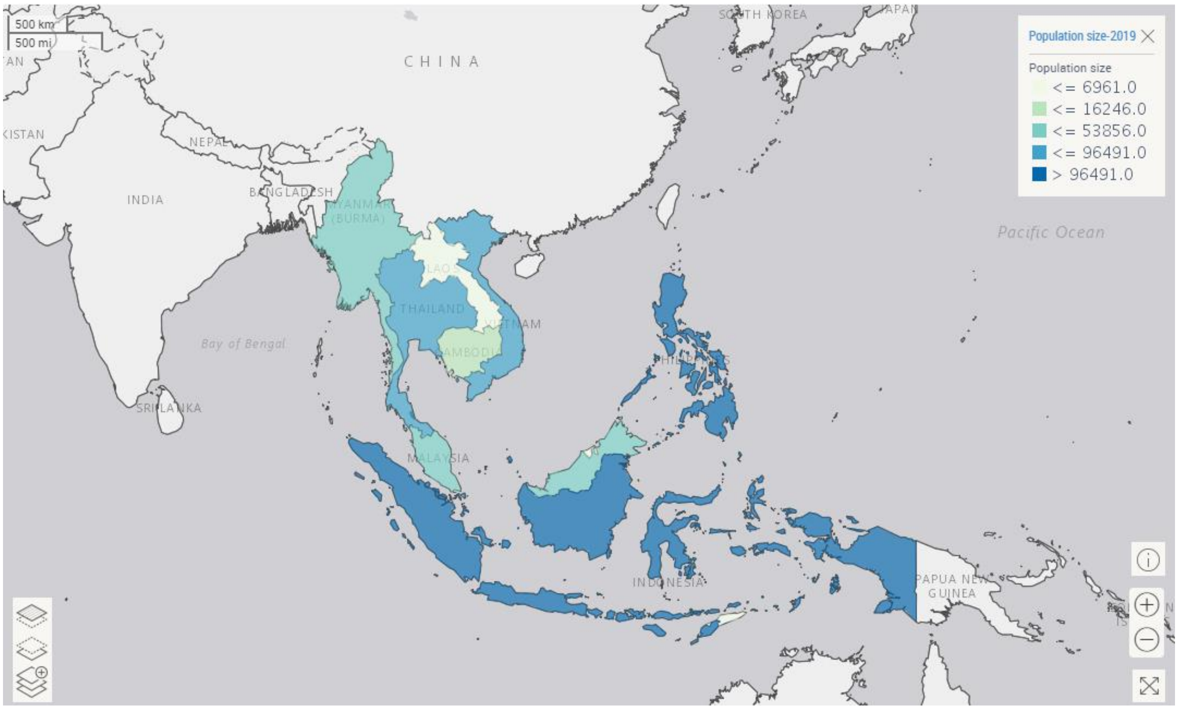
1.4 Study Context: Southeast Asia

Southeast Asia is one of five sub-regions that comprise the Asia-Pacific region, situated with East Asia to the North, South Asia to the West and the Pacific to the East (Figure 1.2). With the exception of Timor-Leste, all countries in Southeast Asia are member states of the Association of Southeast Asian Nations (ASEAN), an economic and intergovernmental entity that promotes cooperation between its members, political stability and sociocultural integration (ASEAN, 2019). Globally, it is the third most populated geographical sub-region after South and East Asia and currently has a population of 656 million people (UNESCAP, 2018) residing in the eleven countries that make up this sub-region. Despite rapid population growth between 1950 and 2010, when the population of Southeast Asia tripled (Hirschman and Bonaparte, 2012), improvements in life expectancy and a concurrent fall in marriage and birth rates have propelled a growing demographic concern in the region, with a gradual shift towards population ageing. Total fertility

[6] SDG2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture (UN General Assembly, 2015).
[7] SDG3: Ensure healthy lives and promote well-being for all at all ages (UN General Assembly, 2015).

rate in the sub-region sits just above replacement level at 2.2 children per woman of childbearing age, ranging from as low as 1.3 in Singapore to 5.3 in Timor-Leste (UNESCAP, 2018). Of all the countries in this sub-region, Indonesia is the most populous, making it the fourth most populated country in the world and, by land cover, the largest archipelago in the world consisting of 18,000 islands.

Figure 1.2 Map of Southeast Asia and population sizes, by country



Source: UNESCAP Statistical Database, 2018

The majority of countries in Southeast Asia share a similar tropical monsoon climate, with distinctive wet and dry seasons, providing favourable conditions for agricultural activities such as rice production which is one of the main exports of this sub-region. According to the World Bank (2019) country income classifications, Singapore and Brunei Darussalam are considered to be high income countries whose economic development has historically relied on the petroleum industry, or, in the case of Singapore, on the export of electronics, technology and a lucrative finance sector. All of the remaining countries in the sub-region are classified as lower- or upper-middle-income countries, with countries such as Thailand, Indonesia, Malaysia and the Philippines being known as the emerging economies and countries such as Cambodia, Myanmar and Lao PDR known for their heavy dependence on agricultural industry. Southeast Asia as a whole is an extremely heterogeneous region with a diversity of ethnicities, religions, languages and cultures spanning its entirety.

1.4.1 Social, cultural and economic overview of Southeast Asia

From as early as the mid-16th century, countries of Southeast Asia have been subject to the colonial powers of Europe, Japan and the United States, with Brunei Darussalam being the last country to gain independence from British colonial rule in 1984 (Christie, 2000). Colonialism introduced the demarcation of Southeast Asia into clearly drawn boundaries of a previously borderless sub-region (Lee, 2018), with shared regionally fluid identity. Since gaining independence, Southeast Asia witnessed significant conflict throughout the 20th century, including the Vietnam War, the Indonesian invasion of East Timor, the Cambodian Genocide under the rule of the Khmer Rouge regime, and ethnic and religious insurgencies in Southern parts of Thailand and the Philippines (Beeson, 2009). Although at the sub-regional level the region remains relatively stable, domestic ethnic conflicts have prevailed in Thailand, Myanmar and the Philippines in recent decades. From the political perspective, countries of Southeast Asia have been known for their authoritarian rule in the post-colonial period, however there have been movements to establish democratic political systems in countries such as Thailand and Indonesia (Beeson, 2009). Nevertheless, different forms of constitutional monarchy still exist in Thailand, Brunei and Cambodia and communism still prevails in Vietnam and Lao PDR.

In terms of the socio-cultural characteristics of the sub-region, Southeast Asia is religiously diverse and Cambodia and Brunei are the only countries that exhibit religious homogeneity, with the majority of the population in Cambodia Buddhist and Brunei being predominately Muslim (Beeson, 2009). However, at the sub-regional level, Southeast Asia is known for its heterogeneous religious identity. Although Indonesia and Malaysia are predominately Muslim, a smaller proportion of the population are Buddhist, Christian or Hindu (*ibid.)*. Similarly, in Thailand, Vietnam, Singapore and Myanmar where the main religion is Buddhism, other religious identities co-exist *(ibid)*. Historical literature has tended to portray Southeast Asia as less patriarchal than other sub-regions in Asia (Booth, 2016), from both an economic and social perspective. Even during the pre-colonial era, when agriculture was the main form of industry in this sub-region, work tasks were supposedly shared evenly between men and women (Reid, 1988), and in more recent times a larger proportion of women participate in income-earning activities outside the home than in other Asian sub-regions (Booth, 2016). Moreover, even when religion is taken into consideration, both Indonesia and Malaysia exhibit better results on many gender empowerment indicators compared to other Muslim-majority countries in other regions, and similar findings have been found when comparing the Philippines to other Catholic-majority countries (*ibid.*). Primary school net enrolment rates also support this hypothesis, as Southeast Asia has the narrowest gender gap on this indicator compared to other sub-regions in the Asia-

Pacific region, with the lowest levels seen in Thailand with 89.4% of girls enrolled in primary education and 100.0% in Indonesia which has the highest net enrolment (UNESCAP, 2015). Although female labour force participation rates are relatively high in Southeast Asia, with 58.8% of women participating in the labour force (ILO, 2017), in five out of the six countries with recent data women are more likely to be employed in the informal sector than men which introduces concerns over lack of legal protection and employment benefits such as maternity leave.

Following the Asian financial crisis in 1997, in which GDP drastically declined in the emerging countries of Southeast Asia (Lane, 1999), the economy gradually stabilised and is predicted to continue growing at 5.2% in the 2019-2023 period (OECD, 2018). International labour migration from the Southeast Asia region is an increasingly common phenomenon, with an approximate 9.9 million people moving within the ASEAN region in 2017, of which approximately half were women (48.7%) (UN WOMEN, n.d.). Although internal migration from rural to urban areas in search of work is harder to measure, it is clear that this type of migration has also significantly altered the demographic structure of most Southeast Asian countries (UNESCO, 2018). Furthermore, this migration pattern is typically gendered, with female migrants being more likely to participate in longer-term rural-urban migration or short-term international migration within Southeast Asian countries, the Middle-East, and Europe, often leaving children behind to be cared for by grandparents (*ibid.)*. These rural households where one or both parents have migrated in search of work, are referred to as “skip generation households” and studies have suggested negative implications for child development (Institute of Population and Social Research, 2012). On the theme of rural to urban migration, rapid urbanisation is also placing an additional pressure on the sub-region with a total 48.9% of the population residing in urban areas in 2018 (UNESCAP, 2018) which generates further multiplicative environmental, societal and economic concerns.

1.5 Cambodia, Myanmar and Indonesia

The study context for this thesis is provided by Cambodia, Myanmar and Indonesia: three economically, socially and culturally diverse countries that aptly represent just some of the diversity that exists throughout Southeast Asia. Geographically speaking, Cambodia and Myanmar are considered part of mainland Southeast Asia, and Indonesia which is the largest archipelago in the world is part of maritime Southeast Asia, and together these countries account for over half of the population of Southeast Asia (UNESCAP, 2018) (Table 1.1).

Table 1.1 Demographic and economic characteristics of selected countries. Latest estimates based on available data.

	Indicator								
Country	Total. Pop (thousands)[a]	Pop. Growth rate[a]	TFR (total fertility rate)[a]	% of pop (0-14 years)[a]	GDP per capita (US$)[b]	Gini coefficient	% of pop urban areas[a]	Under-5 mortality rate (per 1,000 live births)[c]	Female labour force participation rate[d]
Cambodia	16246	1.5%	2.5	31%	$1,384	0.31 (2012)	23.4%	29.2	75.2%
Indonesia	266795	1.0%	2.3	27%	$3,846	0.40 (2013)	55.3%	25.4	52.2%
Myanmar	53856	0.9%	2.2	26%	$1,257	0.38 (2015)	30.6%	48.6	47.7%

Data source: [a] UNESCAP Statistical database (2018), [b] World Bank (2017), [c] UNESCAP Statistical database (2017) and [d]ILOSTAT (2018)

Based on the latest World Bank country income classifications by Gross National Income (GNI) per capita (2018), all three countries are considered to be lower-middle-income economies. Latest estimates of Gini coefficients (Table 1.1) suggest that Indonesia has the highest income inequality of the three, with a coefficient of 0.40 in 2013, and Cambodia the lowest, with a coefficient of 0.31 in 2012 (UNESCAP, 2018). Indonesia has the largest economy in Southeast Asia and the 10th largest globally, obtaining title of an 'emerging middle-income country' (The World Bank, 2019). Indonesia's growing economy has relied on the exportation of crude petroleum, rubber, cocoa and palm oil, but more recently the economy has transitioned towards secondary and tertiary industries such as manufacturing and services. Although the garment industry, construction and tourism are the main propellants of economic growth in Cambodia, the agricultural industry represents approximately 35% of total GDP and a large proportion of the population are employed in this sector (FAO, n.d.), with rice production being the main export. The importance of the agricultural sector is also reflected in the fact that over three-quarters of the population live in rural areas (Table 1.1).

Similar to Cambodia, Myanmar is predominantly an agricultural economy, employing approximately 70% of the labour force (FAO, n.d.) and economic growth has been relatively stable over recent years (The World Bank, 2019). However, Myanmar has the lowest GDP per capita of all three countries, and has struggled with ongoing conflict in the Rakhine State region which encompasses one-third of the country. The proportion of women participating in the labour force in both Cambodia and Indonesia is greater than the global average of 47.9 as of 2018 (ILOSTAT, 2018), and in Cambodia the proportion is significantly higher with over three-quarters of women participating in the labour force (Table 1.1). Nevertheless, in all three countries, over two-thirds of this female employment occurs within the informal sector (UNESCAP, 2018), in jobs which are normally associated with lower wages, unsafe working conditions, lack of legislation over sick leave, health benefits and maternity leave. Despite the fact that all three countries have implemented official maternity legislation, which varies from 12 weeks in Cambodia, 13 weeks in Indonesia to 14 weeks in Myanmar, (ASEAN and UNICEF EAPRO 2016), women who are self-employed - which is often the case with informal employment in LMICs - are not entitled to the same benefits. Furthermore, for mothers who are eligible for maternity leave, the legislation in Indonesia and Myanmar states that six weeks of the maternity leave should be taken before delivery, which has potential negative implications for breastfeeding continuation (Walters et al., 2016).

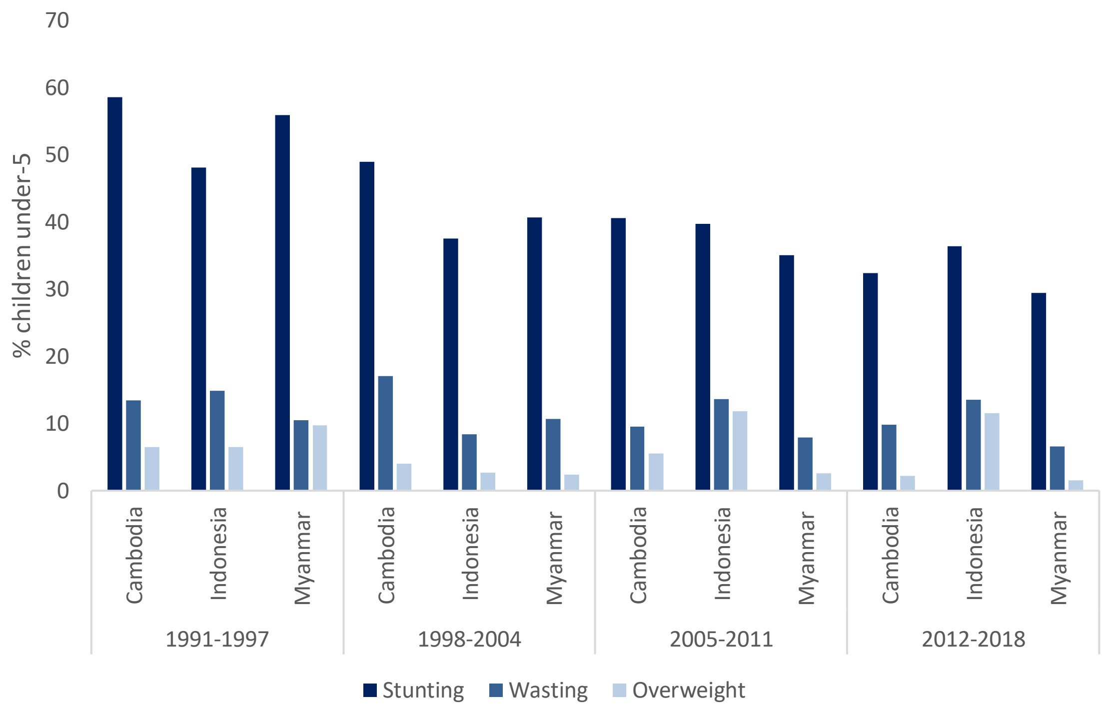
Of all three countries, Indonesia is the most culturally diverse with more than 300 ethnic groups and six official religions spread across the country (Islam, Protestantism, Catholicism, Hinduism, Buddhism and Confucianism), although the majority of the population are Muslim (Beeson, 2009). Similarly, in Myanmar where Buddhism is the main religion, Christianity and Islam are also practiced (*ibid*). Comparatively, Cambodia is religiously homogenous with 97% of the population practising Buddhism (*ibid.*). In terms of social development, Cambodia has made good progress in education and health outcomes, with the under-five mortality rate reducing by more than half from 83 per thousand live births in 2005 to 35 per 1,000 live births in 2014 (World Bank, 2019). On the other hand, ongoing conflict in Myanmar has hindered development, causing the internal displacement of 150,000 people and the out-migration of more than 700,000 people trying to escape the humanitarian crisis in Rakhine State (World Bank, 2019). Indonesian progress in sustainable development has been more mixed: whilst the percentage of the population living in poverty has fallen from 17.8% in 2006 to 10.7% in 2016 (UN SDG Knowledge Platform, 2017), the absolute number of people still experiencing poverty (22.76 million people) is very high because of the sheer population size.

The next sections will provide a brief contextual overview of the nutrition situation and infant and young child feeding practices specific to Cambodia, Myanmar and Indonesia.

1.5.1 The nutrition situation in Cambodia, Myanmar and Indonesia

According to the 2017 United Nations SDG Report (UNESCAP, 2017), Southeast Asia was the only sub-region in Asia and Pacific where progress regressed (baseline: 2000) for SDG2, which focuses on eradicating hunger and ending all forms of malnutrition. Although significant strides have been achieved in reducing undernutrition in the form of stunting in children under-5 years in Cambodia, Myanmar and Indonesia (Figure 1.3), latest estimates for the 2012-2018 period suggest that still a third or more of children in each of these countries is affected by stunting (32.4% in Cambodia, 36.4% in Indonesia and 29.2% in Myanmar).

Figure 1.3 Percentage of children under-5 years stunted, wasted and overweight. Mean estimate for each time period.



Note: Estimates derived from a range of data sources including Demographic and Health Surveys, Multiple Indicator Cluster Surveys, National Health Survey, Indonesia, Indonesia Basic Health Survey, National report on basic health research, Indonesia, National Nutrition Survey, Myanmar (UNICEF, WHO and The World Bank Group, 2018).

Furthermore, the nutrition landscape has been shifting rapidly in Southeast Asia (Haddad, Cameron and Barnett, 2015; Popkin, 2012), which has been particularly evident in Indonesia with the rise in prevalence of overweight and obesity in children under-5 years from 1.5% in 2000 to 11.5% in 2013 (UNICEF, 2019). Prevailing forms of undernutrition and concurrent increases in overweight and obesity have given way to a double burden of malnutrition in Indonesia and an associated rise in non-communicable co-morbidities (Hanandita and Tampubolon, 2015). Dietary changes characteristic of the nutrition transition have shaped this emerging nutrition and disease profile, which in Asia has involved an increase in daily energy sourced from oils, fats, refined sugars, processed foods and wheat-based carbohydrates (Kelly, 2016), along with a rise in sedentary lifestyles. Although rising incomes and increased food availability have been cited as the main causes of the double burden of malnutrition in Asia (Drewnowski and Popkin, 1997), these nutrition transitions are also becoming more pronounced amongst the economically disadvantaged (Popkin et al., 2012).

Although the nutrition situation in Indonesia is compounded by a rise in overnutrition at the same time as persisting undernutrition, a commonality shared between all three countries under study in this thesis is the prevailing rates of undernutrition in children under-5 years. In terms of characteristics of the diet, all three countries share a high dependence on rice-based and often vegetarian diets, which often provide inadequate micro-nutrients (Chaparro, Oot and Sethuraman 2014).

1.5.2 IYCF practices in Cambodia, Myanmar and Indonesia: empirical evidence

Breastfeeding practices

Although the majority of children in Southeast Asia receive at least some breast milk in the first six months of life (Walters et al., 2016), the proportion of children exclusively breastfed in the selected study countries ranges from 40.9% in Indonesia, 51.2% in Myanmar, to 65.2% in Cambodia (UNICEF, 2018). On the other hand, rates of continued breastfeeding amongst children 0 to <24 months are considerably higher, with recent estimates suggesting 75.4% of children in this age group were receiving some breast milk in Cambodia, 77.7% in Indonesia and 87.9% in Myanmar (*ibid.*).

In terms of improvements in rates of exclusive breastfeeding practices, Cambodia has made the most impressive gains since 2000 when just 10.8% of children were exclusively breastfed, increasing more than seven-fold by 2010 to 72.8%, to decrease again by 2014 to 65.2%. Breastfeeding promotion campaigns in Cambodia were successful in improving rates of exclusive breastfeeding as well as early initiation of breastfeeding (Som et al., 2018), but it was also noted that during the same period (2000-2010), use of breast milk substitutes and bottle-feeding increased among children aged over 6 months (Prak et al., 2014). Furthermore, a qualitative study conducted by Bazzano and colleagues (2015) in Takeo province in Cambodia found that, despite women in the study demonstrating a comprehensive knowledge of the benefits associated with exclusive breastfeeding which they had heard or seen from media campaigns, in practice many participants reported using breast milk substitutes at some point. Interestingly, these mothers were from a range of socioeconomic backgrounds and had different levels of education. The increased use of breast milk substitutes during the period 2000 to 2010 in Cambodia (Prak et al., 2014) has been attributed at least in part to the increasing trend in elective caesarean sections among wealthier women residing in urban areas (UNICEF, 2016) and the persistent promotion of formula milk in hospitals despite the enforcement of sub-Decree 133[8] (Som et al., 2018). In fact, Prak and colleagues (2014) reported that breast milk substitute use in

[8] Sub-Decree 133 on Marketing of Products for Infant and Young Child Feeding was established by the Royal Government of Cambodia and the Ministry of Health in 2001, in line with the International Code of Marketing of Breast milk Substitutes, which prevents the promotion of IYCF products at point-of-sale and within healthcare facilities.

children born in private clinics was five times greater than those delivering in a public institution, highlighting a weak enforcement of sub-Decree 133. Research conducted in the capital of Cambodia – Phnom Penh - using a cross-sectional survey, also indicated higher likelihood of formula milk usage amongst working mothers, suggesting that preferential attitudes towards formula milk still exist with a large proportion of women in the study reporting that it was "healthy" or would make their children "smart" (Pries et al., 2016). Pre-lacteal feeding[9] also presents a significant barrier to achieving exclusive breastfeeding in Cambodia, and data revealed that between 2000 and 2014, the proportion of children who received pre-lacteal feeds in the first three days following birth had increased by 8.6% and moreover approximately doubled in urban areas, with more than half of urban new-borns receiving pre-lacteal feeds in 2014 (UNICEF, 2015).

Over the period 1991 to 2012, the proportion of children aged less than six months exclusively breastfed actually declined in Indonesia from 46.8% in 1991 to 40.9% in 2012 (UNICEF, 2018). Large variation in exclusive breastfeeding prevalence also exists across the 34 provinces of Indonesia with the lowest reported rates in Maluku with 25% of children exclusively breastfed and the highest in West Nusa Tenggara at 80% (Spagnoletti et al., 2018). In an attempt to improve rates of exclusive breastfeeding, the Indonesian government enacted a law[10] in 2009 which stated that every baby should be exclusively breastfed for six months with either breast milk from the biological mother or a milk donor, with the exception of situations where there are medical contraindications for doing so (Shetty, 2014). Islam has also influenced the way in which Muslim Indonesian women view breastfeeding and the optimal duration. A study conducted by Winikoff et al. (1981) found that nearly all the Indonesian women in their study concurred that breastfeeding was a Muslim woman's duty to her child and that two years of breastfeeding is actually prescribed in the Qur'an (Sapgnoletti et al., 2018). Whilst rates of exclusive breastfeeding have witnessed minimal or negative change over recent decades in Indonesia, prevalence of continued breastfeeding has stayed much the same, a pattern also noted by other researchers (Geertz, 1961; Marzuki et al., 2014; Nuzrina, Roshita and Basuki, 2016). It has been suggested that although breastfeeding is a normative practice throughout Indonesia, there is a prevailing perception amongst Indonesian mothers than breast milk has insufficient nutritional content to

[9] When using DHS data, pre-lacteal feeding is defined by a variable that measures whether or not the child was given any additional foods or liquids in the three days following birth. As exclusive breastfeeding is measured using the WHO exclusive breastfeeding indicator (2008), current status data is used to assess whether the child was exclusively breastfed in the 24 hours prior to survey. Therefore, under this definition, even children who received pre-lacteal feeds can be classified as exclusively breastfed if they only received breast milk in the day prior to the interview.
[10] This law is known as National Health Law 36 (2009), or it is referred to locally as UU 36/2009 (Spagnoletti et al., 2018).

be able to provide all of the infant's needs. Marzuki and colleagues (2014) also noted, from their qualitative study in four provinces, that social stigma towards breastfeeding in urban areas posed a significant barrier for breastfeeding and in these situations formula milk was the favourable feeding method. Breastfeeding practices vary broadly over the vast expanse of the Indonesian archipelago according to local customs and culture, it has been reported that in some areas such as Nias Island, pre-lacteal feeding is a common occurrence due to strong cultural perceptions that the colostrum should be discarded because it is regarded as being potentially harmful to the infant's health (Inayati et al., 2012). In this particular study, sugar water and formula milk were the two most commonly reported pre-lacteal feeds.

Prevalence of exclusive breastfeeding in infants under six months has improved significantly in Myanmar from 10.5% in 2000 to 51.2% in 2015 (UNICEF, 2018). Qualitative research from the Ayeyarwaddy region in Myanmar (Thet et al., 2016) highlighted that socio-cultural perceptions hindered improvements in exclusive breastfeeding practices, despite respondents demonstrating high levels of knowledge on the benefits of breastfeeding and especially exclusive breastfeeding. Traditional myths and conceptions that promote the early introduction of complementary foods before six months as being beneficial for a child's health are also detrimental to the achievement of exclusive breastfeeding in Myanmar (Thet et al., 2016). Labour force participation has also been cited as one of the main barriers to exclusive breastfeeding among mothers in Myanmar (Thet et al., 2016; Hmone et al., 2016) due to limited time allocation to unpaid, domestic care in the household.

Complementary feeding practices

Latest data from all three countries suggest that few children aged 6 to <24 months receive the minimum acceptable diet[11], ranging from just 15.9% of children in this age group in Myanmar (2015), 30.4% in Cambodia (2014) to 36.6% in Indonesia (2012) (UNICEF, 2018) Further examination of minimum dietary diversity and minimum meal frequency, which together comprise the minimum acceptable diet indicator, reveals that minimum dietary diversity is the main aspect of complementary feeding falling short in all three countries. Of the children who did not meet the requirements for a minimum acceptable diet, the proportion of children who had not received minimum dietary diversity ranged from 66.0% in Indonesia, 75.4% in Cambodia and 89.5% in Myanmar[12]. Estimates from the same years show that overall just 24.6% of children

[11] Minimum acceptable diet: the proportion of children aged 6 to <24 months who received the minimum dietary diversity and the minimum meal frequency in the 24h previous, calculated separately for breastfed and non-breastfed children (WHO, 2008).
[12] These estimates were calculated using CDHS (2014), IDHS (2012) and MDHS (2015-16) data.

aged 6 to <24 months met requirements for minimum dietary diversity in Myanmar (2015), 47.7% of children in Cambodia (2014) and 58.2% of children in Indonesia (2012) (*ibid.*). On the other hand, minimum meal frequency was met by a larger proportion of children with 58.0% of children aged 6 to <24 months in Myanmar (2015), 72.4% in Cambodia and 66.6% in Indonesia (*ibid.*).

Despite the success of a national nutrition campaign in spreading awareness of good complementary feeding practices in Cambodia (*COMBI* - Communication for Behavioural Impact) from 2011-2014, still too few children are fed according to WHO recommendations (Som et al., 2018). Evidence from multiple studies conducted in different regions throughout Cambodia suggest that the types of complementary food consumed by children may be one of the main contributing factors to inadequate dietary diversity. Rice is a staple food in Cambodia, accounting for approximately 60% of total daily energy intake of adults (IFREDI, 2013), and is often administered to young children as a complementary food in the form of a rice porridge known locally as *borbor* (Stone, Senemaud and Thai, 1989; Anderson et al., 2008) along with soups. Although these types of traditional complementary foods are usually prepared in the home, which is something promoted by the COMBI campaign, these complementary foods are low in animal-source protein and vitamin-A rich plant-based foods which are crucial for preventing micronutrient deficiencies (*ibid.*). Perhaps more concerning is the reported increased consumption of unhealthy commercially produced snack foods such as crisps, biscuits, cakes and sugary beverages in young children, especially in urban areas such as Phnom Penh (Anderson et al., 2008; Wren and Chambers, 2011; Pries et al., 2016). In their study conducted in Phnom Penh, Pries and colleagues (2016) found that over half of their sample of 294 children (55%) aged 6 to <24 months consumed commercially produced snack foods such as savoury snacks with a high salt content and sugary sweet snacks. Whilst these foods are typically energy dense and more convenient, they are also nutrient-poor and may displace consumption of healthier, micronutrient-rich alternatives (Anderson et al., 2008).

Similarly, in Indonesia the types of food consumed by children during the complementary feeding period appeared to be a primary factor in most studies concerned with dietary diversity, with rice being a key staple in the Indonesian diet and constituting the highest proportion of energy intake from grains in the adult population, globally (Vermeulen et al., 2019). This is usually administered to children as their first complementary foods in the form of a rice porridge known as *bubur* or simply boiled steam rice (Inayati et al., 2012). Due to the substantial diversity throughout Indonesia, these staple complementary foods vary from province to province, for example in eastern Indonesia sago porridge known as locally as *papeda* - made from sago flour - is one of the first complementary foods consumed by young children (Santika, Fahmida and Ferguson, 2009). However, whilst these types of foods are often energy-dense, they lack the micronutrients essential for healthy growth and cognitive development in this age period, such as calcium, iron and zinc (Diana et al., 2017).

Although there are very few studies on complementary feeding practices that have been conducted in Myanmar, some qualitative studies have suggested that children are introduced early to complementary foods (before six months) (Chit, Kyi and Thwin, 2003; Thet et al., 2016). The most common foods or liquids introduced to infants before age 6 months included mashed rice known as *ghazi,* sweet milk (condensed or emulsified) or infant formula (Sandar, 2006). Analogous to the complementary feeding situation in Cambodia and Indonesia, the low nutritional quality of the complementary foods is of a primary concern, and a lack of consumption of iron-rich foods such as meat and other animal-source produced, which was found to be at levels even lower than in Cambodia and Indonesia (Mya, Kyaw and Tun, 2019).

In summary, although there may be regional differences in the types of traditional complementary foods which are consumed by children aged between 6 and less than 24 months in Cambodia, Myanmar and Indonesia, a commonality shared by all three countries is the micronutrient-poor complementary foods, based primarily on some variation of rice. The majority of children in all three countries receive some breast milk and continued breastfeeding is often practiced, however low rates of exclusive breastfeeding can be attributed to traditional beliefs or misconceptions about the sufficiency of breast milk to provide for a child's nutritional needs for the first six months, as well as significant socioeconomic barriers that vary between population groups. The ways in which socioeconomic status impacts child nutrition through infant and young child feeding practices, in Cambodia, Myanmar and Indonesia is discussed in more detail in the following section.

1.5.3 Socioeconomic inequality and the implications for IYCF practices

According to the 2017 SDG report for the Asia Pacific region, Southeast Asia was the only sub-region for which inequality increased, causing a regression in progress towards achieving SDG10[13] (UNESCAP, 2017). This was also demonstrated by the rise in Gini coefficient for this sub-region from 32.6% in 1990-99 to 39.1% in 2014 (UNESCAP, 2018). Although Southeast Asia has experienced impressive economic growth in recent decades which has lifted millions of people out of poverty (OXFAM, 2018), the implications of rising inequality on young child feeding practices are varied.

[13] Sustainable Development Goal (SDG) 10: Reduce inequality within and among countries.

In terms of socioeconomic inequalities, increasing household incomes and subsequent rises in consumer purchasing power have increased access to a diverse range of food types in a small strata of Southeast Asian populations, namely wealthier, urban households. The rising prevalence of supermarkets in this region (Haddad, Cameron and Barnett, 2015), especially in urban areas, has compounded the issue, providing access to a wide range of both healthy and unhealthy food products. Increased access to obesogenic food types, coupled with an increase in sedentary lifestyles in urban areas has been one of the main propellants of increases in overnutrition in young Indonesian children (World Bank, 2015), predominantly those from richer, urban households. However, 14.3% of the population in Indonesia still live below the poverty line and have been affected by rising food prices, such as the cost of rice which is now between 50-70% more expensive than in neighbouring countries (WFP, 2019). Poorer households in rural areas, which rely on agricultural production, are the most affected by food insecurity, as is the case in Cambodia and Myanmar (WFP, 2019), where there is a greater reliance on staple food sources such as rice. For example in Cambodia, children from the poorest households were four times less likely to receive the minimum acceptable diet and children from rural households were twice as likely to not receive the minimum acceptable diet (Som et al., 2018).

Prevalence rates of exclusive breastfeeding in Cambodia, Myanmar and Indonesia also have a marked urban-rural and socioeconomic patterning, with women from richer, urban households less likely to exclusively breastfeed (Senarath et al., 2010) than those from poorer, rural households. Furthermore, increased use of breast milk substitutes has been observed among richer, urban women in Cambodia (Prak et al., 2014), further exaggerated by the surge in elective caesarean sections in private clinics (Som et al., 2018), where breast milk substitutes are freely available. Other studies such as the one conducted by Bazzano et al., (2015) found no clear association between socioeconomic status or level of education and use of breast milk substitutes in Cambodia, which suggests that the use of breast milk substitutes is expanding within all population groups.

When considering the role of socioeconomic inequality on child nutritional status, it is important to also acknowledge other factors which may influence nutrition but that are not necessarily related to dietary quality. For example, children from poorer households are less likely to have access to good quality healthcare or adequate WASH services, and so the quality of infant and young child feeding practices is likely to play an even greater role for these children. In a sub-region which is rapidly urbanizing, it is particularly important to consider these rural-urban inequalities as the proportion of populations residing in urban areas increases.

1.6 Candidate's contribution

I conceptualised the proposal for this thesis including the objectives and research questions. I identified suitable data sources and obtained permission to access the datasets from the Demographic and Health Survey (DHS) Programme and the RAND Corporation who hold the data for the Indonesian Family Life Survey (IFLS). Prior to opening the datasets, ethical approval was sought from the University of Southampton *Ethics and Research Governance Online* (ERGO). I undertook the data cleaning for the three DHS datasets for Cambodia, Myanmar and Indonesia, and selected the appropriate populations for the analyses, in addition to recoding variables, and creating composite indicators where necessary. The process of preparing the IFLS data for analysis involved merging data files from individual waves to create a new dataset that included children who had appeared in the first wave of the IFLS, and who were followed-up in at least one subsequent wave. To compute child growth measurements, I applied the WHO Anthro (for children aged 0-5 years) and WHO AnthroPlus (for children aged 5-19 years) packages for Stata (2007), which calculate child growth measurements using the latest WHO growth references (2007). I recorded and assessed survey attrition and decided on the most suitable way to approach this in the analysis. I was responsible for conceptualising, conducting and writing up each of the analyses included in this thesis, and where necessary attended the appropriate training courses in order to implement particular analytical methods. I was fully responsible for the interpretation of the data and the conclusions drawn.

1.7 Thesis Structure

The thesis is organised into seven chapters, based on a traditional thesis format.

Following the Introduction in Chapter 1, Chapter 2 provides a literature review on the theoretical concepts referred to throughout this thesis and the empirical evidence that relates to them. Information about the data sources and statistical methods used in this thesis are presented in Chapter 3. Chapter 4 contains results of the first analysis, which is a sub-regional snapshot of socioeconomic factors associated with exclusive breastfeeding in children aged 0 to <6 months and minimum dietary diversity in children aged 6 to <24 months in Cambodia, Myanmar and Indonesia. The results from this chapter relating to minimum dietary diversity were published in *Public Health Nutrition* (Harvey, Newell and Padmadas, 2018). Before publication, this paper was also presented at the *Nutrition & Growth Conference*, Paris 2018.

Results from the second analysis are presented in Chapter 5, which focuses on the role of dietary diversity and continued breastfeeding in pathways to stunting in Cambodia and how this varies according to contextually relevant, underlying socioeconomic factors. Chapter 6 consists of the final analysis which examines the longer-term associations between early life feeding practices and BMI trajectories, using longitudinal data from Indonesia.

Finally, Chapter 7 summarises the key findings from each analysis chapter followed by an extended discussion with reference to existing research and theoretical concepts and the potential policy implications and future research.

Chapter 2 Theoretical Background and Empirical Evidence

The purpose of this literature review is to introduce and critically evaluate the theoretical concepts that are referred to throughout this thesis (section 2.1), and present evidence relating to infant and young child feeding practices and implications for health and nutrition throughout the life course (section 2.2-2.5). Through conducting a thorough review of existing evidence, the aim is to highlight the gap in this field of research and to provide justification for the value of this PhD research

As the objective of this review was to provide a broad overview of the several topics addressed in this thesis (life course perspective, infant and young child feeding practices, child nutritional outcomes and the conceptual framework) and not to address a specific, focused research question, a literature review done systematically, rather than a formal systematic review, was deemed appropriate.

The literature review was conducted systematically, with literature obtained using the search engines PubMed and Web of Science, as well as Google Scholar for official publications or reports by international organizations. Firstly, the key words and phrases were identified for the sub-headings to be included in this review, and synonyms were identified to ensure that all publications with different interpretations of words and phrases were included. For example, for the sub-heading 'Life course perspective', the following search terms were used: life-course; lifecourse; life course; life course perspective; life course theory; life course approach; life course paradigm; life cycle; life-cycle. In order to account for variations in alternative spellings, abbreviations or phrasing of these key terms, Boolean operators were used in search queries to refine the literature search. Search results were reviewed for relevance on title only, and then by abstract. The relevant sub-headings were based on the different themes that were considered key to this thesis (life course perspective; nutrition transition; early life nutrition; indicators of child nutritional status; infant and young child feeding practices; infant and young child feeding practices in the context of Southeast Asia; role of socioeconomic status on infant and young child feeding practices; conceptual frameworks for child nutritional status). Only papers published from 1990 onwards were included (unless a publication was deemed key to the study). All search results were stored and organised under relevant sub-headings within Mendeley Reference Management Software.

2.1 Life course perspective and the importance of early life

2.1.1 Life course perspective

Life course approaches to disease aetiology and prevention have become commonplace in the field of epidemiology and highlight the role of developmental exposure to disease in early life and cumulative, lifetime risk factors. Life course approaches can also be applied to the study of infectious disease and wellbeing but, in the context of this thesis, they will be discussed in terms of non-communicable disease. Although early demographic analyses drew attention to birth cohort effects on the causes of mortality (Davey and Kuh, 2001), it was William Kermack (1934) who first suggested that later life health outcomes may well be determined by health during infancy and childhood, along with environmental influences. However, conventional research concerning susceptibility to disease throughout the life course has traditionally focussed on the immediate, mid-life determinants of chronic disease prevalence up until the 1980s (Gluckman, Hanson and Low, 2011), when new research emerged which highlighted the importance of early life exposure to disease risks in adulthood.

It was the work of Barker and Osmond (1986) that really emphasised early life as a critical period for determining the health of the adult, where it is thought there is a complex interplay between genetic and developmental factors, which are further influenced by environmental, social and cultural factors. Now known as 'Barker's hypothesis', the theory highlighted that observed heterogeneity in health outcomes, within and between populations, could be explained by the effect of the external environment interacting with biological characteristics. Although this work focused mainly on the 'fetal origins' of adulthood disease and physiological changes occurring during intrauterine development, it paved the way for further examination into the additive nature of adverse risks that may be experienced during gestation, infancy, childhood, adolescence and adulthood. Furthermore, the life course perspective extends beyond the health of the individual at a specific point in time and emphasises the strong intergenerational effects of risk factors, from mother to child and the future generation, via the prospective offspring of that child (Boo and Harding, 2006). For example, children born to women with gestational diabetes are themselves at increased risk of obesity and diabetes in later life (Bush et al., 2011; Nicholson et al., 2012).

When considering models of life course perspective, there are a few conceptual challenges to bear in mind. A model of life course perspective should ideally incorporate both the 'critical period model' and 'accumulation of risk' (Ben-Schlomo and Kuh, 2002; WHO, 2000) to reflect developmental origins of disease, occurring at specific intervals, and lifestyle-related risk factors that present themselves during adulthood. The 'critical period' concept is characterised by adverse biological programming that may occur in early life, the results of which may be irreversible. The accumulation of risk accounts for the exposures in later life which may positively or negatively influence susceptibility to chronic disease. The life course perspective should therefore help to classify the different pathways to disease, by identifying the interactions between risk factors, which may occur at different stages of life, in addition to reflecting on the variations in risk factors that occur due to the broader sociological context (WHO, 2000).

One of the main findings that has emerged from research using a life course perspective relates to the idea of developmental plasticity, and the epigenetic mechanisms that interact with lifestyle risk factors in early life (Gluckman, Hanson and Low, 2011). Research using observational data from birth cohorts suggested a strong association between undernutrition during gestation and the risk of low birth weight, which in turn is a risk factor in itself for subsequent overweight if accompanied by rapid 'catch-up' growth during infancy, and a marker for the development of cardiac or metabolic conditions in later life (Barker, 1998). In an age of an obesity epidemic, which is also seeing increases in associated non-communicable diseases, Gluckman, Hanson and Low (2011) argue that there needs to be more recognition of this overall life course perspective in order to promote targeted interventions from pre-conception. As it currently stands, with reference to the first 1000 days framework (conception to two years of age), there is a substantial amount of research focusing on exposure to risk factors during the intrauterine and pre-conception period. Whilst there are a range of factors that also influence later health during the preconception and intrauterine period such as maternal pre-pregnancy BMI, gestational weight gain and gestational diabetes, the postnatal period from birth to two years is perhaps a final opportunity in which health outcomes may be adjusted (Woo Baidal et al., 2016) during this period of health 'programming', as it has been referred to by David Barker and Thornburg (2013). Therefore, the period following birth warrants further study, since it is also during the postnatal period, infancy and early childhood that a myriad of external risk factors interact with each other, which may also have the potential to determine later life health. The main factors that come into play during this postnatal period include but are not limited to children's dietary intake, physical activity, infectious morbidity and conditions of the surrounding socio-economic and physical environment (Pietrobelli, Agosti and the MeNu Group, 2017). Characteristics of the pre-conception and intrauterine period also interact with postnatal factors, highlighting the importance of considering a life course perspective to healthy growth and development. For example, Barker highlighted the association between fetal undernutrition, consequent fetal growth retardation, low birthweight and incidence of coronary disease in adulthood (1995). The complex mechanisms through which these exposures determine later life morbidity are important to understand, especially in light of the increasing global burden of non-communicable disease.

2.1.2 Nutrition Transition: the emergence of a double burden of malnutrition in low- and middle-income countries

Global obesity[14] prevalence more than tripled between 1975 and 2018, with 39% of adults suffering from overweight[15] in 2014, and a further 13% from obesity (WHO 2018). This surge in global BMI poses multiple threats to lifelong health because of its association with non-communicable diseases such as cardiovascular disease, type-2 diabetes, musculoskeletal disorders and some cancers in adulthood (*ibid.*). Childhood obesity acts as a particular exposure to the later onset of these chronic conditions in adult life, but also has an effect on immediate morbidity of the child including hypertension, insulin resistance and psychological effects (*ibid.*). Extensive research that has taken place since 1980 recognizes the importance of the developmental origins of disease and has confirmed that environmental exposures during this early life period influence later disease susceptibility (Popkin, Adair and Ng, 2013).

Similar to the geographical and social patterning of life course health outcomes, shifts in nutritional status have also been determined by underlying socioeconomic and demographic changes, which have in turn caused a distinctive distribution of nutrition- and lifestyle-related health outcomes. The transitioning of societies from pre-industrial agrarian economies to those characterized by industrialization, has occurred concurrently with gains in life expectancy and fertility decline, which are considered to be the main drivers of this distinct epidemiological transition (Drewnowski and Popkin, 1997). The resulting rapid economic development from this industrial transition exaggerated this epidemiological shift, from contexts plagued by infectious disease and undernutrition to ones where non-communicable disease are also prevalent (Popkin and Bisgrove, 1988). However, unlike developed countries that had previously undergone this transition gradually, the process for many low- and middle-income countries has been exponential. This accelerated transition in developing contexts has essentially created a double burden of malnutrition, where undernutrition and food insecurity co-exist in the same context as overnutrition and obesity (Roemling and Qaim, 2012). Globally, 104 million children still suffer from underweight, whilst at the same time 43 million children under the age of five years are overweight; this paradoxical effect can be observed both at the population level and the household level. A study conducted by Doak et al. (2005) supported this double effect, with a

[14] Adult obesity is defined as a BMI greater than or equal to 30 (WHO, 2018).
[15] Adult overweight is defined as a BMI greater than or equal to 25 (WHO, 2018).

finding that dual burden households were more likely to be located in middle-income countries; in six of the seven countries they examined, the percentage of households with both an underweight and overweight individual ranged from 22 to 66%. Furthermore, obesity and chronic conditions which were previously associated with higher socioeconomic status in transitioning economies (Subramanian et al. 2011), are increasingly likely to be prevalent amongst sub-groups of the population with lower socioeconomic position. Evidence from a study of 39 lower income countries suggested that the rate of increase in prevalence of overweight was faster in lower socioeconomic groups in some countries (Jones-Smith et al. 2012), than in households with higher socioeconomic status.

This apparent nutrition transition has resulted in distinctive dietary shifts, changes in physical activity and consequent body composition. Firstly, rapid urbanisation, which has been traditionally associated with increases in GDP, has become an independent process in low- and middle-income countries, occurring even in the absence of substantial economic gains (Popkin, 1999). Urbanisation partnered with industrialisation has subsequently influenced other dimensions of lifestyle such as a shift from labour intensive work to more sedentary, commercial roles and changes in time-allocation within the household. Popkin and Bisgrove (1988) also identified large urban/rural differentials in diet, which were particularly contrasting in low- and middle-income settings due to the availability of "westernized" food products and growth of disposable incomes. Structural changes in food prices and transformation of agricultural policies since World War II are thought to have been the main determinants of shifting diets, which have increasingly consisted of animal-source protein, low quality processed foods high in saturated fats, cheap edible oils and caloric sweeteners (Popkin, Adair and Ng, 2013). Diets that once consisted of legumes, coarse grains, vegetables and moderate animal protein have been replaced by 'obesogenic' food types (*ibid.*) with little nutritional value. However, it is important to note that although the determinants of poor diet in high-income contexts often reflect low socioeconomic status, the opposite effect holds for many low- and middle-income countries, where household income is often inversely related to quality of diet (ibid). Moreover, disparities in diet between urban/rural locations are so distinct in LMIC contexts that the effect of socioeconomic status in urban environments is often independent of diet, which highlights that urbanisation is perhaps the dominant determinant here. This finding is supported by research conducted by Monteiro et al. (2000) showing that the effect of urban growth dominates the effect of income in a study which explored maternal obesity in Brazil. The results of this analysis suggested that the independent effect of income did not remain in urban settings, where women from both poor and rich households were just as likely to present with obesity, however urban women with a higher level of education were less likely to be obese. This finding concurred with the results of a regression model created by Popkin (1999), that predicted the independent effects of urbanisation on quality of diet across varying levels of socioeconomic status.

Although this nutrition transition has implications at all ages, rapid economic growth has posed a significant threat during early life, adversely affecting child nutritional outcomes. The nutritional vulnerability during this early life period has been further emphasised by the changing roles of women in society and the household in low- and middle-income countries. This poses an additional risk factor for suboptimal nutrition, as, despite the positive impact of female emancipation, gender equality is rarely reflected in maternity legislation that should protect mothers participating in the work force (Popkin, 1999). Changes in time allocation due to work commitments and work outside of the home - often in the informal sector - act as additional barriers to optimal feeding practices during the first few years of life, especially in transitioning economies. Rollins et al. (2016) confirmed this negative impact of maternal work on infant feeding practices, with the majority of studies included in their systematic review showing patterns of early weaning amongst mothers returning to work. This is further accentuated by the fact that only 98 out of 185 countries meet the international standard of 14 weeks maternity leave, proposed by the International Labour Organization (2014).

However, the challenge that remains in low- and middle-income countries is creating a policy which targets both reductions in food insecurity and undernutrition, whilst at the same time addressing the burden of overweight and obesity due to overnutrition (Popkin, Adair and Ng, 2013). Schwarzenberg and Georgieff (2018) encapsulate the difficulty of managing the dual burden of under- and overnutrition by analogising nutrition to a U-shaped risk curve, where both nutritional insufficiencies and nutritional excess have adverse health impacts. The increasing burden of lifestyle-attributed non-communicable diseases also puts considerable strain on health services due to accumulated morbidity throughout the life course, which also causes declines in productivity and poorer quality of life (Popkin 1999).

This distinctive nutrition transition, which has driven a double burden of malnutrition in many low- and middle-income countries, has highlighted the ways in which lifestyle transformation interacts with biological disposition, to influence exposure to non- communicable disease. When this double burden of malnutrition is considered in conjunction with life course theory to health, it highlights the importance of early life as a prime intervention window for optimum nutrition. The rationale for targeting this early life period can be explained using the developmental origins of disease (DOHaD) paradigm, which suggests that plasticity in this early life period may be programmed to benefit patterns of growth, body composition and later life health outcomes

(Uauy, Kain and Corvalan, 2011). This subsequently opens a window of opportunity, where interventions that promote maternal, infant and child nutritional status should be implemented in order to establish a healthy path from the start of life.

2.1.3 The role of early life nutrition in the life course perspective to health

The focus on early life as a critical window for optimum nutrition is reinforced by the developmental origins of disease, which suggest that this age presents a malleable period in which later life health can be shaped by positive inputs at the beginning of life. Furthermore, in contexts where there is evidence of a double burden of malnutrition, the theory of 'mismatch' also becomes an important factor during this early life period (Gluckman et al., 2009). This theory describes periods of undernutrition, which are followed by periods of excess and overnutrition, which can have negative implications on growth, especially in this early life period, in which there is already increased sensitivity to growth faltering (Uuay, Kain and Corvalan, 2011). Evidence surrounding nutrition and weight gain during infancy and childhood is conflicting, and has particular ramifications for environments where this double burden exists. 'Rapid growth' in malnourished children is encouraged in low-income settings as it reduces morbidity in early life and improves child survival, therefore promoting short-term health outcomes (Adair et al., 2009; Victora et al. 2008). On the other hand, evidence suggests that rapid, compensatory growth may have negative implications for longer-term health outcomes, leading to elevated risk of developing overweight and obesity, along with associated co-morbidities (Salgin et al., 2015). Conversely, pooled analysis using birth cohorts from five low- and middle-income countries (Adair et al. 2009) suggests that although weight gain in infancy and childhood may lead to elevated risk of high blood pressure in adults, the tempo and timing of this weight gain is insignificant, concluding that weight gains at other ages also have equal relevance for later health outcomes. These studies highlight that nutrition and subsequent growth during infancy and childhood has a programming effect on later life adiposity, with associated short- and long-term health outcomes, but that this effect is difficult to quantify.

In light of the nutrition transition in low- and middle-income countries, it is important to understand the role of potential interventions during the first 1000 days which can improve both short-term child survival and promote positive later life health. Optimal breastfeeding practices can act as a health intervention in contexts experiencing the double burden of malnutrition, as it is associated with protection against infectious disease in infancy and childhood, as well as reductions in non- communicable diseases occurring in later life (Victora et al., 2016). Similarly, the characteristics of complementary feeding can also influence nutritional programming in early life, in terms of the nutritional quality of foods administered to the infant and the role of taste and preference that may determine later dietary patterns (Beauchamp and Mennella, 2009).

2.2 Conceptual Framework for this thesis

The overarching aim of this PhD thesis was to examine the role of early feeding practices on child nutritional status and growth in Southeast Asia. Specifically, due to the rapid economic and socio-cultural shifts occurring in this region as well as in other LMICs, the influence of underlying socioeconomic factors on both early feeding practices and child nutritional status were also assessed. However, these associations cannot be considered in the absence of broader contextual factors which also play a role in how children are fed and their nutrition and growth outcomes throughout early childhood through to adolescence. Therefore, the conceptual framework presented in Figure 2.1 (p.55)depicts the role of infant and young child feeding practices as proximate factors in pathways to healthy growth and development, within a broader context of the relevant social, cultural, economic and political environment. Adapted from the WHO conceptual framework for *Childhood Stunting: Context, Causes and Consequences* (Stewart et al., 2013), this framework highlights the determinants and contextual factors associated with healthy growth and development in young children, in particular framing the role of the multiple dimensions of early feeding practices in addition to exclusive breastfeeding, such as pre-lacteal feeding, timely introduction of complementary foods, dietary diversity, feeding frequency and continued breastfeeding. Stewart and colleagues (2013) highlight that although there has been significant research and movement made in support of breastfeeding over previous decades, attention was only attuned to complementary feeding practices in 2008 when the WHO IYCF recommendations were updated (WHO, 2008). Therefore, it is essential to position complementary feeding practices in a broader framework of child nutrition and growth, in order to strengthen the complementary feeding aspects of international IYCF policy and recommendations (Piwoz et al., 2003; Daelmans et al., 2009). For the purpose of this PhD research, the WHO framework was also adapted to reflect the hierarchical nature of different groups of factors, as was demonstrated in the conceptual framework presented by Wamani and colleagues (2006) for assessing the factors associated with poor anthropometric status in young children in Uganda.

To ensure applicability of this framework throughout this thesis, healthy growth and development was used as an umbrella term to define children following normal growth trajectories, free of all manifestations of malnutrition: stunting, underweight, wasting, overweight and micronutrient deficiencies. At the very top of the framework, both the short- and long-term benefits of optimal growth and development were depicted, to emphasise the full potential over the life course. The short-term consequences encompassed reduced morbidity and mortality, healthy cognitive development and reduced economic burden associated with health care expenditure of caring for a sick child. On the other hand, long-term consequences included reduced risk of obesity and associated co-morbidities, better academic performance and therefore an increased working capacity and earning potential.

The inherent (biological) factors represented the genetic characteristics of children and mothers that are known to be associated with child growth outcomes, and symbolize the transgenerational impact of nutritional status from mother to child.

The proximate level factors (Figure 2.1, p.55) represent the immediate and direct influences on child growth and nutritional outcomes. IYCF practices and incidence of disease constitute the proximate factors in this framework which also operate synergistically in a positive feedback cycle. Incidence of infectious disease has the potential to depreciate nutritional status through reduced appetite and weakened intestinal functioning and in turn, nutrient deficiencies from inadequate feeding practices impair immune system responses, offering reduced protection from infection (Stewart et al., 2013; Scrimshaw, Taylor and Gordon, 1968; Brown, 2003; Solomons, 2007).

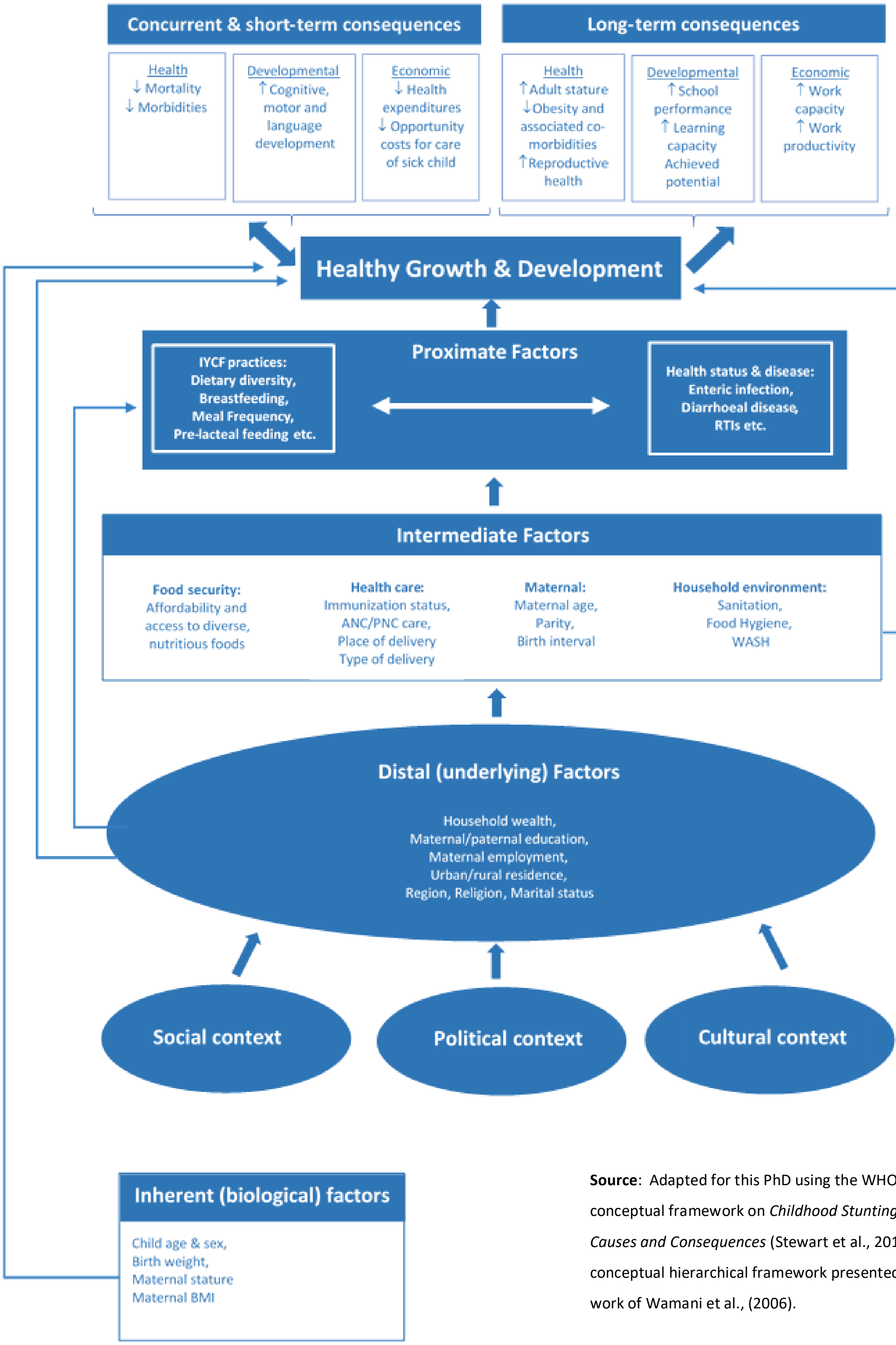
On the other hand, intermediate factors are those which may be directly associated with healthy growth and development of children or directly through their impact on the proximate factors. These are factors related to characteristics of birth and contact with health facilities, the hygiene of the household environment, food security and certain demographic characteristics of the mother and child such as birth interval, parity and maternal age at birth, all of which are likely influenced by underlying socioeconomic conditions.

Factors pertaining to the underlying, broader socioeconomic context are represented by the distal (underlying factors). Although it was highlighted by Mosley and Chen (1984) in their framework of child survival, that it is difficult to determine direct associations between socioeconomic conditions and the outcome - which in their case was mortality - it is clear that these underlying factors mostly act through other intermediate and proximate level factors to influence the outcome of interest. The direct link between the distal (underlying) factors and healthy growth and development is still retained in this conceptual framework, in order to account for other factors that are not possible to measure or are unaccounted for in this framework.

Finally, the overall influence of the political, social and cultural context is also considered in this conceptual framework as these aspects may vary considerably between study locations, but are perhaps the most difficult elements to measure. Although difficult to measure quantitatively, the broader contextual background should be accounted for, as food and feeding behaviours are often deeply rooted in cultural beliefs, knowledge and perceptions (Kuhnlein and Pelto, 1997).

Although the framework presented here provides a relatively comprehensive overview of factors associated with healthy growth and development in young children, which are relevant for this thesis, it is not exhaustive, i.e. there may be other factors not accounted for in this framework. It depicts the interrelated and complex pathways that are examined throughout this thesis and positions infant and young child feeding practices as mediating factors in the association between underlying socioeconomic conditions and optimal growth and nutritional status. This conceptual framework is utilised as a tool throughout this thesis for examining the complex layers of factors associated with specific IYCF behaviours and the consequences for child nutrition and growth trajectories.

Figure 2.1 Conceptual framework which contextualises infant and young child feeding practices in a broader framework for healthy growth and development of young children and the complex pathways between different levels of factors.



Source: Adapted for this PhD using the WHO conceptual framework on *Childhood Stunting: Context, Causes and Consequences* (Stewart et al., 2013) and the conceptual hierarchical framework presented in the work of Wamani et al., (2006).

2.3 Child nutritional status

According to the WHO (2016), malnutrition can be defined as deficiencies, excesses or imbalances in nutrient and/or energy intake. It encompasses two groups of conditions that appear at opposite ends of the malnutrition spectrum. Undernutrition includes stunting (low height-for-age), wasting (low weight-for-height), underweight (low weight-for-age) and micronutrient deficiencies (insufficient intake of vitamins and minerals). On the other end of the spectrum, overnutrition incorporates overweight, obesity and diet-related non-communicable diseases, such as cardiovascular disease, hypertension, diabetes and cancer.

Indicators of child growth are considered to be key markers of nutritional status and population health (WHO, 2010). These indicators are calculated by comparing children's anthropometric measurements, by age and sex, with the WHO Child Growth Standards which provide internationally representative reference charts for the growth of children from birth to five years (WHO, 2006). These new WHO Child Growth Standards were based on the Multicentre Growth Reference Study (MGRS) which was conducted between 1997 and 2003 and collected anthropometric growth data from 8500 children from Brazil, Ghana, India, Norway, Oman and the USA (*ibid.*). These international standards are based on infants fed according to WHO recommendations i.e. infants who were breastfed. (*ibid*). For children aged between 5-19 years, these WHO child growth references were extended for applicable indicators (de Onis et al., 2007). Table 2.1 presents the main child growth references and the age for which they are applicable.

Table 2.1 WHO Child Growth References with interpretation cut-offs (2006)

Indicator	Child age	Nutritional status
Weight-for-age (WAZ)	0-10 years	***Underweight:*** < -2SD of the WHO Child Growth Standards median
Height-for-age (HAZ)	0-19 years	***Stunting:*** < -2SD of the WHO Child Growth Standards median
Weight-for-height (WHZ)	0-5 years	***Wasting:*** < -2SD of the WHO Child Growth Standards median ***Overweight:*** + 2SD of the WHO Child Growth Standards median
BMI-for-age (BMIZ)	0-19 years	***Underweight:*** < -2SD of the WHO Child Growth Standards median ***"At risk of overweight":*** + 1SD of the WHO Child Growth Standards median ***Overweight:*** + 2SD of the WHO Child Growth Standards median (0-5 years), +1SD of the WHO growth reference median (5-19 years) ***Obese:*** + 3SD of the WHO Child Growth Standards median, +2SD of the WHO growth reference median (5-19 years)

SD: Standard Deviation

2.3.1 Indicators, definitions and measurement

Underweight

Prevalence of underweight in young children is represented by a low weight-for-age (WAZ). However, because this indicator is also influenced by both the height of children (height-for-age, HAZ) and weight relative to height (weight-for-height, WHZ), this indicator can also be considered as a composite measure which can obscure interpretation (WHO, 2010). For example, as child weight is compared to a standardized age distribution, no distinction can be made between short children of normal body weight and tall, thin children. Nonetheless, underweight is a critical risk factor for childhood mortality (WHO, 2010) and a leading cause of global morbidity (Ezzati et al., 2002) due to the associated increased risk of communicable diseases such as diarrhoea and pneumonia (Black et al., 2013; Caulfield et al., 2004).

Wasting

On the other hand, wasting is assessed by measuring children's weight relative to their height (weight-for-height, WHZ) and is an indication of acute weight loss due to usually a combination of factors such as household poverty, insufficient food intake, severe micronutrient deficiencies and high incidence of infectious disease, for example diarrhoea (WHO, 2010). In the short-term, wasting weakens the immune system, increasing susceptibility to life-threatening infectious diseases, but in the long-term tends to recur in surviving children, leading to impaired linear growth and delayed cognitive development (Menon and Stoltzfus, 2012; Briend, Khara and Dolan, 2015). Globally, 17 million children under-5 years of age were considered to be affected by severe wasting in 2018 (UNICEF, 2018). At the national level, a prevalence of wasting between 10-14% in children under-5 is considered to be a serious public health concern, and above or equal to 15% is regarded as critical (WHO, 2010).

An alternative indicator of wasting that has received increasing attention is mid-upper arm circumference (MUAC), which has been advocated for use in community or resource-poor settings where scales or height boards may not be available for screening. Although weight-for-height remains the gold standard for assessing wasting and severe acute malnutrition, there is a substantial evidence base that supports use of MUAC as a proxy indicator, as undernutrition causes decreases in subcutaneous fat and muscle (Fiorentino et al. 2016). Comparative studies of weight-for-height and MUAC to identify severe acute malnutrition in children aged between six and sixty months, have shown that these indicators perform equally well and that MUAC predicts child mortality at similar levels of precision to weight-for-height (Hossain et al. 2017; Myatt et al. 2006; Briend et al. 2012). WHO revised guidelines for the management of severe acute malnutrition proposes MUAC cut-off values of below 11.5cm and 12.5cm to identify cases of severe and moderate acute malnutrition (WHO, 2013). Whist MUAC is a simple, effective and inexpensive tool for assessing wasting and severe acute malnutrition, some questions remain over the generalizability of these simple cut-offs that are not age standardized, which is a cause of contention since MUAC increases linearly with age during childhood (Hossain et al. 2017).

Stunting

Stunting reflects a low height-for-age (HAZ) and suggests longer-term malnutrition. Incidence of linear growth faltering (stunting) is indicative of suboptimal child health and the cumulative result of intrauterine growth restriction and undernutrition and infections occurring during the first 1000 days after conception (Black et al., 2013; Victora et al., 2010; de Onis and Branca, 2016). As a result, it has also been adopted as one of the main indicators to measure child malnutrition for SDG 2 of the UN 2030 Agenda for Sustainable Development (United Nations, 2015). Stunting has long-term implications for health and wellbeing, including reduced cognitive and neurodevelopmental function, weakened immune system functioning, increased risk of chronic disease in adulthood, the result of which may be a reduced intellectual and economic capacity at a national level (Black et al., 2008; Black et al., 2013; Victora et al., 2008). Furthermore, linear growth faltering in early life has consequences for the inter-generational cycle of malnutrition (WHO, 2010) as shorter maternal stature can lead to restricted growth in utero and low birth weight, and thus the cycle continues.

Overweight

Childhood overweight is defined as high body weight relative to height and is measured using either weight-for-height (WHZ) for children aged 0 to 5 years, or BMI-for-age (BMIZ) for children 0-19 years. Although, weight-for-height is the clinically recommended measurement of overweight especially in very young children (0 to <2 years), recent research using the new WHO BMI-for-age growth reference charts has shown that comparatively these two indicators perform equally well in assessing childhood overweight (Furlong et al., 2016). Furthermore, the WHO weight-for-height growth references are only available for children aged 0-5 years, so BMI provides a suitable alternative when tracking growth from birth to adulthood, without the need to transition between two different indicators from age five years. As BMI changes rapidly throughout childhood and adolescence, with distinct sex differentials, BMI-for-age is gender and age specific (Hammer et al., 1991; Pietrobelli et al., 1998), in contrast to the static, adult BMI measures. Childhood and adolescent overweight is considered a critical growth indicator because of its value in predicting later life morbidity. Childhood overweight has associations with increased risk of overweight and obesity in adulthood, early onset of non-communicable diseases such as type 2 diabetes (WHO, 2016; Lobstein et al., 2004; Park et al., 2012) and increased morbidity from cardiovascular disease in later adulthood. Multiple studies that have measured BMI through childhood and into adulthood have revealed evidence of BMI tracking, whereby overweight in childhood has continued into adulthood (Whitaker et al., 1997; Guo and Chumlea, 1999; Garn and LaVelle, 1985). Rising childhood overweight and obesity is an increasingly concerning global trend with 41 million children under age 5 year considered overweight in 2016, approximately half of these overweight children residing in Asia (WHO, 2018). Rapid urbanisation and digitalisation have facilitated obesogenic environments, characterised by sedentary lifestyles and consumption of energy-dense, nutrient-poor foods that are rich in fats and sugars (WHO, 2017). Although there have been clear global reductions in all forms of undernutrition (underweight, wasting, stunting), overnutrition in the form of childhood overweight continues to rise, with prevalence expected to increase to 70 million children by 2025 (WHO, 2017).

2.3.2 Factors associated with child nutritional status

The determinants of child malnutrition in low- and middle-income contexts can be considered as a series of related pathways (Lander et al., 2015), drawing connections between the distal and proximate factors that are known to be associated with impaired growth. As is also reflected by the conceptual framework presented in section 2.2, these aforementioned distal determinants constitute socioeconomic, cultural, environmental and political factors, whereas the proximate determinants represent factors such as dietary intake, disease, care and biological features. This framework highlights that there is not one single determinant responsible for malnutrition, but nutritional status is the cumulative outcome of a combination of factors that come into play during the antenatal and early life period (Hanieh et al., 2013). This section focuses mainly on the two forms of malnutrition that are examined in this thesis: childhood stunting and overweight/obesity. The section is organised by the hierarchical level of factors as presented within the conceptual framework (section 2.2).

Inherent biological factors

With reference to the developmental origins of health and disease (DOHaD) hypothesis (Gluckman, Buklijas and Hanson, 2010), birth weight and subsequent early growth during infancy and childhood are influenced by the fetal programming that occurs in the intrauterine environment. One of the critical factors for intrauterine growth is maternal anthropometry pre-pregnancy and during. High maternal BMI has been consistently found to be associated with increased prevalence of overweight and obesity in young children across all geographical contexts (Bhuiyan, Zaman and Ahmad, 2013; Li et al., 2007; Voerman et al., 2019), as well as rapid weight gain trajectories when longer term changes in childhood BMI are assessed (Mattsson et al., 2019). Analysis using the multi-country COHORTS[16] study that included data from five transitional societies (Brazil, Guatemala, India, Philippines and South Africa), showed that maternal stature is also a significant determinant of children's linear growth (Addo et al., 2013). In all five countries, maternal height was positively associated with both children's attained height at different ages and conditional linear growth, with mothers of short stature (<150.1cm) 3.2 times more likely to have a stunted child at two years of age (*ibid.*). Although many of the determinants of birth weight and child nutritional status are interchangeable, birth weight is also an independent predictor of both stunting and overweight/obesity, highlighting the cumulative significance of fetal growth restriction. For example, it was predicted that 20% of all stunting in LMICs could be attributable to low birth weight (Black et al., 2013). Conversely, evidence from other LMICs such as Philippines, Guatemala and Brazil (Adair, 2007; Corvalán et al., 2007; Sacco et al., 2013) highlights the positive association between birth weight and BMI in young children.

In terms of sex differences in prevalence of malnutrition, evidence from multiple studies in LMICs suggests that prevalence of both stunting and overweight/obesity is more likely in male children compared to female children, although these differences are often small (Black et al., 2013; Beal et al., 2018; Rachmi, Li and Baur, 2017).

[16] COHORTS: Consortium on Health Orientated Research in Transitional Societies (Richter et al., 2012).

Proximate factors

In the case of impaired linear growth (stunting), lack of a nutritious diet and recurrent infection are the main known causes, both of which are influenced to differing extents by distal socioeconomic, cultural and environmental factors (Black et al., 2013; Schrimshaw and SanGiovanni 1997; Paciorek et al., 2013). Although there is strong evidence from LMIC contexts supporting the protective effect of breastfeeding against infectious morbidity such as diarrhoeal disease and respiratory infections in early childhood (Horta and Victora, 2013), research on the longer-term impact of breastfeeding on child nutritional status has yielded inconclusive results. One of the main issues is the lack of randomised controlled trials of breastfeeding promotion interventions that also include child nutritional status as an outcome variable (Black et al., 2013). The results from the meta-analyses of 17 studies conducted by Giugliani et al. (2015) showed no significant effect of breastfeeding interventions on mean weight or length/height for age in children aged less than 6 months, in line with an earlier systematic review conducted by Kramer and Kakuma (2012) on the optimal duration of exclusive breastfeeding. Research from multiple study settings such as Nepal (Tiwari, Ausman and Agho, 2014), Sub-Saharan Africa (Akombi et al., 2017), Thailand (Cetthakrikul et al., 2018) and Peru (Marquis et al., 1997) have even reported a negative association between breastfeeding duration and stunting, suggestive of reverse causality, where linear growth is in fact a potential determinant of prolonged breastfeeding. This phenomenon was further examined using MICS data from Thailand (Cetthakrikul et al., 2018), where there was a reported interaction between household wealth and breastfeeding duration and children from the poorest households who were breastfeed for longer than 12 months were more likely to be stunted, compared to children of the same socioeconomic status who did not receive prolonged breastfeeding or those from richer households and prolonged breastfeeding was practiced. A possible explanation for this significant interaction, proposed by the authors, was that among the poorest households, complementary feeding may not be adequate in terms of diversity and amount, and as a result prolonged breastfeeding is practiced to try and make up for the lack of complementary foods (*ibid.*). Furthermore, the symbiotic relationship between the two types of proximate factors (infant and young child feeding practices and disease) which is reflected in the conceptual framework (section 2.2) should also be considered, as ultimately breastfeeding may support linear growth through the prevention of growth-inhibiting infectious diseases, for which the positive effect of such have been well-established (Horta and Victora, 2013). In this sense, dietary quality and infectious morbidity operate in a negative feedback loop, where appetite may be reduced and intestinal absorption compromised as a result of an infectious disease, leading to further malnutrition (Scrimshaw et al., 1968; Brown, 2003; Solomons, 2007; Stewart et al., 2013).

Similarly, although studies have reported a potential protective effect of breastfeeding against development of overweight and obesity in childhood and later life (Horta, Loret de Mola and Victora, 2015), the majority of these studies have been from high-income settings where wealthier, more educated women are more likely to breastfeed for longer durations. However, even when accounting for residual confounding by socioeconomic status and considering studies with large sample sizes only (≥1500 participants) as Horta and Victora did (2013), a protective effect against overweight and obesity remained although this was modest with a pooled odds ratio of 0.88 among the 16 studies that were included in the meta-analysis. In studies that have compared children who were breastfed and those who received formula milk, it has generally been reported that formula fed children gain weight faster than their breastfed counterparts (Imai et al., 2014). Furthermore, significant differences also exist between formula fed children depending on the daily volume they consume; in a study conducted in China it was reported that children fed with a higher-volume of formula milk (≥ 840ml formula/d) were 2.13 times more likely to be overweight at the age of 12 months than children who were breastfed or received a lower volume of formula milk (<840ml formula/d (Huang et al., 2018). Results of a meta-analysis investigating the macronutrient and energy content of formula milk versus breast milk, suggested that the reason for these differences in early growth are due to the fact that formula-fed children usually consume a higher volume of milk which is energy-dense and high in protein, which contributes to rapid weight gain (Hester et al., 2012).

The complementary feeding period also represents a sensitive period for malnutrition; it has been estimated that the majority of linear growth faltering occurs between the ages of 6 and 24 months (Dewey and Huffman, 2009; Victora et al., 2010). Inadequate complementary feeding practices which include early introduction of complementary foods, lack of dietary diversity and insufficient feeding frequency have been highlighted as prominent risk factors for stunting (Bhutta et al., 2013; Ruel and Menon, 2002; Arimond and Ruel, 2004; Marriott et al., 2012). Evidence from 14 LMICs using DHS data demonstrated significant associations between WHO indicators such as minimum acceptable diet and dietary diversity with reduced risk of stunting and underweight (Marriott et al., 2012), consistent with results of an earlier study conducted by Arimond and Ruel in 11 LMICs in which dietary diversity score was significantly and positively associated with height for age Z-scores (2004). Within the Southeast Asia context where diets are often heavily dependent on rice, a study from Indonesia found that amongst urban poor and rural children aged 0-59 months, those living in households with the highest expenditure on animal-source foods experienced decreased risks of stunting (Sari et al., 2010).

However, inappropriate complementary feeding practices also pose risks for development of overweight and obesity, especially in light of the nutrition transition in LMICs and the shift towards obesogenic food types (Popkin, Adair and Ng, 2012). Firstly, early introduction of complementary foods is associated with later development of overweight and obesity in children as it encourages rapid weight gain in early life (Adair, 2012), but perhaps more importantly is the shift in the types of foods that are being consumed by children in countries undergoing the nutrition transition. However, there are very few studies that have examined types of complementary foods given to infants and young children, and the association with later overweight and obesity, especially from LMIC contexts. Of the few studies that exist, two observational studies conducted in high-income countries found that consumption of high sugar content beverages during the complementary feeding period was associated with increased likelihood of obesity at age six (Leermakers et al., 2015; Pan et al., 2014). Another review conducted by Pearce and Langley-Evans (2013) found inconclusive associations between the types of food introduced in the complementary feeding period and risk of childhood obesity, with one study in their review suggesting that a high energy intake in early infancy may be conducive to higher BMI and body fat percentage during childhood (Ong et al., 2006). Although there has been little research conducted on the association between complementary feeding and prevalence of overweight and obesity in later childhood and adolescence, studies from Cambodia and other LMIC have confirmed a significant proportion of children receiving commercially produced snack foods during this complementary feeding period (Pries et al., 2017). For example, over half (55%) of children aged 6 to <24 months residing in urban Cambodia had reportedly consumed unhealthy snack foods in the day prior to interview, such as biscuits, cookies, crisps, chips, cakes, candy and chocolate (Pries et al., 2016).

Although not an issue addressed within this thesis, declines in children's physical activity and a rise in sedentary behaviour in increasingly urbanising LMICs remain a major proximate risk factor for overweight and obesity as physical activity levels decline globally (Lajous et al., 2009). Black et al. (2013) recognise that high levels of television viewing and low levels of physical activity are key risk factors for the development of childhood overweight and obesity.

Intermediate factors

The intermediate level factors that are depicted in the conceptual framework (section 2.2), represent the factors that may mediate the effect between distal (underlying) factors and proximate level factors on child nutritional status. These are factors which are determined by distal (underlying) factors such as socioeconomic status and which with improvements in socioeconomic status, can be adjusted, such as sanitation, maternal age at first pregnancy or birth, antenatal/postnatal care and household food security.

Maternal age at birth or first pregnancy is a factor that has been consistently linked with child nutritional outcomes. Studies from Bangladesh, India and Mexico (Mistry et al., 2018; Aguayo et al., 2016; Varela-Silva et al., 2009) have reported maternal age at first pregnancy or maternal age at birth as a significant risk factor for child stunting among children aged less than two years, with children of younger mothers facing an increased risk. This was also in line with results from the multi-country COHORTS study, where children of younger mothers (< 19 years) were more likely to be stunted in analysis which also adjusted for socioeconomic status, maternal height and parity (Fall et al., 2015). It has been suggested that this association is due to a combination of behavioural, social and biological factors, such as the fact that younger mothers may be less likely to breastfeed or for shorter durations, younger mothers may have less education and their growth needs may compete with the increasing requirements of the fetus which can lead to intrauterine growth restriction (*ibid*). Conversely, research from a high-income context has found that older maternal age (>30 years) is significantly associated with elevated BMI trajectories and risk of late-onset overweight in children aged between 0 and 20 in the United States (Li et al., 2007).

Lack of access to WASH[17] facilities such as a sanitary latrine or toilet, clean drinking water source and basic hygiene practices is a common intermediate factor associated with child stunting in LMIC contexts. Studies from both Cambodia (Ikeda, Irie and Shibuya, 2013) and Indonesia (Beal et al., 2018) have also confirmed this association, which is thought to occur as adequate WASH facilities help reduce incidence of enteric infections which can impair children's immune functioning and worsen nutritional status (Cumming and Cairncross, 2016).

Distal (underlying factors)

The socioeconomic factors that have been found responsible for inequalities in stunting prevalence are maternal education, household wealth and maternal employment (Black et al., 2013; Caldwell, 1979; Caldwell, 1994; Popkin and Solon 1976; Smith, Ruel and Nidaye, 2005). Duration and level of maternal education is consistently and positively associated with improvements in child nutritional status and complementary feeding practices across geographical contexts (Barrera, 1990; Schultz, 2002; Smith, Ruel and Nidaye, 2005). It is theorised that educated mothers are more likely to access health-care facilities for treatment and prevention services, engage with nutritional intervention programs, maintain a clean-living

[17] Water, sanitation and hygiene (UNICEF, n.d.).

environment and possess a good knowledge of recommended feeding practices which may be especially relevant for ensuring a diverse diet (Smith, Ruel and Nidaye, 2005). Further to this, education leads to improved earning potential among women which boosts household income (Bloem et al., 2013), not to mention the demographic consequences such as later marriage, delayed child bearing and wider birth intervals (Caldwell 1979; Caldwell 1994), which is likely conducive to the prioritization of children's nutrition.

The effect of maternal education on child nutritional status in LMICs has presented inconclusive results, especially on overweight and obesity prevalence. A study conducted in Bangladesh found that prevalence of childhood overweight and obesity was higher among more educated mothers (Bhuiyan, Zaman and Ahmad, 2013), whereas the opposite was true for studies conducted in Brazil (Giugliano and Carneiro, 2004) and Iran (Mozaffari and Nabaei, 2007) where lower educational status was a significant risk factor for childhood overweight and obesity. However, the association between low maternal education and stunting is fairly consistent, and was estimated to be the second most important risk factor for stunting after maternal depression, in a multi-country study of 137 LMICs (Fawzi et al., 2019). Women's educational level is an essential underlying factor as it also has the potential to improve socioeconomic status, moreover, in terms of child health and nutrition, leads to better care practices within the household and better use of health care systems for treatment and prevention services (Caldwell, 1979; Caldwell, 1994). Improvements in female education also prompt later age at marriage, delayed childbearing and longer birth intervals which are also associated with lower prevalence of child undernutrition (Schultz, 2002). However, some researchers have argued that the independent effect of maternal education on child nutritional status is questionable (Desai and Alva, 1998), as it may simply represent a proxy for socioeconomic status, yet in the context of the role of infant and young child feeding practices on child nutrition, a clear link may be made between higher maternal education and better knowledge of nutrition and care practices.

Maternal employment in low- and middle-income contexts poses a double-edged sword because whilst it can improve overall household income, it also reduces time allocation for care-taking activities within the household (Popkin and Solon, 1976), activities which Komatsu et al., (2018) refer to as unpaid "reproductive work", disproportionally carried out by women. Maternal employment therefore represents a trade-off between income potential which can be used to increase food availability within the household and the unpaid "reproductive work" such as breastfeeding, cooking and cleaning. Popkin and Solon (1976) highlighted the importance of both income and time for child nutrition, finding that the nutritional status of children from the poorest households in the Philippines were negatively affected by maternal employment, whilst the opposite was true of children from richer households, emphasizing the importance of taking into consideration the type of employment, earnings and working conditions, especially in low- and middle-income countries where a large proportion of work occurs in the informal sector. In terms of the relationship between maternal employment and childhood overweight, studies from the United States and Canada have shown significant associations between maternal employment and increased risk of childhood stunting (Anderson, Butcher and Levine, 2003; Phipps, Lethbridge and Burton, 2006), however a study using DHS data from 45 LMIC contexts found no such association even after adjusting for differences between informal or formal employment. However, BMI Z-scores were higher amongst employed mothers compared to non-employed mothers. Although the association between maternal employment and childhood overweight has rarely been examined in LMIC contexts, it is hypothesised that as countries experience the nutrition transition, energy-dense, processed foods become more affordable and accessible to lower and middle-income households as maternal employment produces additional income (Oddo et al., 2017). The type of work undertaken by mothers is also an important factor to consider in LMICs as informal employment accounts for 67.5% of total female employment in these countries (International Labour Organization, 2018), and the type of employment may have positive and/or negative implications for child care. For example, a study conducted in Indonesia found increased prevalence of obesity in children of mothers in full-time employment compared to those not employed, which was particularly exaggerated for those working in the private sector which may be reflective of both reduced time allocated to child care activities and higher household income (Collins, Pakiz and Rock, 2008).

Household wealth, which is associated with both maternal education and employment, has been repeatedly proven to be a positive predictor of both child nutritional status and adequate linear growth (Smith, Ruel and Nidaye, 2005; Iannotti et al., 2012; Stewart et al., 2013; Greffeuille et al., 2016; Bloem et al., 2013) in LMICs. As a household's purchasing power strengthens, access to diverse, nutrient-dense food types increases which ensures household food security and prevents micronutrient deficiencies in young children (Greffeuille et al., 2016). In addition, household wealth improves access to quality health care, necessary for the prevention and treatment of malnutrition and diarrhoeal disease which is associated with increased risk of stunting. In terms of the connection between household wealth and prevalence of overweight/obesity, in a meta-analysis of 78 LMIC contexts, Black and colleagues (2013) found that although the differences between the richest and poorest quintiles were minimal, prevalence of overweight was approximately 1.31 times higher in children from the richest households, compared to those from the poorest. This also been supported by independent studies from Indonesia (Rachmi, Li and Baur, 2017), Thailand (Sakamoto et al., 2001) and Vietnam (Dieu et al., 2007).

Finally, there is a significant amount of research that confirms distinctive urban-rural inequalities in children's anthropometric status. In a study involving 141 low- and middle-income countries, Paciorek and colleagues (2013) found that rural children were consistently shorter and lighter than their urban counterparts, a finding which was also corroborated by von Braun et al., (1993) where it was estimated with evidence from 33 countries that stunting was approximately 1.6 times more likely in rural areas. This apparent urban advantage appears to be influenced by overall better socioeconomic conditions, less reliance on agriculture and natural resources, higher levels of maternal education and participation in paid work outside the home (Paciorek et al., 2013; Smith, Ruel and Nidaye, 2005), and as a result a greater availability and affordability of a diverse range of foods. Studies have shown that overall, urban populations have improved access to a diverse range of nutrient-dense fruits and vegetables which are more affordable due to economies of scale (Steyn et al., 2006), and an increased consumption of animal-source foods (Maruapula et al., 2010). Similar results were obtained in a study focusing on a sample of South Indian children (Kehoe et al., 2014), where snack and fruit consumption (including sweet beverages, rice, meat, bread and fruit) was observed more children residing in urban areas, perhaps highlighting urban-rural the differences in availability of food types. However, at the micro (household) level, intra-urban inequalities in child nutrition still exist with the omnipresent triple burden of urban malnutrition (undernutrition, overnutrition and micronutrient deficiencies) (Global Panel, 2017), and the expanding of urban informal settlements where micronutrient deficiencies prevail. Living in an urban area in Southeast Asia has been shown to be associated with increased odds of obesity amongst all age groups, and that these differences in prevalence rates are typically more marked in Southeast Asian countries with lower GNI (gross national income) (Angkurawaranon et al., 2014), suggesting that urban-rural inequalities are wider in lower-income countries. For example, urban residence was associated with a 29% higher likelihood of obesity prevalence in Malaysia and Philippines, but more than a 3-fold higher risk in countries with a lower GNI such as Vietnam and Laos. Individual studies focusing on overweight prevalence in young children from Cambodia (Greffeuille et al., 2016) and Indonesia (Rachmi, Li and Baur, 2017).

2.4 Health and developmental implications of infant and young child feeding practices

The study of infant and young child feeding in terms of a life course perspective is fraught with methodological limitations and deficiency of longitudinal data with which to study the effects over the life course. Extensive research has confirmed the short-term health benefits associated with optimal breastfeeding practices and child survival in low- and middle-income countries, yet there is less consensus on the association with lifelong health outcomes for mother and child (Victora et al., 2016). Further, Giugliani et al. (2015) draw attention to the fact that most research concerned with the long-term effects of infant feeding practices has been conducted in high-income countries, bringing in an element of contextual bias. Furthermore, the differences in diet between breastfed and non-breastfed subjects may be so disparate between low- and high-income countries that it is difficult to assess the true effect of not breastfeeding. For example, children who are not breastfed in low-income countries are more likely to receive diluted or lower quality breast milk substitutes (Beasley and Amir, 2007), while children in middle- and high-income countries will likely be administered higher quality formula milk, the quality of which may vary substantially between geographical contexts (Victora et al. 2016).

Compared to breastfeeding, research on the complementary feeding period and associations with longer-term health and nutritional status has received far less attention and the majority of research in this area focuses mainly on the associations between the timing of introduction of complementary foods and child growth, rather than particular aspects of complementary feeding such as the quantities or types of food consumed (Agostoni et al., 2008). However, the complementary feeding period between 6 and 24 months of age represents the window in which the most growth faltering is meant to occur (Shrimpton et al., 2010), which highlights the importance of optimum nutrition in this period, especially in low resource settings.

As with any study involving a health intervention, outcomes are varied and whilst many of the studies provide evidence in support of the health benefits associated with breastfeeding, there are also studies that prove negative or suggest zero effects (Grummer-Strawn and Rollins, 2015). This may in part be explained by methodological issues associated with observational studies on the health effects of optimal infant feeding practices, as most of the data is cross-sectional or retrospective which introduces elements of selection bias and reverse causality (Giugliani et al. 2015). Similarly, the majority of studies which investigate the quality of complementary feeding on child growth and other health outcomes are based on observational studies or intervention studies where the effects of an education strategy about complementary feeding as opposed to a nutritional intervention are assessed. Moreover, the accuracy of meta-analyses on health outcomes associated with optimal feeding practices should be interpreted with caution, due to the varied classification of health outcomes and differences in the age at which the outcome was measured. As a result, heterogeneity between studies in systematic reviews often prevents suitable meta-analyses.

The following section defines infant and young child feeding practices in terms of measurement, indicators, current recommendations and the challenges associated with these. The short- and long-term impacts of optimal IYCF practices on child nutritional status and morbidity is discussed with review of the literature pertaining to the long-term effects by non- communicable disease type and finally, the impact of complementary feeding will be considered with the aim of highlighting the importance of the weaning period.

2.4.1 Definitions and indicators of infant and young child feeding

Defining infant and young child feeding practices in an accurate and consistent manner is of paramount importance for clinicians, statisticians and policy makers to allow for comparability between countries and studies. This presents challenges in research where the dependent variable is a particular health outcome such as the prevalence of obesity, as slight variability in the measurement of an infant feeding practice and the use of inconsistent definitions may be associated with differing health outcomes (Thulier 2010). Renfrew et al. (2007) highlighted these challenges in their systematic review of 80 intervention studies focusing on the promotion and support of breastfeeding, finding that the majority of studies were methodologically questionable, often using inconsistent definitions of breastfeeding, resulting in misinterpretation of data. Although the focus thus far has been mainly on the differentiation between breastfeeding and artificial feeding, and the level of exclusivity of breastfeeding, clear definitions of feeding practices occurring during the complementary feeding period (beyond 6 months of age) and the indicators pertaining to this period have received less attention. Prior to 2008 when specific complementary feeding recommendations and indicators were established (WHO, 2008), the scientific evidence base for the effectiveness of interventions to improve complementary feeding were lacking (Dewey and Adu-Afarwuah, 2008) and remain limited today.

Current definitions of infant feeding practices set out by the WHO (Table 2.2, p.70) focus primarily on the content of feeds, rather than the mode of food delivery, with each category specifying the amount of breast milk that the infant should receive in addition to other nutrient sources.

Labbok and Krasovec (1990) first advocated for consistency in breastfeeding definitions at the Interagency Group for Action on Breastfeeding in 1988, where they pushed for a set of definitions that further delineated the act of breastfeeding based on the content of the infant's diet, as well as the development of a schema through which more comprehensive definitions could be established. These definitions simply divided breastfeeding behaviour into two main groups: "full" and "partial" breastfeeding, with an additional category for "token" breastfeeding. It was at this meeting that a general consensus was met regarding the importance of defining the exclusivity of breastfeeding practices, due to the differences in morbidity and mortality outcomes when other supplements are added to the infant's diet. These definitions and indicators have since been further honed and updated by the WHO, with the most recent set of definitions outlined in a 2008 report (WHO, 2008).

Table 2.2 WHO Infant Feeding definitions

Feeding practice	Requires that the infant receive	Allows the infant to receive	Does not allow the infant to receive
Exclusive breastfeeding	Breast milk (including milk expressed or from a wet nurse)	ORS, drops, syrups (vitamins, minerals, medicines)	Anything else
Predominant breastfeeding	Breast milk (including milk expressed or from a wet nurse) as the predominant source of nourishment	Certain liquids (water and water-based drinks, fruit juice, ritual fluids and ORS, drops or syrups, vitamins, minerals, medicines)	Anything else (in particular, non-human milk, food-based fluids)
Complementary feeding	Breast milk (including milk expressed or from a wet nurse) and solid or semi-solid foods	Anything else: any food or liquid including non-human milk and formula	N/A
Breastfeeding	Breast milk (including milk expressed or from a wet nurse)	Anything else: any food or liquid including non-human milk and formula	N/A
Bottle-feeding	Any liquid (including breast milk) or semi-solid food from a bottle with a nipple/teat	Anything else: any food or liquid including non-human milk and formula	N/A

Source: WHO "Indicators for assessing infant and young child feeding practices. Part I: Definitions" (2008)

It is important to note that exclusive breastfeeding is defined in this framework in the strictest sense, stipulating that the infant may receive only ORS, drops or syrups for vitamins, minerals and medicinal purposes (when needed) in addition to breast milk, in the first six months of life. Duration and exclusivity are therefore usually the measures of interest for studies focusing on breastfeeding practices, since the benefits associated with optimal breastfeeding is dose dependent, whereby the benefits associated with the practice depend on the amount of breast milk an infant receives and the duration of this practice (Noel-Weiss et al. 2012). In their study on the long-term effects of breastfeeding, Horta and Victora (2013) emphasise the importance of establishing clear definitions of feeding practices where two groups of infants are compared. Due to lack of detailed data or for ease of comparability between studies, infants who were ever breastfed are often compared to those who were never breastfed. Whilst Horta and Victora point out that this is acceptable if the focus is on the first few hours of life as a critical window, for studies looking at the cumulative effects of breastfeeding on long-term health, this mode of comparison may actually underestimate associations. Grummer-Strawn and Rollins suggest that the mode of feeding may be of interest in some studies, which may be affected by other variables such as the mode of delivery, malocclusion and obesity (2015).

In order to determine the type of infant feeding practice, the WHO advises that a 24- hour recall period be used to collect current status data during a study visit on what and how the child was fed in the day previous to the visit. This allows for the measurement of population-level indicators, avoiding the heaping that often occurs when collecting retrospective data on the duration of breastfeeding.

Ultimately, it is worth noting that literature pertaining to infant and young child feeding definitions and population-based surveys have mostly focused on differentiating between breastfeeding practices occurring before six months of age. However, less is known about indicators which measure feeding behaviours in the critical period between six and 23 months, where the quality and timing of complementary feeding practices should be the focus.

The challenge associated with defining complementary feeding practices is perhaps exacerbated by the way in which the WHO defines “complementary food”. As per the most recent WHO recommendations that were adapted in 2008 following a thorough systematic review of scientific evidence and expert consultation, all human milk substitutes, artificial formula and follow-on formula were included under the umbrella term of “complementary food”. Whilst the intention was to highlight the importance of breastfeeding and further encourage its practice, the ESPGHAN Committee on Nutrition suggest that it has further complicated the categorisation of infants who have been fed with artificial milk since birth (Agostoni et al., 2008). Furthermore, the WHO has advised that use of the term “weaning” be avoided since in some contexts it may be associated with the complete cessation of breastfeeding (Fewtrell et al. 2007) rather than the process that starts by the introduction of complementary foods; the term “complementary feeding” is used to define this transition from exclusive breastfeeding and the introduction of semi-solid/solid foods. Although there are no specific recommendations for the optimal age for the introduction of complementary foods for infants formula-fed from birth or from before 6 months of life, generally practice is to follow the recommendations for breastfed infants.

2.4.2 Infant and young child feeding recommendations

Ultimately, optimum nutrition in early life can be considered a human rights issue, since every child has the right to lead a healthy and fulfilling life (UN General Assembly, 1989, Art.4, p.7), and women should be able to access the resources necessary to make an informed choice about the way in which they feed their child. Nutritional inputs during this critical early life period has the potential to determine child survival and later longevity. Furthermore, support for optimal feeding practices is also critical for achieving progress towards many of the Sustainable Development Goals (SDGs), the UN development agenda adopted by global leaders in 2015 (UNICEF 2016). The multiple links that optimal nutrition has with the Sustainable Development Agenda highlights the need for evidence-based recommendations that can be applied globally:

SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Breast milk and appropriate complementary foods provides vital nutrition to infants that can help reduce later prevalence of malnutrition-related conditions such as underweight/ stunting/ overweight, which is of particular importance for resource-poor environments.

SDG 3: Ensure healthy lives and promote well-being for all at all ages

Optimal breastfeeding practice is associated with lifelong immunity against several chronic conditions in addition to significant associations with reduced prevalence of gastrointestinal and respiratory tract infections during infancy. It has been estimated that increasing breastfeeding rates to meet target levels could boost the survival of 820,000 children under the age of five, 87% of which aged under six months (Victora et al. 2016). In addition, associations have also been found between longer durations of breastfeeding and maternal health outcomes such as the reduced incidence of breast and ovarian cancers.

SDG 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

SDG 4 highlights the importance of early childhood development as a key to sustainable development and evidence exists to suggest that breastfeeding has a positive effect on cognitive ability, and consequent educational achievement with improved later life opportunities and productivity.

SDG 5: Achieve gender equality and empower all women and girls

Breastfeeding also helps to promote gender equality, since it increases the longevity of birth spacing, which allows women a greater reproductive autonomy and is also linked with issues of maternity and workplace rights.

SDG 12: Ensure sustainable consumption and production patterns

In terms of environmental sustainability, breast milk requires no manufacturing and its consumption has no ecological impacts.

In the past three decades, infant and young child feeding recommendations have evolved based on a wealth of epidemiological evidence that has proven the programming role of early nutrition on health throughout the life course.

2.4.2.1 Infant and young child feeding recommendations for children aged 0 to <6 months

The WHO and UNICEF recommend the following for children aged between 0 to < 6 months (WHO, 2003):

- Breastfeeding should be initiated within the first hour of life;
- Exclusive breastfeeding for the first six months (allowing for ORS (oral rehydration salts), drops, syrups, vitamins, minerals and medicines).

The most recent recommendations endorsed by the World Health Organization are based on a WHO-commissioned systematic review conducted by Kramer and Kakuma in 2002, which, following expert consultation, was adopted by the WHO and UNICEF as the Global Strategy for infant and young child feeding (2003). Amongst other recommendations that emerged from the influential systematic review by Kramer and Kakuma (2002), which was updated in 2012 (Kramer and Kakuma, 2012), the recommended duration of exclusive breastfeeding was increased from four to six months, based on limited evidence relating to maternal and child health outcomes of infants exclusively breastfed for six months, compared to those breastfed for three to four months. In addition, this global strategy also advised that breastfeeding should be initiated within the first hour post-birth, and that nutritionally-adequate and safe complementary foods be introduced from six months along with continued breastfeeding up to two years of age and beyond.

However, these newly adapted recommendations have spurred debate amongst advisory bodies within many countries, since they seemingly fail to acknowledge the differential nutritional needs of infants in different geographical contexts and there is an apparent lack of recommendations for infants fed exclusively with formula milk.

Firstly, the increase of the recommended duration of exclusive breastfeeding has caused a clear division in opinion, due to the strength of evidence on which this change was based, resulting in some countries choosing to adopt the new recommendation and others continuing to recommend four to six months of exclusive breastfeeding (Agostini et al. 2008). For example, 65% of European states, as well as the United States have chosen to follow the older recommendation of four to six months of exclusive breastfeeding (Fewtrell et al. 2011). The systematic review (Kramer and Kakuma 2002) which provided evidence in support of this adaptation of the exclusive breastfeeding recommendation was based on 16 studies, 2 of which were randomised trials conducted in Honduras and the remaining 14 consisting of observational studies. Of all the studies included in the review, 7 were from developing countries. A study included in this review was from the Belarus promotion of breastfeeding intervention trial (PROBIT), which showed that six months of exclusive breastfeeding was associated with significantly reduced risk of gastroenteritis compared to three to four months of exclusive breastfeeding. Overall, this review confirmed that morbidity was lower amongst infants exclusively breastfed for six months with no obvious growth deficits but highlighted the need for further randomised trials to rule out the potential adverse effect of iron deficiency associated with infants who were exclusively breastfed for longer durations (Fewtrell et al. 2007).

The change in the recommended duration of exclusive breastfeeding sparked disagreement amongst advisory bodies and academics in developed countries due to concern that prolonged exclusive breastfeeding would not be sufficient to support the energy requirements of infants growing up in a developed context (*ibid.*). The criticisms by Fewtrell and colleagues (2011) are supported by evidence that suggests that infants who are exclusively breastfed for longer periods are more prone to allergies, iron deficiencies and coeliac disease; evidence later derived from studies which were conducted after the 2002 WHO review. It has also been suggested that prolonging the duration of exclusive breastfeeding may reduce exposure to certain food types which can be introduced during complementary feeding, offering a critical window in which tastes are developed that can further shape taste preference in later life. Fewtrell et al. (2011) further criticise the WHO review for including mostly observational studies, where direct causation is difficult to determine. In conclusion, whilst countries are at liberty to adapt the recommended duration of exclusive breastfeeding, it seems there may only be marginal differences in health outcomes associated with four to six versus six months of exclusive breastfeeding, but it is clear that in some resource- poor settings where morbidity and mortality from infectious disease is high, the most recent WHO recommendation of six months of exclusive breastfeeding can be endorsed.

2.4.2.2 Infant and young child feeding recommendations for children aged between 6 and <24 months

The recommendations proposed by the 2003 Global Strategy for infant and young child feeding provided relatively vague recommendations for the progression of breastfed infants on to complementary foods, which were even more ambiguous for infants who had been previously fed with formula milk. The 2003 recommendations stated that as complementary feeding commences, children should be fed in a *timely, adequate and safe* manner, to ensure that their nutritional requirements are met (WHO, 2003). These recommendations have been since updated (WHO, 2008) with a set of indicators that can be used to measure national progress. For children aged between 6 and <24 months, the WHO and UNICEF recommends that:

- Breastfeeding continues up to two years of age and beyond;
- Introduction of nutritionally-adequate and safe complementary foods from six months onwards which gradually increases in consistency and variety;
- The number of meals per day should be gradually increased from 2-3 meals per day for breastfed infants aged 6-8 months, 3-4 meals per day for breastfed infants 9-23 months and four meals a day for non-breastfed children aged 6-23 months.

Minimum dietary diversity (MDD) is assessed using an indicator that measures whether a child aged 6 to <24 months receives foods from four or more food groups[18] from a total of seven, which can be considered as a proxy indicator for micronutrient-density of foods (WHO, 2008). Minimum

[18] This indicator was updated by the WHO and UNICEF in 2017, to include breast milk as one of the food groups as it was previously not counted as a food group, resulting in this indicator favouring formula fed children as this was considered in the 'dairy' food group. As of 2017, this indicator considers breast milk as one of the food groups and children are classified as receiving MDD if they consumed five or more (out of a total 8) food groups in a 24-hr recall (UNICEF & WHO, 2017). For the purpose of consistency, the older definition of dietary diversity is used throughout this thesis.

meal frequency (MMF) which measures whether a child receives an appropriate amount of food, represents a proxy indicator for energy intake and is calculated separately for breastfed and non-breastfed children. For breastfed children, this includes 2-3 meals per day for those aged 6-8 months, 3-4 meals per day for those aged 9-23 months and for non-breastfed children four meals per day from the age of 6 to 23 months, where “meals” are defined as meals or snacks (*ibid.*). A summary indicator was also devised for assessing minimum acceptable diet (MAD) which incorporates both aspects of complementary feeding (MDD and MFF), and is calculated separately for breastfed and non-breastfed children.

One of the main challenges of the WHO recommendations for complementary feeding is the applicability to all population subgroups, within and between diverse geographical locations. This phenomenon has otherwise been coined the “weanling’s dilemma” (Rowland, 1986) and represents the difficulties with applying the complementary feeding recommendations to both high income and LMIC contexts where complementary feeding practices may be quite diverse in terms of the types of food administered and the quality of breast milk substitutes/follow-on formulas. Stewart et al., (p.29, 2013) also highlight the fact that complementary feeding consists of an interrelated set of behaviours that range from the ‘timing of introduction, food choice and dietary diversity, preparation methods, quantity, feeding frequency, responsiveness to infant cues and safe preparation and storage of foods’. As a result, it is likely that context-specific barriers exist, which a broad set of recommendations cannot account for.

Additional policy recommendations also exist to assist in promoting and encouraging optimal feeding habits, as evidence has proven that nationally implemented policies can positively influence breastfeeding rates (Rollins et al. 2016). Such policies include ILO’s maternity protection convention which promotes longer maternity leave and increased benefits, UNICEF’s Baby-friendly Hospital Initiative and the International Code of Marketing of Breast milk Substitutes. However, perhaps the most successful strategies to improve complementary feeding practices have been interventions that focus on nutrition education and behaviour change communication (BCC) strategies (Bégin and Aguayo, 2017), as these can be tailored to local environments and cultures where local food availability varies.

2.4.3 Short-term impacts of optimal early life feeding practices

The protective effect of optimal breastfeeding practices on infectious diseases in children under five years of age is clear and particularly pertinent in developing countries where the burden of communicable disease remains high. In fact, *The Global Burden of Diseases, Injuries and Risk Factors Study* (Roberts, Carnahan and Gakidou, 2013) positioned suboptimal breastfeeding as the second highest risk factor for under-5 morbidity, accounting for an equivalent of 47.5 million DALYs lost in 2010.

The results from a meta-analysis conducted in low- and middle-income countries considered the effect of exclusivity of breastfeeding on all-cause mortality in children under-5, showing that infants who were exclusively breastfed experienced only 12 % of the risk of death when compared to their non-exclusively breastfed counterparts (Black et al., 2013). These results were consistent with the findings of the earlier Bellagio Child Survival Series (Jones et al., 2003), which estimated that optimal breastfeeding practices could prevent 13% of deaths in children under-5 year of age, highlighting the valuable effect of exclusivity. Extending on the effect of exclusivity of breastfeeding, Sankar et al. (2015) found that there was a positive, incremental correlation between the quality of breastfeeding practice and short-term protection from mortality and morbidity, with partial and predominant breastfeeding also offering positive influences when compared to never-breastfeeding. Based on 66 analyses from mainly low- and middle-income countries, it has been estimated that optimal breastfeeding practices could reduce the incidence of diarrhoea by half and respiratory infections by a third, in children under-5 years (Victora et al. 2016). Similarly, using UK data from the Millennium Cohort Study, Quigley et al. (2007) estimated that hospital admissions due to diarrhoea and lower respiratory tract infections could be reduced with optimal breastfeeding practices, suggesting that the short-term health benefits are still relevant for high-income countries, with the potential to reduce health-care costs.

It is also important to consider that in low- and middle-income countries the adverse effects of not breastfeeding are often exaggerated by the poorer quality alternatives, such as the use of animal milk and low-quality formula substitutes which are often diluted, as well as increased risk of infection from combining these with contaminated water (Grummer-Strawn and Rollins, 2015). Nevertheless, the short-term health benefits of optimal breastfeeding practices are not only confined to low- and middle- income countries, with results from six meta-analyses conducted in high-income settings, suggesting that there is a 36% reduction of sudden infant deaths associated with ever-breastfeeding (Victora et al., 2016). In addition, a condition which is associated with high mortality in all contexts is the prevalence of necrotising enterocolitis, which, although rare, was shown to decrease by 58% among ever-breastfed children, on the basis of four randomised control trials (*ibid.*).

Although many analyses use dichotomous variables to measure the standard of breastfeeding, for example exclusive vs. non-exclusive, alternative studies have explored the ways in which duration of breastfeeding has differential effects on health outcomes. Kramer et al. (2003) studied the effect of duration of exclusive breastfeeding using an observational cohort in Belarus, finding that infants exclusively breastfed for 6 months or more had lower risk of gastrointestinal disease than those exclusively breastfed for 3 months. In terms of oral health outcomes and duration of breastfeeding, infants breastfed for longer periods were less likely to experience malocclusions, than those breastfed for shorter periods (Peres et al., 2015).

Extensive research into short-term child morbidity and mortality has proven the value of optimal breastfeeding practices as a child health intervention in all contexts, but of special importance in low- and middle-income countries where preventable deaths of children under-5 years still occur. To simulate the likely benefit of improving breastfeeding practices, with use of the Lives Saved Tool it has been estimated that 823,000 child deaths could have been averted in 2015 alone in 75 low- and middle-income countries if breastfeeding had been scaled up to reach near universal levels (Victora et al. 2016). Rollins et al. (2016) even went as far as to estimate the health-care expenditure that could be saved by up-scaling exclusive and continued breastfeeding. Accounting for the treatment costs of five most common childhood diseases in four countries, the authors estimated that this supposed improvement in breastfeeding practices would have the potential to reduce health-care costs by $312 million in the USA, $7.8 million in the UK, $30 million in urban China, and $1.8 million in Brazil (*ibid.*). Although the short-term benefits of optimal breastfeeding practices are well evidenced and have the potential to prevent mortality and morbidity in early life, the long-term benefits associated with optimal feeding practices warrant further study.

2.4.4 Long-term impacts of optimal early life feeding practices

With reference to life course theory and the developmental origins of disease, it is apparent that later-life health and the onset of non-communicable disease may be determined by early exposure to nutrition in gestation, infancy and childhood. A wealth of evidence suggests that nutritional inputs during this critical period, which spans the first 1000 days of life, from conception to two years, may determine susceptibility to later onset, chronic disease. This thesis focuses on the nutritional inputs from birth to two years of age and the importance of early infant feeding practices in the context of a life course perspective to health. For this, it is important to identify the long- term health outcomes associated with early feeding practices, and critically discuss the existing evidence, as well as outlining any limitations that occur from such study. In this regard, the following section will involve a thorough discussion of the long-term health outcomes associated with early feeding practices.

Although the short-term benefits of optimal breastfeeding practices have been clarified, it is important to consider its relevance for long-term health, especially in wake of the obesity epidemic that is occurring in many low- and middle-income countries and the putative association between breastfeeding practices and obesity prevalence. One of a series of recent papers published in *The Lancet* highlighted significant associations between longer durations of breastfeeding and reduced incidence of malocclusions, and potential protection against overweight and obesity in later childhood and adolescence, as well as improvements in intelligence (Victora et al. 2016). Weaker associations were found between breastfeeding and incidence of asthma, allergies, blood pressure and cholesterol, despite some studies reporting significant results. It is important to emphasise the positive effects of optimal breastfeeding practices on long-term health, since it may facilitate in reducing long-term health inequalities (Victora et al. 2016) which are often determined by factors such as wealth, education and urban/rural residence. In this way, breastfeeding provides a cost-free health intervention which in principle is available to all, and can provide long-lasting benefits throughout the life-course, irrespective of socio-demographic characteristics.

The positive association between optimal breastfeeding practices and reduced incidence of overweight and obesity in later life, is one of the most important health outcomes to consider since they act as a pre-condition for the development of other chronic diseases such as cardiovascular disease, type 2 diabetes, cancer and raised systolic blood pressure (Horta and Victora 2013). The biological mechanisms behind the protective effect of breastfeeding on overweight and obesity are thought to be associated with the lower protein content of breast milk and the lower energy metabolism of breastfed infants (Horta and Victora 2013). Therefore, the differences in protein content between formula milk and breast milk is thought to trigger different hormonal responses in infants, where formula fed infants are more likely than breastfed infants to have a greater insulin response, which in turn is associated with later fat deposition (Horta and Victora 2013; Horta et al. 2015). Aside from the direct biological mechanisms that are at play between breastfeeding and overweight and obesity, infant feeding practices are thought to influence later taste preferences, which may determine a child's diet and later risk of becoming overweight. Menella, Jagnow and Beauchamp (2001) suggest that the constant variation in the composition and taste of breast milk over time, which is also dependent on maternal diet, may increase the acceptance of a more diversified diet in breastfed infants. In fact, in a study of Dutch children aged seven year, Scholtens et al. (2008) found that those who had been breastfed for more than 16 weeks were more likely to have a diet rich in fruit and vegetables, when compared to those who were never breastfed, and likewise those who were not breastfed were more likely to have a higher intake of white bread, soft drinks, chocolate and fried snacks. However, not only is this study fraught with issues of residual confounding due to the fact that mothers who breastfeed their children are also more likely to insist on a healthy diet as the child grows, but once the authors adjusted for diet at seven years, the associations between breastfeeding and obesity were unchanged. This suggests that the link between breastfeeding, the consequent development of taste preferences and obesity presents an unlikely pathway to influencing the incidence of overweight or obesity.

Whilst many studies have shown a positive association between breast feeding and a reduction in overweight and obesity (Huus et al. 2008; Scholtens et al. 2007), there are also many studies with an increased incidence of overweight and obesity amongst breastfed subjects or with inconclusive results (Al-Qaoud et al. 2009; Neutzling et al. 2009; Procter and Holcomb, 2008; Toschke et al. 2007). This apparent contradictory evidence highlights the importance of taking into consideration the methodological limitations of each study such as the effect of smaller studies which may overestimate the influence of breastfeeding (Horta and Victora 2013). Horta and colleagues (2015) hinted at the challenges with overestimating of the effect of breastfeeding, as they found that although breastfeeding was positively associated with incidence of overweight and obesity, this association decreased among the 11 studies with the most rigorous methodologies. In their systematic review of the long- term effects of breastfeeding, Horta et al. (2015) also noted that there was a larger effect of breastfeeding on overweight and obesity when measured during childhood or adolescence rather than later adulthood, which would suggest that the potential impact that breastfeeding perhaps wanes over time. Nonetheless, identifying the prevalence of overweight or obesity in childhood or adolescence remains important since it is often a predictor of overweight or obesity in adulthood and measuring the incidence of this during adolescence has a stronger predictive effect than during childhood (Gillman et al. 2001). Furthermore, due to the difficulties with treating overweight and obesity once it has manifested, it further highlights the importance of promoting potentially protective measures such as breastfeeding.

Moreover, overweight and obesity are not only health concerns in themselves, but also act as health markers for other conditions such as diabetes. Type 2 diabetes is considered to be associated with suboptimal breastfeeding practices, through the pathway of overweight and obesity, in addition to having its own biological interactions with breastfeeding itself. The differences in insulin secretion between breast- and formula-fed infants influences their glucose metabolism and therefore the incidence of type 2 diabetes; breastfed infants have lower insulin concentrations and therefore reduced risk of B-cell failure (Horta and Victora 2013). In a random effects model, which constituted part of a meta-analysis, breastfed subjects were less likely to develop type 2 diabetes, with a pooled odds ratio of 0.66 (*ibid.*). Amongst the studies included in the analysis, when earlier BMI measurements were adjusted for, the effect of breastfeeding on type 2 diabetes incidence was smaller, highlighting the role of conditional weight gain which is dependent on earlier anthropometric measurements.

More complex is defining the association between breastfeeding and intelligence and cognitive performance, since residual confounding with socio-economic factors is a prominent issue. In the most recent meta-analysis of 17 studies on the relationship between breastfeeding and intelligence, Horta et al. (2015) found that breastfeeding was associated with a higher IQ, with little evidence of publication bias. Nevertheless, when maternal IQ was included in the model, it reduced the positive association with breastfeeding. Residual confounding with socioeconomic status is a major limitation of these types of studies, especially those studies that are conducted in high-income countries, as breastfeeding duration is positively associated with higher socioeconomic status whilst at the same time, higher IQ is also linked with higher income. This was a criticism of the study conducted by Victora et al. (2015) which even went on to suggest the effects that breastfeeding has on income at age 30 years, whilst not including any information on mother's IQ which is a heritable characteristic, not to mention its confounding with socioeconomic status and considerably loss to follow up. Nevertheless, evidence from a randomised cluster trial in Belarus, which controlled for breastfeeding support in hospitals, suggests that the positive effect that breastfeeding has on verbal IQ may be causal, with on average a 7.5 point difference between subjects who received the intervention and those who did not (Kramer et al. 2008). The biological argument for this association rests on the biochemical make up of breast milk which contains long-chain polyunsaturated fatty acids which promotes brain development (Isaacs et al. 2010).

Evidence pertaining to the relationship between breastfeeding and allergies or asthma is reasonably inconclusive, with the most recent meta-analysis showing that longer breastfeeding durations had a small protective effect on incidence of asthma at age 5-18 year, but a weaker association with allergic rhinitis and eczema (Lodge et al. 2015). Part of these inconclusive results can be explained by the fact that the biological interaction between infant immunity and allergic diseases is not yet fully understood (*ibid.*).

Whilst this review has mentioned just some of the long-term health benefits associated with breastfeeding and the protective effect it may have, there are other health benefits which have not been mentioned here since they are less relevant for this thesis. However, the protective effect that breastfeeding may have against maternal cancers, maternal postpartum depression, HIV transmission, blood pressure and cholesterol should not be overlooked.

2.5 Factors associated with infant and young child feeding practices in LMIC contexts

Understanding which factors are associated with specific infant and young child feeding practices is crucial for identifying the populations that are most at risk from suboptimal feeding practices and the accompanying poorer health outcomes for children. The application of a universal, comprehensive framework facilitates comparisons between studies of infant and young child feeding, to identify mutual risk factors, as well as allowing for the consideration of confounding predictors (Scott et al. 2001). Therefore, the conceptual framework presented in Figure 2.1, p.55 was employed throughout the thesis as a basis for explaining pathways to child growth and development, as well as the explanatory variables operating at different levels of causation.

Inherent (biological) factors

The factor that is most consistently associated with breastfeeding and complementary feeding practices across all geographical contexts is age of child. Cessation of breastfeeding is more likely to occur as a child grows older, often as a result of the perceived or real inadequacy of breast milk to satisfy the growing child (Setegn et al. 2012). Conversely, in terms of indicators of complementary feeding practices, an increase in the child's age is positively associated with introduction of complementary foods, improved dietary diversity and minimum meal frequency (Senarath et al. 2012). The effect of child sex on child nutrition can infer certain sociocultural conventions, particularly in traditionally patriarchal societies such as in Vietnam, where Confucian culture is thought to influence male preference (Guilmoto, 2012). If this pattern were confirmed, one would expect male children to perhaps receive better nutritional inputs, however, most studies reviewed demonstrated no evidence of a significant association between child sex and infant and young child feeding practices throughout Southeast Asia (Kounnavong et al. 2013; Senarath et al. 2010).

Proximate factors

In terms of the proximate factors associated with IYCF practices, child morbidity is an important factor which often determines the premature cessation of exclusive breastfeeding or the early introduction of complementary foods, although breastfeeding is reported to protect against morbidities such as diarrhoeal disease (Popkin et al., 1990; Lamberti et al., 2011). Although there is limited evidence from Southeast Asian countries on the association between prevalence of diarrhoea or acute respiratory infections and IYCF practices, in a study of Sri Lankan infants, those who had respiratory infection symptoms in the two weeks preceding survey were more likely to not receive the minimum dietary diversity or the minimum acceptable diet (Senarath et al. 2012).

In line with these findings, Mihrshahi et al. (2007) noted that the prevalence of both illnesses in children in Bangladesh was also significantly associated with non-exclusive breastfeeding. However, as is also depicted on the conceptual framework (Figure 2.1, p.55) morbidity and IYCF practices share a synergetic relationship, whereby one may cause the other, for example early introduction of complementary foods before the infant is ready may lead to diarrhoeal disease, conversely children suffering from diarrhoeal disease may be introduced to complementary foods earlier than if they were healthy.

Furthermore, IYCF practices also interact with each other, such as pre-lacteal feeding which is typically associated with delayed initiation and non-exclusive breastfeeding (Pérez-Escamilla et al., 1996), and is particularly germane for the Southeast Asian context where pre-lacteal feeding is a common occurrence (Nguyen et al., 2013; Brewster, 2014; UNICEF, 2015; Inayati et al., 2012). During the complementary feeding period from six months of age, continued breastfeeding, minimum dietary diversity and minimum meal frequency may also be inextricably linked in LMIC settings where prolonged breastfeeding may be practiced as a means to make up for limited financial resources to purchase appropriate and adequate quantities of complementary foods, as was the case in a study conducted in Thailand (Cetthakrikul et al., 2018).

Intermediate factors

Despite strong and consistent associations between maternal age and breastfeeding initiation and duration in developed contexts (Scott and Bins, 1999), the effect in low- and middle-income countries is more ambiguous. Senarath et al. (2010) also confirmed this finding in their study of the factors associated with non-exclusive breastfeeding in five East and Southeast Asian countries, where there was no significant or consistent association between maternal age and non-exclusive breastfeeding. Studies conducted in developing countries in other world regions suggest that the zero or marginal effect of maternal age is not a recurring theme in all low- and middle-income settings. Evidence from Ethiopia and China verified that increasing maternal age is positively associated with exclusive breastfeeding rates (Asemahagn, 2016; Tang, Lee and Binns, 2015), whereas in other countries such as Brazil, younger women are more likely to breastfeed than their older counterparts (Wenzel et al. 2010). The relationship between maternal age and complementary feeding practices in Southeast Asia is even weaker than for breastfeeding practices, however evidence from Myanmar demonstrated that women over 30 years of age are more likely to practice adequate feeding[19] compared to women under 20 years of age (Thet et al. 2016).

Utilisation of mass media, including newspapers, radio and television, has the potential to promote educational messages about healthy infant and young child feeding practices and the health benefits associated with this. Although a negative association between high exposure to media and minimum dietary diversity (Ng et al. 2012) was reported in Indonesia, results collected from some South Asian countries suggested that increased utilization of media was positively associated with adequate meal frequency for 6 to 23 month olds[20] in India and Sri Lanka, and appropriate dietary diversity[21] in India, Nepal and Sri Lanka (Senarath et al. 2012). Evidence from a successful mass media campaign which was established by UNICEF in Jordan (1988) to promote the benefits of breastfeeding (McDivitt et al., 1993), provides testament to the utilization of mass media as a tool for educating parents. In the two years following the launch of this initiative, knowledge surrounding the timely initiation of breastfeeding and the associated benefits of colostrum markedly increased (*ibid.*).

Higher order births seemed to be associated with an increased risk of not exclusively breastfeeding in both Indonesia and the Philippines (Senarath et al. 2010), yet evidence from selected South Asian countries suggested that increased birth order is associated with the later introduction of complementary foods, beyond the recommended age of six months (Senarath et al. 2012).

In terms of the aspects relating to the mother-infant dyad, the birth of the child and the role of professional health care facilities, existing literature suggests that these factors tend to be more relevant for determining breastfeeding practices rather than complementary feeding practices. Whilst a caesarean route of delivery is often cited as having a negative impact on the initiation of breastfeeding and duration (Scott et al. 2001; Shawky and Abalkhail, 2003), others (Dennis, 2003) note that once breastfeeding has commenced, there are minimal differences between those children born naturally and those through caesarean section. Nevertheless, there was limited evidence of the effect of route of delivery on breastfeeding practices in Southeast Asia: only in

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[19] Age-specific adequate feeding: infants 6-11 months should be breastfed and receive complementary foods at least 2 times a day, and at least 3 times a day for those 9-11 months.

[20] Adequate meal frequency refers to children who received the minimum meal frequency, as defined by the WHO (2010). The recommended minimum number of times a child should receive solid, semi-solid, or soft foods is 2 times for breastfed infants aged 6-8 months, 3 times for breastfed children 9-23 months and 4 times for non-breastfed children 6-23 months. This is recommendation is made on the basis that the energy density of meals is between 0.8-1 kcal/g.

[21] Appropriate dietary diversity is used here to define children meeting the WHO (2010) recommendations for receiving food from four or more food groups.

Vietnam, mothers who had a caesarean section were reported as having lower odds of exclusive breastfeeding (Le et al., 2018). Other factors related to the healthcare environment also produced mixed results in multiple Southeast Asian countries. In Timor-Leste and Philippines giving birth in a health facility was significantly associated with suboptimal breastfeeding rates in comparison to mothers who had a home delivery (Senarath et al. 2010). Similarly, in Myanmar delivering with a skilled birth assistant was indicative of inadequate feeding practices in children aged 6-11 months (Thet et al. 2016). On the other hand, increased number of antenatal visits was associated with increased rates of exclusive breastfeeding in Indonesia, Myanmar and Cambodia (Senarath et al. 2010; Thet et al. 2016; Sasaki et al. 2010), as well as with appropriate complementary feeding in infants aged 6-11 months in Myanmar. Furthermore, giving birth in a healthcare facility and skilled birth attendance were significantly and positively associated with receiving the minimum dietary diversity in children aged 6-23 months in Indonesia (Ng et al. 2012), although there was a higher prevalence of bottle-feeding amongst women who gave birth in a health facility. The inconsistent associations between healthcare utilization and infant and young child feeding practices across Southeast Asia suggests that the level of support and lactation counselling provided to women in health care facilities and by health professionals is varied, reflecting intra-country and within country differences in healthcare utilization during pregnancy and childbirth and that this may be further determined by socioeconomic status. Furthermore, the observed negative effect of healthcare utilization in some settings may also be indicative of birth complications, as these women are more likely to seek professional care and experience problems feeding their children following a difficult labour.

An additional barrier to exclusive breastfeeding which was documented in Indonesia (Shetty, 2014) is the role of community health workers, otherwise known as posyandus. Despite there being regulations in place that monitor the information and services distributed by formal health-care workers and institutions, these do not extend to traditional health workers, which possibly further endangers the protection of exclusive breastfeeding. Moreover, even within formal health care settings such as hospitals and clinics in Indonesia, enforcement of legislation to protect breastfeeding is lacking, as formula milk is often distributed to new mothers, in spite of this practice being illegal and under regulation of the *International Code of Marketing of Breast milk Substitutes* (*ibid.*).

Distal (underlying) factors

Socioeconomic factors associated with breastfeeding and complementary feeding may be present at the individual and household, community, regional or national level. Factors relating to the social and economic position of an individual and the surrounding environment is particularly critical for child nutrition in LMICs, many of which have experienced recent, rapid economic growth (Popkin et al., 1999).

Contrary to the trends in IYCF practices in high-income countries, longer breastfeeding durations are most prevalent among the poorest households in LMICs, a finding which has been observed in Brazil, Ethiopia, Indonesia, Philippines, Timor-Leste and Laos (Wenzel et al. 2010; Asemahagn 2016; Senarath et al. 2010; Kounnavong et al. 2013) and higher household wealth associated with lower rates of initiation and shorter breastfeeding durations. In terms of complementary feeding practices, evidence from developing countries suggests that increasing household wealth has a positive effect on the timely introduction of complementary foods and meeting minimum dietary diversity, which means that children from the poorest households are most at risk when it comes to this transition (Senarath et al. 2012). In fact, evidence from Indonesia suggested that although women in the poorest households expressed a firm knowledge of the importance of dietary diversity, the discrepancy between knowledge and putting the knowledge into practice implies that insufficient financial resources are the primary barrier for mothers (Ng et al. 2012). This notion of a knowledge-practice discrepancy was also supported by evidence from Uganda (Wamani et al. 2006).

Maternal education is a factor that often assimilates with wealth or income, and a common pattern in developing countries is for women of a lower educational level to have an increased likelihood of breastfeeding (Senarath et al. 2010). Evidence from Laos (Kounnavong et al. 2013) showed that although mothers with a higher education were more likely to initiate breastfeeding, mothers with a lower educational status were more likely to practice continued breastfeeding at one year of age. Similar to the effect of household wealth, mothers in Indonesia with no formal education were less likely to introduce complementary foods between 6-8 months, to provide the minimum dietary diversity and minimum meal frequency (Ng et al. 2012). Findings from a study conducted in South Asian countries using DHS data also confirmed that a lack of maternal education was the strongest factor associated with poor complementary feeding practices in Pakistan, Sri Lanka, Nepal, India and Bangladesh (Senarath et al. 2012).

Maternal employment is perhaps one of the most significant factors associated with infant and young child feeding practices, especially breastfeeding since its implications are multi-dimensional (Rollins et al. 2016). Returning to work not only makes it physically challenging to continue breastfeeding due to time spent away from the child, but often results in mothers having to make a difficult choice about the opportunity costs of breastfeeding and return to work. There are numerous studies which indicate the strong effect of mothers returning to work and premature cessation of breastfeeding in the first year postpartum (Roe et al. 1999; Dearden et al. 2002; Guendelman et al. 2009), with most of these studies conducted in high-income countries. However, if such a strong effect of maternal employment is observed in high-income countries, it reinforces the relevance of this factor for low- and middle- income countries, where legislation for maternity leave is often too short or non- existent and women have no choice but to return to work soon after giving birth. In fact, results from a study conducted in the UK found that maternity leave of less than six weeks was associated with four times the odds of not initiating, or premature cessation, of breastfeeding (Hawkins et al. 2007). In addition, there is a large collection of studies from low- and middle-income countries which confirm these results: in Malayisa, Tan (2011) reports that non-working mothers were 3.5 times more likely to exclusively breastfeed than those who were working. Qualitative evidence from Thailand also found that urban women in particular and women working in the formal sector faced many barriers to breastfeeding, including difficulties juggling paid work and maintaining lactation, limited breaks and often prevention from leaving the place of work during working hours (Yimyam and Morrow, 1999).

Meanwhile, in terms of maternal employment and dietary diversity, the associations did not appear quite as clear cut as with exclusive breastfeeding, however evidence was limited. For example in Nepal, working mothers were 1.5 times more likely to not provide a diverse diet for their child, whereas in Sri Lanka mothers who were working were 1.29 times more likely to provide the minimum dietary diversity (Senarath et al., 2012). In Indonesia however, children of non-working women were less likely to meet the requirements for a minimum acceptable diet[22] (Ng et al. 2012), perhaps indicative of lack of financial resources due to not working. Although employed women are more likely to purchase nutrient-rich foods (Yoong, Rabinovich and Diepeveen, 2012), the time constraints associated with employment may also pose a challenge for time allocated to caregiving and preparing nutritious meals and consequently increase the likelihood of providing convenience processed foods.

In nearly all countries of Southeast Asia, Senarath et al. (2010) found that mothers residing in urban areas had exclusive breastfeeding rates that were significantly lower than their rural counterparts. This association was also supported by separate evidence from Myanmar (Thet et al., 2016) and Malaysia (Tan, 2011). Some authors suggest that rapid urbanisation in low- and middle-income countries has resulted in a subsequent rapid uptake in formula milk which is often

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[22] Minimum acceptable diet as defined by WHO, is the proportion of children aged 6-23 months who receive the minimum dietary diversity and minimum meal frequency in the 24 hours preceding the interview. This indicator is calculated separately for breastfed and non-breastfed children.

seen as the modern, scientifically advanced and convenient mode of feeding (Piwoz and Huffman, 2015). However, the opposite effect may be true for complementary feeding, due to the availability of alternative supplementary foods that can promote dietary diversity, especially where time constraints of a working mother are a primary barrier. Although data is very limited for examining the effects of multiple factors on complementary feeding practices, evidence from Indonesia suggests that children residing in rural areas are less likely to meet the minimum dietary diversity and minimum acceptable diet (Ng et al. 2012).

Although marital status is often suggested to be strongly associated with breastfeeding rates in most high-income countries, with higher incidence and duration amongst married women (Evers, Doran and Schellenberg, 1998; Callen and Pinelli 2004), the association is less clear in developing countries. Thorough review of the literature on Southeast Asia clarified that marital status rarely appears in multivariable models due to its insignificant effect on the outcome of breastfeeding or complementary feeding practices univariably. However, evidence from Indonesia suggested a negative association between marital status and minimum meal frequency amongst children aged 6-23 months (Ng et al. 2012), in line with the positive association observed in high-income countries between marriage/union and IYCF practices. Significant observations can be observed in other LMIC contexts, such as in Kenya (Kimani-Murage et al. 2011), where married women were less likely to introduce complementary foods before six months of age. Giugliani (1994) argues that this supposed association could be due to the role of emotional, social and economic support of a partner.

2.6 Summary

This present chapter introduced and discussed the theories relevant to the study of early life, feeding practices and child growth, highlighting the important role of optimal nutritional inputs in the first 1000 days for short- and long-term growth and development. Section 2.2 presented the conceptual framework which was adapted especially for use in this thesis and Section 2.3 and 2.4 defined key indicators of child nutritional status and IYCF practices, in addition to the factors associated with these.

Chapter 3 Data and Methodology

3.1 Introduction

This thesis employed quantitative methodologies for the analysis of nationally representative secondary data from Cambodia, Myanmar and Indonesia, presented in the form of three linked analysis chapters. Cross-sectional data from Demographic and Health Surveys (DHS) from Cambodia (CDHS, 2014) (National Institute of Statistics and ICF International, 2015); Myanmar (MDHS, 2015-16) (Ministry of Health and Sports and ICF International, 2017); and Indonesia (IDHS, 2012) (Statistics Indonesia and ICF International, 2013) were selected as the data sources for the first analysis chapter (4), with the second analysis chapter (5) focusing on the Cambodian DHS (2014). The final analysis chapter (6) used longitudinal data from the first four waves of the Indonesian Family Life Survey (IFLS) (RAND Corporation, 1993; RAND Corporation 1997; RAND Corporation, 2000; RAND Corporation, 2007).

Single-country data were used in the second analysis chapter (Chapter 5) because the factors included in a hypothetical structural path models may differ greatly between countries, and direct comparison of the same structural path model would thus not have been appropriate or possible. Although further, future analysis could examine how explanatory factors differ between countries, this was outside the scope of this study. Further, anthropometric data were not available in the Indonesian DHS survey, and sample sizes were small in the Myanmar DHS. Single-country data was also employed in the third analysis chapter (Chapter 6) due to the limited availability of longitudinal surveys which track children from infancy to adulthood in an LMIC context.

The analytical methods for each study were based on their suitability for addressing the research questions proposed at the beginning of this thesis, and their applicability to the data types. All statistical analyses in this thesis were conducted using Stata SE version 15.1 (StataCorp, 2017).

This chapter describes the data sources and analytical methods employed throughout this thesis, and discusses issues relating to data quality of methodological limitations.

Ethical approval for this research was obtained from the University of Southampton Ethics and Research Governance Online (ERGO)[23]. Approval for using the DHS and IFLS datasets was obtained prior to being granted access.

3.2 Section A: Analysis 1

The first analysis chapter presented a sub-regional overview of the factors associated with exclusive breastfeeding from birth to six months, and with minimum dietary diversity in 6 to <24 month olds in Cambodia, Myanmar and Indonesia. The most recent Demographic and Health Surveys were obtained for these three countries, which had data from 2012 or later. For each country, two separate multivariable logistic regression models were applied to examine factors associated with exclusive breastfeeding and minimum dietary diversity. Definitions for these indicators are detailed in Section 3.2.4.

3.2.1 Data source: Demographic and Health Surveys

Demographic and Health Surveys (ICF, n.d.) are nationally representative surveys that collect and disseminate cross-sectional data on fertility, mortality, family planning, maternal and child health, sex, HIV, malaria and nutrition. Since 1984, the DHS programme has included over 300 surveys in 90 countries, with surveys generally carried out every five years (ICF, n.d.). The DHS programme is funded by the U.S. Agency for International Development (USAID). Data are collected using four types of standardized questionnaires which collect information on the household, individual women, individual men and biomarker information for selected individuals; all these are conducted by specially trained interviewers. Although the standard questionnaires are designed to be replicative in each country, some countries may choose to add or remove questions or modules that are deemed relevant/irrelevant, and customise their national survey each time.

Eligibility for interview are women of reproductive age (15-49 year) and men aged 15-49, 15-54, or 15-59 year (Rutstein and Rojas, 2006). Information on infant and young child feeding practices are covered in the woman's questionnaire. Data on the prevalence and initiation of breastfeeding is collected for all children in the household under 36 months at the time of the survey visit, and the 24 hour-recall of additional liquids and solid foods is collected for the youngest child born in the 36 months preceding the survey. Although the DHS does not provide data on the exclusivity of breastfeeding as such (questionnaires asks whether the infant/child is still being breastfed), this can be calculated combining available information in the dataset (see section 3.2.4).

[23] Submission ID: 21399

The DHS Programme has rigorous ethical protocols in place to protect the privacy of respondents in all DHS surveys, and all respondents must provide informed consent which ensures that participation is completely voluntary. Anonymisation of respondents is maintained in the dissemination of data, with individual respondents being identified by a series of numbers only.

3.2.2 Survey design

The primary DHS sampling procedure is a stratified two-stage cluster design, which uses enumeration areas (EAs) provided by national census data. These EAs are selected using a procedure known as probability proportional to size, and are otherwise referred to as the primary sampling units (PSUs) (Rutstein and Rojas, 2006). Following the collation of all households within each EA, the second stage of sampling involves the systematic selection of households for interview using a fixed or varying number within each EA. Once selected households have been contacted, information provided in the household questionnaire is used to determine eligibility of individual household members for interview. All women aged between 15-49 years are interviewed, however the sample of men chosen for interview varies between survey, in terms of the age range and selection procedure. For example, all men aged between 15-49 years living or staying in the household (the night before the interview) were eligible for interview in every second household in the Myanmar DHS (2015-16). Similarly, the Cambodian DHS (2014) also interviewed all men aged 15-49 years living or staying in the household, but only in one-third of eligible households. However, in Indonesia, only currently married men aged 15-54 year were eligible for interview in every third household, as were never-married men aged between 15 to 24 years.

In order to make statistical inferences about the study population, variance in response rates as well as under- and over-sampling in different regions was accounted for using the sampling weights provided in DHS datasets. The unit of analysis for this chapter was the child, so the DHS children's data file was used which includes data about the child, as well as the socio-demographic characteristics of the mother.

DHS Cambodia, 2014

The Cambodian DHS, or CDHS, (2014) included 15,825 households, with 17,578 women aged 15-49 years and 5,190 men age 15-49 years and was the fourth DHS conducted in the country (National Institute of Statistics and ICF International, 2015). To allow production of data at the subnational level, 19 sampling domains were defined for the survey, 14 of these individual provinces and 5 reflecting grouped provinces, which, when divided by urban/rural residence, produced 38 sampling strata from which primary sampling units (PSUs) were selected. Response rates were 99% at the household level, 98% for women and 95% for men. The survey was implemented by the Directorate General for Health (DGH) of the Ministry of Health and the National Institute of Statistics of the Ministry of Planning (National Institute of Statistics and ICF International, 2015).

DHS Myanmar, 2015-16

The Myanmar DHS, or MDHS, (2015-16) represented the first Demographic and Health Survey to be implemented in Myanmar, with results used in the 5-year National Health Plan (2017-2021) (Ministry of Health and Sports and ICF, 2017). The MDHS included 12,500 households, 12,885 women aged 15-49 years and 4,737 men aged 15-49. In total, 442 clusters in urban and rural areas were outlined, within each of which 30 households were selected. Response rates varied from 98% for households, to 96% of women and 91% of men eligible for interview. The survey was carried out by the Ministry of Health and Sports (MoHS) (*ibid.*).

DHS Indonesia, 2012

As the seventh survey in the Indonesian DHS, or IDHS, series, the IDSH 2013 is a particularly valuable source of information for Indonesia, which is the world's fourth most populous country, bringing with it a variety of population pressures and the need for evidence based family planning programs (Statistics Indonesia and ICF International, 2013). Members of 43,852 households were successfully interviewed, of which 45,607 were women aged 15-49 years and 9,306 married men aged 15-54 years. The survey was conducted in all 33 provinces of Indonesia and was implemented by Statistics Indonesia (BPS), together with the National Population and Family Planning Board and Ministry of Health. Response rates varied from 99% at the level of the household, to 96% of women and 92% of eligible married men.

3.2.3 Study sample

Two separate study samples were drawn from all three DHS for the analyses presented in this first analysis chapter, which focused on two separate Infant and Young Child Feeding (IYCF) indicators: exclusive breastfeeding and minimum dietary diversity.

For the study of exclusive breastfeeding in children aged between 0 to <6 months, a sample based on one eligible woman per household reporting on her youngest, singleton child aged 0-5.9 months, living with their mother at the time of survey was selected (Table 3.1).

Table 3.1 Sample sizes of children aged 0 to <6 months at the time of survey, by country

Country	Sample size (*n*)
Cambodia (2014)	688
Myanmar (2015-16)	468
Indonesia (2012)	1,686

The sample for the study of minimum dietary diversity in children aged between 6 to <24 months, was based on one eligible woman per household reporting on her youngest, singleton child aged 6 to <24 months, living with their mother at the time of survey (Table 3.2).

Table 3.2 Sample sizes of children aged 6 to <24 months at the time of survey, by country

Country	Sample size (*n*)
Cambodia (2014)	2,127
Myanmar (2015-16)	1,339
Indonesia (2012)	5,193

3.2.4 Dependent variables

Two separate dependent variables were created, corresponding to the two IYCF indicators under study: exclusive breastfeeding and minimum dietary diversity. These were based on the indicators as specified by the WHO (2010).

Y = Exclusive breastfeeding (0 to <6 months)

The WHO (2010) exclusive breastfeeding indicator represents the proportion of children aged between 0 to < 6 months who were fed exclusively with breast milk in the day prior to interview. This variable was calculated as follows:

$$\frac{Infants\ 0\ to{<}6\ months\ of\ age\ who\ received\ only\ breast\ milk\ during\ the\ previous\ day}{Infants\ 0\ to{<}6\ months\ of\ age}$$

The exclusive breastfeeding variable was coded as 0 for infants who did not exclusively receive breast milk in the 24 hours prior to survey and 1 for those who did.

Y= Minimum dietary diversity (6 to <24 months)

This indicator measures the proportion of children aged between 6 to 23.9 months who received foods from four or more of the seven defined food groups (WHO, 2010). The seven official food groups are:

- Grains, roots and tubers
- Legumes and nuts
- Dairy products (e.g. milk, yoghurt and cheese)
- Flesh foods (e.g. meat, fish, poultry and liver/organ meats)
- Eggs
- Vitamin-A rich fruits and vegetables (e.g. Carrots, sweet potato, spinach, Mango)
- Other fruits and vegetables

This variable was calculated as follows:

$$\frac{Children\ 6\ to < 24\ months\ of\ age\ who\ received\ foods\ from\ \geq 4\ food\ groups\ during\ the\ previous\ day}{Children\ 6\ to < 24\ months}$$

Breastfed and non-breastfed children were recorded as having received the minimum dietary diversity if they consumed at least four of these seven food groups in the 24 hours prior to interview (WHO 2008) (see Equation 2). It is important to note that in this variable no distinction is made between breastfed and non-breastfed children as breast milk is not included in any of the food groups. As a result, in non-breastfed children in populations where it is common for children to receive formula and/or milk the MDD may be higher than in breastfed children who do not get any other milk. However, in the analyses presented in Chapter 4, breastfeeding at the time of survey is allowed for in the analyses, and results as thus in line with the most current WHO definition.

3.2.5 Independent variables

Explanatory variables for this analysis were selected based on previous literature on IYCF practices in Southeast Asia (Ng et al., 2012; Hlaing et al., 2016; Sasaki et al., 2010; Kounnavong et al., 2013; Mya, Kyaw and Tun, 2019) and the conceptual framework introduced earlier in this thesis (Chapter 3.5), and were grouped according to the level of influence as depicted in the framework (i.e. proximate or intermediate factors). Table 3.3 describes the explanatory variables employed in the analysis of Chapter 4 and a more in-depth explanation follows (section 3.2.5.1), detailing how key independent variables were computed for analysis.

Table 3.3 Definition and coding of variables for analyses presented in Chapter 4

Variable	**Definition and coding**
Inherent (biological) factors	
Child's age (0 to <6 month sample)	Age in months. Categorised into groups: <3 m, ≥3 m
Child's age (6 to <24 month sample)	Age in months. Categorised into groups: 6-11 m, 12-17m, 18-23m
Sex	Coded as (1) male; (2) female
Birth weight	Child's birth weight as recorded from either health card or respondent's recall was grouped as (1) <2.5 kg; (2) 2.5 kg<4 kg; (3) ≥4 kg; (4) missing/not weight
Proximate factors	
Breastfeeding status	Whether or not child was still being breastfed at time of survey (any breastfeeding). Coded as (0) not currently breastfed; (1) currently breastfed
Pre-lacteal feeds	Whether or not child received any other foods or liquids aside from breast milk, in the 3 days after birth. Coded as (0) none; (1) received pre-lacteal feeds; (2) never breastfed (3) missing
Child morbidity	Symptoms of diarrhoea, ARI (Acute Respiratory Infection) or fever in past 2 weeks, as reported by mother. Coded as (0) no symptoms; (1) at least one symptom
Intermediate factors	
Birth order	Birth order was grouped by (1) first; (2) 2-3; (3) 4+
Birth interval	Previous birth interval, coded as (0) no previous interval; (1) <24 months; (2) ≥24 months
Birth place	Place of birth was grouped into 3 categories: (1) at home; (2) private facility; (3) public facility
Delivery by caesarean section	Coded as (0) no; (1) yes, caesarean section
ANC visits	The number of ANC visits during pregnancy was categorised into 3 groups: (1) 0-1 visits; (2) 2-4 visits; (3) 5+ visits
Maternal age (years)	Categorised into groups: 15-24, 25-34, 35-49
Distal (underlying) factors	
Marital status	Marital status was grouped into 2 categories: (1) married/co-habiting; (2) widowed/divorced/separated
Exposure to media	Composite indicator, measuring the extent of exposure of respondent to all 2 forms of media (newspaper, radio and TV). Coded as (1) limited; (2) moderate; (3) frequent
Maternal education level	Mother's highest level of completed education. Categorised into 2 groups: (1) no education/primary; (2) Secondary/higher
Maternal active labour force participation	Composite indicator measuring level of maternal labour force participation, based on 5 components of employment (employment in past 12 months, employer, occupation, earnings type, seasonality of work). Coded as: (0) not working (past 12 months); (1) low level of participation; (2) high level of participation
Household wealth index	Quintiles of household wealth, computed separately for urban/rural areas. Coded as: (1) poorest; (2) poorer; (3) middle; (4) richer; (5) richest
Sex of household head	Coded as (1) male; (2) female
Residence	Coded as (1) rural; (2) urban

Variable	Definition and coding
Geographical region	Geographical regions were recoded for each country to reduce the number of categories

3.2.5.1 Computation of key independent variables of interest

Although most of the independent variables were recoded from original variables available in the DHS datasets, some of the variables considered in this analysis were computed especially for this thesis and are described below:

Morbidity

This variable was computed using three separate variables from the DHS datasets. Children were defined as experiencing morbidity if the mother reported that in the two weeks prior to DHS visit the child had experienced either diarrhoea or coughing, trouble breathing and fever (symptoms of Acute Respiratory Infection, ARI). Responses were combined to create one child morbidity variable that was coded as (0) for no symptoms and (1) as having any symptoms.

Exposure to media

This variable was designed to reflect how often the respondent (mother) interacted with different forms of media such as reading the newspaper, listening to radio or watching television. It was computed using principal component analysis (PCA) to combine three separate variables into one media exposure variable. The PCA factor that was selected had an eigenvalue larger than one and each component had factor loadings greater than 0.5, which have been suggested as reasonable cut-off values (Acock, 2013).

Maternal active labour force participation

A composite indicator was computed to assess the level of maternal labour force participation, using principal component analysis, where five independent variables were transformed into one. As was also computed by Sebayang, Efendi and Astutik (2017), this variable was designed to consider five different aspects of maternal employment: (1) employment status in the past 12 months (working/not working); (2) for whom the mother works (not working, work for family members, work for someone else, self-employed); (3) occupation (not working, agricultural, unskilled labour, skilled labour, professional); (4) type of earnings (not working, not paid, paid in-kind, paid in cash only; (5) seasonality of employment (not working, work occasionally, work seasonally, work all year). Again, the PCA factor with an eigenvalue greater than one was selected, ensuring that factor loadings for each component were larger than 0.5.

Household wealth

Traditionally, DHS have included a household wealth quintile variable, representative of long-term economic status. It is computed using variables which relate to the possession of a wide range of assets, services and amenities, which are analysed using principal component analysis, to create one standardized index which ranks households relative to other households in the country. However, this index of household wealth has received criticism that it is too "urban" in its calculation because rural areas tend to not have the same public amenities as urban areas do, such as electricity, piped water and sewers (Rutstein, 2008). Further concern relates to the fact that this overall index of household wealth was not representative of the poorest of the poor households, particularly in rural areas (*ibid.*).

Although recent phases of DHS have included a household wealth quintile variable with indices specific to urban and rural areas, older phases such as the 2012 Indonesian DHS do not contain such indexes. Therefore, for the Indonesian DHS, household wealth was computed separately for urban and rural areas using PCA, using the household data file and the list of variables provided by DHS for the calculation of household wealth index.

Geographical Region

The sub-national boundaries defined in each DHS were numerous, so for the purpose of the analysis presented in Chapter 4, the number of categories was reduced by recoding this variable according to alternative official definitions of regions or geographical boundaries (Table 4.2). The number of boundaries for the Cambodian DHS (2014) was reduced from 19 regions to 5, on the basis of the definition by the (National Institute of Statistics, Cambodia (2008)). A total of 15 regions were defined in the Myanmar DHS (2015-16), which were reduced to 6 larger regions for this analysis, based on geographical location alone, as there were no official larger boundaries defined from an official source. The 33 regions that were defined in the Indonesian DHS (2012) were re-grouped to seven main island regions based on the categorisation proposed by the Indonesian National Statistics Office (Badan Pusat Statistik, 2012).

Table 3.4 Re-categorisation of geographical regions, by country

Geographical Region	Cambodia	Myanmar	Indonesia
Region1	Phnom Penh	North Myanmar	Sumatra
Region 2	Plain	East Myanmar	Java
Region 3	Tonle Sap	South Myanmar	Lesser Sunda Islands
Region 4	Coast	West Myanmar	Kalimantan
Region 5	Plateau/mountain	Lower Myanmar	Sulawesi
Region 6		Central Myanmar	Maluku Islands
Region 7			New Guinea

3.2.6 Data Quality

Missing data on independent variables was minimal (<2% missing), and thus where data was missing, it was assumed to be missing at random. Although these observations were used in bivariate analysis, multivariable models used listwise deletion to treat observations with any missing data. For independent variables where there was more than 2% of data missing, such as birth weight, a missing category was added to the variable so that all available information was used in adjusted models.

In terms of survey representativeness, response rates for all three DHS were high (over 96% among contacted women), which supports the use of DHS data for population-level study. However, sample sizes did vary considerably between countries, and small sample sizes in the 0 to <6 month group may limit interpretation due to wider confidence intervals.

3.2.6.1 Current-status data

One of the main methodological drawbacks of using cross-sectional data to calculate the WHO IYCF indicators (2008), is that these indicators represent a prevalence at one point in time, rather than an actual duration of exclusive breastfeeding or a consistency of dietary diversity over a longer period of time (Pullum, 2014). Studies which have compared cross-sectional and prospective data sources in the same population and time period have suggested that there is a significant discordance between the actual duration of exclusive breastfeeding and the current-status indicator, with the latter likely to overestimate the proportion of children being exclusively breastfed (Aarts et al., 2000; Roberts et al., 2018). The WHO recommendation for exclusive breastfeeding (2008) refers to a duration of 6 months, but when current-status data is used, the assumption is made that the feeding behaviours recorded in the 24 hours prior to survey are reflective of the entire period that came before that. Therefore, there is some clear misalignment between the recommendation and the indicator.

In terms of calculating exclusive breastfeeding, earlier phases of DHS included a question which asked women “how long did you breastfeed [name]?”, but this approach resulted in significant data heaping on multiples of three and six months (Pullum, 2014), hindering meaningful analysis on the duration of breastfeeding. The most recent DHS now include a question which asks women with a child under 36 months about their current status of breastfeeding. Following a “currently breastfeeding” response, a list of follow-up questions are asked about any additional liquids or solids that were fed to the child in the 24 hours preceding the survey, which then allows for the further classification of whether the child was being exclusively breastfed or not. Grummer-Strawn (1993) recognized the empirical limitations of retrospective data and recommended that current-status data are more reliable, as long as there is consideration for the potential of overestimation. Although use of current-status data may involve some manipulation using techniques such as imputation or smoothing, it is thought that recall bias is reduced as respondents are more likely to accurately report current behaviour (Lesthaeghe and Page, 1980).

Similarly, in terms of dietary diversity, the 24-hour recall method is also employed in the DHS for recording the other types of supplementary foods that a child may have received in the previous day. The 24- hour recall method is recognised as the gold standard for collecting accurate dietary data (FAO, 2013), despite the fact that it is not known whether a child’s diet in the past 24 hours truly reflects their feeding patterns since birth.

Whilst using retrospective data is fraught with methodological bias, current status data also has its own drawbacks, the main one being the overestimation of the proportion of infants breastfed to six months of age and the proportion of children who receive the minimum dietary diversity. However, due to data availability in the countries that have been chosen for this research, current-status data is employed to replicate the WHO infant and young child feeding indicators.

3.2.7 Analytical Method: Binary logistic regression

Descriptive analysis of the sample characteristics adjusted for the complex sampling design of DHS surveys, using the ‘svy’ command and the population weights provided in the surveys. In order to identify the explanatory variables that had an association with the two outcomes of interest, bivariate analysis was conducted with Chi-square test of association. Explanatory variables that showed significant associations with the outcome variables in bivariate analysis were then retained for univariable and multivariable logistic regression modelling. Single level logistic regression models were chosen as the preferable analytical method, opposed to hierarchical modelling, due to insufficient cluster sizes at the level of the primary sampling unit.

Binary logistic regression models are nonlinear regression models for the analysis of dichotomous dependent variables that follow a binomial distribution (Long and Freese, 2006). Therefore, they assess how the probability of change in the outcome variable varies by independent variables.

The two binary response variables considered in this analysis were exclusive breastfeeding and minimum dietary diversity, where each binary response (y_i) was defined as:

$$y_i = \begin{cases} 1 & if\ the\ i{-}th\ child\ is\ exclusively\ breastfed \\ 0 & otherwise \end{cases}$$

$$y_i = \begin{cases} 1 & if\ the\ i{-}th\ child\ meets\ minimum\ dietary\ diversity \\ 0 & otherwise \end{cases}$$

Therefore, the logit transformation of the probability of either of these two outcome variables being 1 and the relationship with multiple explanatory variables can be expressed in the following equation, where *p* is the probability of the outcome of interest:

$$logit(p) = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + \cdots + b_kX_k$$

and the logit transformation is defined as the logged odds:

$$odds = \frac{p}{1-p} = \frac{probability\ of\ presence\ of\ outcome}{probability\ of\ absence\ of\ outcome}$$

and

$$logit(p) = \ln\left(\frac{p}{1-p}\right)$$

The results of logistic regression models were expressed in terms of odds ratios, where $exp(B_0)$ represented the odds that the outcome was present in an observation *i* when X_i=0 (i.e. at baseline):

$$\frac{\exp(\beta_0 + \beta_1(x_{i1} + 1))}{\exp(\beta_0 + \beta_1 x_{i1})} = \exp(\beta_1)$$

<u>Assessment of model fit</u>

For each country, two logistic regression models were fit: the first estimating exclusive breastfeeding amongst children aged between 0 to <6 months and the second estimating minimum dietary diversity amongst children aged between 6 to <24 months. Independent variables with a significant Wald test statistic (p<0.05) in univariable analysis were included in the final multivariable logistic models. The model-building process involved the purposive selection of variables, which was an iterative process, whereby variables that were insignificant in the multivariable model were removed and re-added one by one to assess their effect on other covariates. The final models included variables that tested significant in univariable analysis, and some additional variables that were hypothesised to be theoretically important despite an insignificant test statistic. Identical explanatory variables were included for each country to maintain comparability between models, and the most parsimonious models were identified for all three countries, by using the Hosmer-Lemeshow test for goodness of fit (Hosmer et al., 1997). Collinearity between explanatory variables was assessed using the estimated variance inflation factors (VIFs), all of which had values below five in the final models (Craney and Surles, 2002).

Interactions were considered where there was theoretical reasoning for them, but all were found to be insignificant and were thus excluded from the final adjusted multivariable models. In addition to these separate multivariable models for each country, a pooled analysis was also conducted for both exclusive breastfeeding and minimum dietary diversity, in order to determine whether there were any differences in achieving the outcome by country.

The results of the final multivariable logistic regression models are presented in terms of odds ratios for likelihood of exclusive breastfeeding amongst children aged between 0 and <6 months and likelihood of achieving minimum dietary diversity in children aged 6 to <24 months.

3.3 Section B: Analysis 2

The second analysis chapter in this thesis used DHS data from Cambodia (2014) to examine the role of dietary diversity and continued breastfeeding in pathways to height-for-age in children aged 6 to <24 months and the influence of contextually relevant underlying socioeconomic factors (maternal education, maternal employment and household wealth). A further aspect of this analysis also sought to assess whether these associations were moderated by the effect of urban/rural residence. In order to examine the inter-relationships between explanatory variables and their impact on children's height-for-age Z-scores, structural path analysis was the preferred analytical method.

3.3.1 Data source: Cambodian Demographic and Health Survey

This study used data from the Cambodian Demographic and Health Survey (CDHS, 2014). This data source and survey design has been previously described in section 3.2.1 (p.90) and 3.2.2 (p.91).

3.3.2 Study sample

The sample of interest for this study was the youngest, living singleton child, aged between 6 and < 24 months at the time of survey, who were living in the same household as their mother. A total of 2,127 children aged 6 to <24 months were selected for analysis from the children's recode file. However, since the outcome of interest for this study was height-for-age Z-scores (HAZ), a further inclusion criterion was specified, that children have plausible height-for-age values[24]. As a result of the CDHS (2014) sampling design, anthropometric measurements were only taken in two-thirds of households, meaning that weight and height information was not available for one third of children in this sample (Table 3.5).

Table 3.5 Sample size: children aged 6 to <24 months with plausible anthropometric measurements, Cambodia (2014)

	n
Children 6-23.9 months	2,127
Children 6-23.9 months with anthropometric measurements	1,397
Children 6-23.9 months with plausible anthropometric measurements	**1,365**

The final sample size for this study was 1,365 Cambodian children aged between 6 and <24 months with biologically plausible anthropometric measurements.

[24] Plausible HAZ scores should fall between -6 and +6 standard deviations, according to WHO SD flag limits (WHO, 2006).

3.3.3 Dependent variable

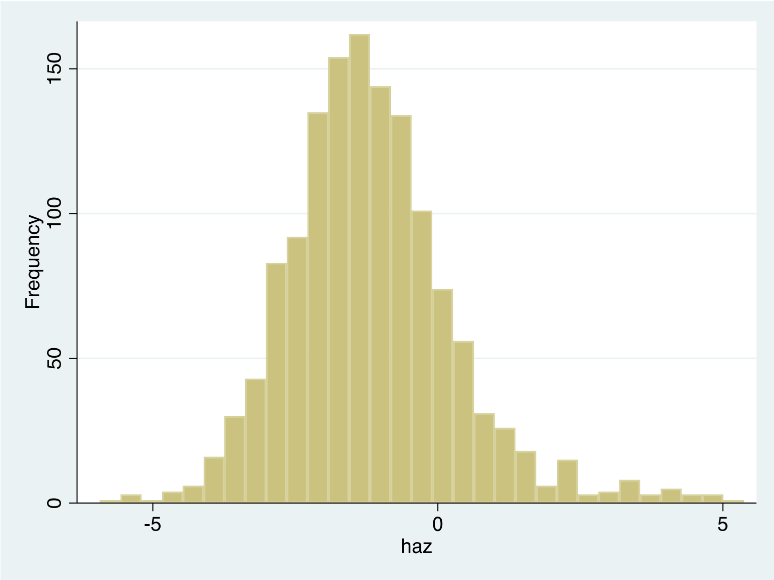
The dependent variable for this analysis was a continuous measure of children's height-for-age Z-scores. Anthropometric information was collected by trained interviewers and height measurements were performed using a SECA measuring board[25]. The CDHS documentation explains that for children less than 24 months, recumbent length (lying down) measurements were taken and for older children, standing height was measured (CDHS, 2015). However, within the dataset itself some children less than 24 months were recorded as being measured standing up. After consultation with the DHS Lead Nutrition Research Associate, it was explained that anthropometrists were sometimes unable to measure children under 24 months lying down due to excessive fussiness or in some cases cultural beliefs, in which case children were measured standing. However, the DHS accounted for this factor in the data processing stage by adding 0.7cm to children's height when they were measured standing.

Height-for-age Z-scores were computed using the 2006 WHO child growth standards[26] (WHO, 2006). According to the WHO (2006), children whose height-for-age Z-score falls below minus two standard deviations (-2 SD) from the mean of the reference population should be classified as short for their age (stunted) and those who are below minus three standard deviations (-3 SD) below the referent mean to be considered severely stunted. However, this analysis uses height-for-age Z-scores as a continuous measure with the assumption that explanatory variables have varying degrees of effect on different parts of the HAZ distribution and by dichotomizing this indicator, some information would be lost, such as the differences between mildly stunted and a severely stunted child.

Height-for-age Z-scores represent a standardized distribution which is by default a normal distribution (depicted in Figure 3.1).

[25] A measuring board which was designed and manufactured under guidance from UNICEF (CDHS, 2015).
[26] The 2006 WHO child growth standards were created using a sample of children from the WHO Multicentre Growth Reference Study, which included a variety of ethnically, culturally and genetically diverse populations (Brazil, Ghana, India, Norway, Oman and the United States), where the breastfed child was considered as the normative model for growth and development.

Figure 3.1 Distribution of height-for-age Z-scores, Cambodia (2014)



3.3.4 Independent variables

Based on previous research on the association between child stunting and IYCF practices in low- and middle-income countries, dietary diversity and continued breastfeeding were selected as the two main proximate factors. These two variables were selected based on evidence from the Cambodian DHS, that the main reason for Cambodian children not meeting the minimum acceptable diet was due to inadequate dietary diversity and not meal frequency. Further, young children's dietary diversity cannot be examined in the absence of continued breastfeeding as this likely influences diversity.

Table 3.6 Definition and coding of independent variables for the second analysis

Variable	Definition and coding
Proximate factors	
Dietary diversity tercile	Terciles of dietary diversity computed from the number of food groups consumed by child in 24 hr recall. Coded as (1) low diversity; (2) middle diversity; (3) high diversity
Continued breastfeeding	Whether or not the child was still being breastfed at time of survey. Coded as (0) not breastfed; (1) still breastfed
Distal (underlying) factors	
Maternal education	Highest level of achieved maternal education was grouped as (1) no education; (2) primary education; (3) secondary & higher

Household wealth quintile	Quintiles stratified by urban/rural areas were used and coded as: (1) poorest; (2) poorer; (3) middle; (4) richer; (5) richest
Maternal employment (high level of participation)	Composite indicator measuring level of maternal labour force participation, based on 5 components of employment (employment in past 12 months, employer, occupation, earnings type, seasonality of work). Coded as: (0) not working (past 12 months) or low level of participation; (1) high level of participation

3.3.4.1 Computation of key Independent Variables of interest

Dietary Diversity Tercile

Terciles of dietary diversity computed by age based on the number of food types consumed by the child in the 24 hours preceding survey. These food groups consisted of the seven main food groups as outlined by the WHO and UNICEF:

- Grains, roots and tubers
- Legumes and nuts
- Dairy products (milk, yoghurt and cheese)
- Flesh foods (meat, fish, poultry and liver/organ meats)
- Eggs
- Vitamin-A rich fruits and vegetables
- Other fruits and vegetables.

The rationale for creating these terciles by child age group was to account for the gradual introduction of complementary foods i.e. under the assumption that dietary diversity increases rapidly with age, as was proposed by Arimond and Ruel (2004). Therefore, children were regarded as having a low, middle or high diversity, relative to children of the same age. The definition of the terciles vary by age; Table 3.7 presents the distributions of this dietary diversity tercile by age in the CDHS.

Table 3.7 Distribution of dietary diversity tercile by child's age, adjusted estimates, Cambodia (2014)

	Age in months (*n* = 1,381)								
	6-8 (*n*=242)		**9-11 (*n*=208)**		**12-17 (*n*=463)**		**18-23 (*n*=468)**		**6-23 (*n*=1,381)**
Dietary Diversity Tercile	%	**DDS range**	**%**	**DDS range**	**%**	**DDS range**	**%**	**DDS range**	**%**
Low	44.9	0-1 groups	41.0	0-2 groups	49.5	0-3 groups	37.0	0-3 groups	**43.2**
Middle	17.9	2 groups	43.0	3-4 groups	26.2	4 groups	45.4	4-5 groups	**33.8**
High	37.2	≥ 3 groups	16.0	≥ 5 groups	24.4	≥ 5 groups	17.6	≥ 6 groups	**23.1**

Continued breastfeeding

This was a simple dichotomous variable of whether the child was currently being breastfed at the time of survey. The distribution of children who were still being breastfed at time of survey is presented in Table 3.8.

Table 3.8 Distribution of breastfeeding status by child's age, adjusted estimates, Cambodia (2014)

	Age in months (*n* = 1381)				
Age (months)	6-8	9-11	12-17	18-23	**6-23**
N	242	208	463	468	**1381**
Breastfeeding (%)	90.7	90.0	81.8	39.0	**70.1**

Maternal education

Maternal education reflected the highest level of completed education and was categorised into no education, primary, secondary & higher.

Household wealth Quintile

Quintiles of household wealth were computed separately for urban and rural areas by DHS using principal component analysis, to ensure the representation of the poorest of the poor households, especially in rural areas (Rutstein, 2008).

Maternal Employment (high level of participation)

This is a composite indicator which was created and used for the analysis presented in Chapter 5. Previous literature suggests that children's nutritional status and feeding practices may be determined by a combination of different aspects of maternal employment. This variable was computed using principal component analysis to incorporate five different aspects of maternal employment:

- Working status over the past 12 months
- Self-employed/employed by family member/employed by somebody else
- Occupation
- Type of earnings
- Seasonality of work: All year, seasonal, occasional.

Following principal component analysis, three distinctive categories of maternal employment were identified: not working, low level of participation, high level of participation. For example, mothers who were considered to have a high level of participation in employment were generally those who reported working for somebody else or were self-employed, worked all year round, were paid in cash and involved in a range of occupations from clerical, sales and services, to professional roles. On the other hand, low level of participation in employment was characterised disproportionately by occupations in the agricultural sector, mainly seasonal work and sometimes associated with payment in-kind.

For the purpose of this study, women with a high level of participation in employment were the population of interest due to the associations with improvements in dietary diversity and height-for-age, but deterioration in breastfeeding practices. Therefore, this variable was finally dichotomized into those who were considered to have a high level of participation in employment and those who had low participation or were not working.

3.3.5 Analytical method: Structural path analysis

Analysis was conducted using Stata/SE 15.1 (StataCorp, 2017). All descriptive and exploratory analysis accounted for the complex survey design of the CDHS using the appropriate sample weights. Bivariate analysis between explanatory variables and the outcome - height-for-age Z-scores - involved testing the significance of differences between means, using adjusted Wald tests for joint hypothesis testing. These explanatory variables were purposefully selected based on the conceptual framework presented earlier in this thesis and previous literature on the factors associated with child stunting. Statistical significance was considered at the <0.05 level.

Based on significant associations in bivariate analysis, key explanatory variables that were statistically significant ($p<0.05$), or had some theoretical basis for inclusion were retained and considered for the structural path model. Structural path analysis was selected as the main analytical method under the hypothesis that there are both indirect and direct mechanisms through which socioeconomic factors influence height-for-age, where dietary diversity and breastfeeding act as mediators in the association and that these factors are also interrelated.

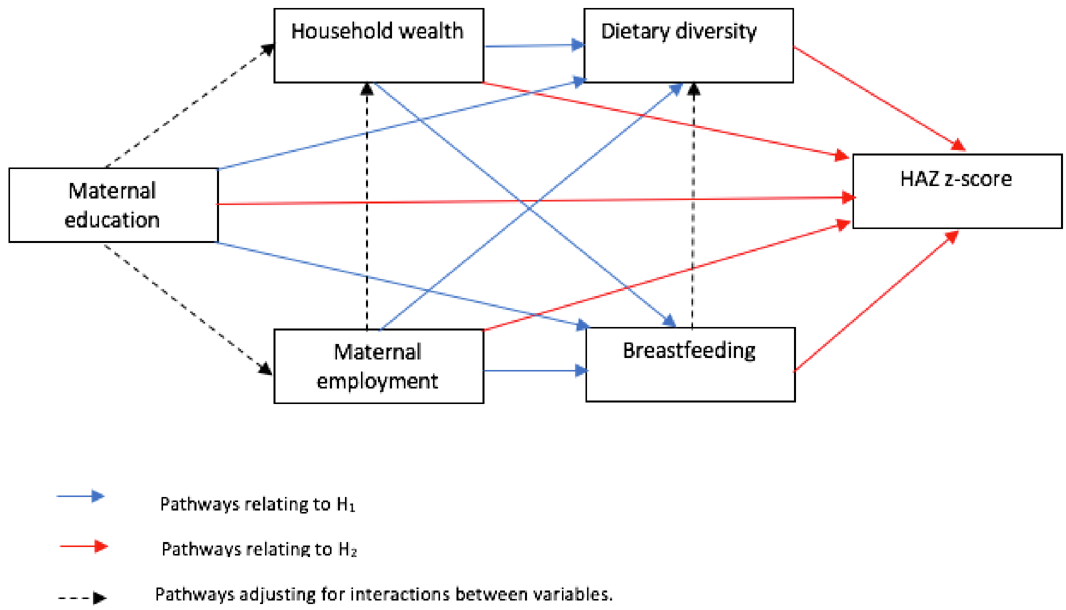
Structural path analysis is the structural component of structural equation modelling and involves the modelling of observed variables only, whereas structural equation models consist of both measurement and structural components when latent constructs are considered (Acock, 2013). Path analysis facilitates the study of direct and indirect effects of multiple independent and dependent variables simultaneously, based on a generalized multi-equation framework for examining multiple hypotheses about interdependencies between these variables (Grace and

Bollen, 2005; Hox and Bechger, 1999). As opposed to more traditional modelling techniques such as an OLS linear regression, structural path models usually begin with the construction of a hypothetical pathway diagram that depicts directional links between exogenous and endogenous variables. Although structural equation modelling assumes linearity of observed variables, it is commonplace to see the use of ordinal and dichotomous independent variables, in so far as they fulfil the assumption of linearity. Therefore, the assumption of linear normality amongst pseudo-continuous variables was tested with likelihood ratio tests (and BIC/AIC tests). Most independent variables showed no evidence of non-linearity, and their inclusion in the model as continuous variables could be justified. However, LR-tests suggested that it was not suitable to regard level of maternal employment as a continuous independent variable, therefore a dummy variable was created to adjust for high level of participation in employment, as this was the category of interest for this study.

Assessment of model fit

Structural path analysis was undertaken using the SEM program in Stata/SE 15.1. All models were estimated using maximum likelihood with missing values (MLMV). Goodness of fit of the data to the models were assessed using the root-mean-square error of approximation (RMSEA $< .06$) and the comparative fit index (CFI $\geq .95$ for acceptance) (Schreiber et al., 2006). The first step of analysis involved creating a hypothetical "causal" pathway diagram between the independent variables of interest and the outcome HAZ (Figure 3.3). The selection of variables and hypothesised pathways between them was based on previous literature, the conceptual framework and results from exploratory analysis. Both non-standardized and standardized coefficients are presented, but only standardized results are interpreted and presented on path diagrams. The standardized coefficients which ensure the comparability of coefficients should be interpreted in terms standard deviation differences (Grace and Bollen, 2005). To address the second hypothesis of this study that suggests dietary diversity and breastfeeding are mediators in the association between socioeconomic status and children's height-for-age Z-scores, standardized indirect effects were calculated.

Figure 3.2 Hypothesised pathways between selected socioeconomic factors, dietary diversity, breastfeeding and height-for-age (HAZ) Z-scores



Finally, to test the moderating effect of urban-rural residence on path coefficients, as per the third hypothesis of this study, two approaches were taken. This part of the analysis involved comparing whether the associations presented in the hypothesised path model, varied by urban-rural residence and whether there were statistical differences for specific paths between urban-rural areas. Stata's SEM function facilitates the simultaneous analysis of the path model for different groups, to air comparison. The first approach involved an unconstrained model, where all parameters were permitted to vary by urban-rural residence and the second method involved a constrained solution in which all but one pathway was constrained to be the same. Results from both the unconstrained and constrained solution are presented.

3.4 Section C: Analysis 3

In response to the results of the second analysis which examined the pathways of association between early life feeding practices and growth < 24 months of age in terms of height-for-age, the final analysis aimed to assess the role of early life factors on longer-term growth throughout childhood and adolescence. This study used longitudinal data from the Indonesian Family Life Survey (IFLS) and examined BMI growth trajectories of a total of 873 children who were aged between 6 and <36 months in IFLS-1 (1993). This study employed two main analytical methods: the first being group-based trajectory models (GBTM) to identify distinctive BMI growth trajectories over time. Binary logistic regression models were then used to examine which factors were associated with trajectory group membership.

3.4.1 Data source: Indonesian Family Life Survey

The Indonesian Family Life Survey (IFLS) is a longitudinal household and community survey collecting information on fertility, health, education, migration and employment (Frankenberg and Karoly, 1995). Overall, the survey consists of 30,000 randomly selected respondents at IFLS-1, living in 13 of the 27 provinces of Indonesia, representative of approximately 83% of the Indonesian population (*ibid.)*. In addition to household data, the survey collects data on community and facilities from the enumeration areas in which the households were selected. The survey consists of five waves, spanning the period from 1993 to 2014-15.

Although the survey collects detailed demographic, social and health information on individual household members, it was not designed to be a child health and nutrition study such as the Cebu Longitudinal Health and Nutrition Survey (Adair et al., 2011) which was designed specifically to collect data on infant feeding practices and early growth. As such, the IFLS contains limited information on infant feeding practices for those infants and children who were aged between 0 and 36 months in IFLS-1 (1993). However, the IFLS offers a unique opportunity to model longer-term growth in young children, following them through to adolescence. Although the IFLS contains five waves of data, only the first four waves of this survey were used, which follows children up the ages of between 14 and 17 years, as there was significant attrition of these survey respondents in the final wave. Table 3.9 presents the year and age of children at each IFLS wave.

Table 3.9 Survey year and age of selected children at each wave of the IFLS

IFLS-1	IFLS-2	IFLS-3	IFLS-4
1993	1997	2000	2007
6-36 months [6 months-3 years]	48-84 months [4-7 years]	84-120 months [7-10 years]	168-204 months [14-17 years]

3.4.2 Data merging

All of the information concerning children younger than 15 years was included in the women's data file, so the first step of the data merging process involved selecting mothers with a last-born singleton child aged between 6 months and less than 36 months at IFLS-1, living in the same household as the mother. The unit of analysis for this study was the child, so for the first wave of the IFLS, a unique identification number had to be created for each child, in order to facilitate the merging of data from IFLS-1 to subsequent waves where children were followed up.

3.4.3 Study sample

A sample of children aged 6-36 months in IFLS-1 (1993) were selected for study, as the complementary feeding period from six months onwards has been a primary focus of this thesis, with children included <36 months, as appropriate and to increase the sample size. Thirteen sets of twins were omitted from analysis. Children aged < 6 months at time of survey were also omitted from the study due to limited information on infant feeding practices.

The following selection criteria were used to create the eligible final sample:

- Youngest living child between the ages of 6 and <36 months, residing in the same household as mother in IFLS-1, with complete data in the pregnancy history file[27].
- Children with biologically plausible anthropometric measurements in each wave. Biological implausibility was defined in line with WHO Child Growth Standards (2006): height-for-age Z-scores below -6 SD and above +6 SD, weight-for-age Z-scores below -6 SD and above +5 SD.
- Children who were alive throughout the study period from IFLS-1 to IFLS-4, with at least two observations (including the first observation at IFLS-1).

A final sample of *n*=873 children were selected for study (Table 3.10).

[27] This is essential since the infant feeding data is included in the pregnancy history file.

Table 3.10 Missing data distribution: no. of data points per subject

No. of data points	Samples available for analysis
1	881
2	**873**
3	704
4	660
TOTAL[A]	881

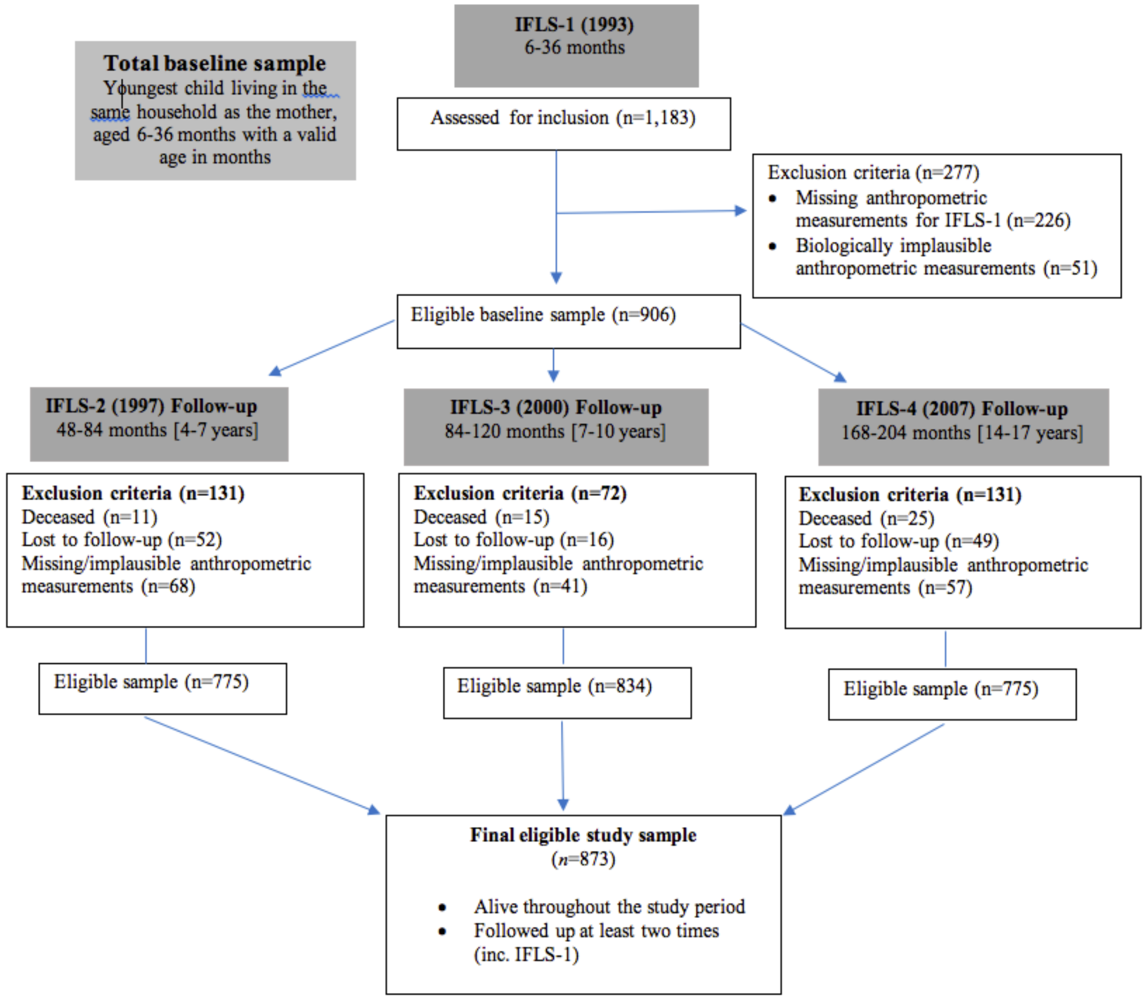
Note: [A] Refers to the total number of children alive over the entire study period (1993-2007) who had valid anthropometric measurements at IFLS-1

3.4.3.1 Survey attrition

As expected with most longitudinal surveys, attrition between survey waves is an important factor to consider with this data type and should be examined, or ideally accounted for in the study. Figure 4.4 depicts in more detail the attrition between waves for the eligible sample of children selected at IFLS-1. Overall, according to the aforementioned eligibility criteria, 906 children aged between 6 and <36 months were considered eligible for study. After excluding children who had died over the study period between 1993 and 2007, those who were lost to follow-up or had missing/implausible anthropometric measurements, the eligible sample size was 660; each child with plausible anthropometric measurements from each of the four waves of the survey.

In order to eliminate bias due to non-random attrition, further exploratory analysis was conducted for children who were lost to follow-up or died over the course of the study period. As suggested by Fitzgerald, Gottschalk and Moffitt (1998), attrition was explored using T-tests and Pearson chi-square tests to determine whether there were any associations with the outcome variable and other explanatory variables between the sample of children who remained in the survey and those who died or were lost to follow-up (Appendix A, p.228). The results of these exploratory tests suggested that there were no significant differences between the final selected sample of children and those who were excluded from study.

Figure 3.3 Sample attrition in Indonesian Family Life Survey: children aged 6-<36 months in IFLS-1 (1993) followed through to IFLS-4 (2007)



3.4.4 Anthropometric data

All respondents eligible for detailed interview in the Indonesian Family Life Survey were measured and weighed by an anthropometrist, following international standards as proposed by United Nations (1986). Before entering the field, the anthropometrists attended a specialized training programme.

Indicators of child growth were calculated using the WHO Anthro (igrowup) macro for children aged 0 to <5 years and the WHO Anthroplus macro for children aged 5 to <19 years, using Stata 15.1 SE. The WHO Anthro software was designed as an anthropometric calculator and application tool for WHO Child Growth Standards to assess growth, nutritional status and motor development in children aged between 0 and <5 years (WHO 2010). It utilises child growth standards based on the WHO Multicentre Growth Reference Study: a study which was established in order to develop growth curves from birth to 5 years (de Onis et al., 2006, WHO, 2006). These international growth standards are based on pooled data from six countries (Brazil, Ghana, India, Norway, Oman and the USA), where breastfeeding is considered the "norm" and therefore used as the reference population in the construction of these standards. To calculate anthropometric measures when children were aged 5 years and over, AnthroPlus macros were employed which utilises the most recent WHO Reference 2007 for 5-19 year olds, providing a consistent continuation from the child growth standards for 0-5 years.

The information required for these calculations included: weight, height, sex and age in months. All measures were calculated separately for boys and girls, since growth charts differ by sex. For the calculation of BMI values for children aged 0-2 years it was also necessary to indicate whether the child had been measured in the recumbent position which is the standard procedure or whether they were measured standing. In cases where the child was measured standing, the software automatically added 0.7 cm to the child's height before BMI calculation (WHO 2011). Along similar lines, when it was indicated that a child older than 2 years had been measured in the recumbent position, 0.7cm was subtracted from their height in order to convert length to height. BMI-for-age z-scores were computed based on WHO growth standards, allowing for comparison to an international reference population.

3.4.5 Dependent variable

Despite the widespread use and application of BMI as a measure of body fat amongst adults, its use as a growth standard for children and adolescents has long been contested. It is argued that due to rapid growth during childhood and adolescence (5-18 years), and increases in BMI by as much as 50% during this period, its interpretation as a child growth standard is more complex (Freedman and Sherry, 2009). However, there is growing evidence to support the analysis and tracking of childhood BMI into adulthood, which is supported by longitudinal evidence that childhood BMI is predictive of adulthood BMI (Must and Strauss, 1999; Power et al., 1997; Parsons et al., 1999; Singh et al., 2008). Children exhibiting a higher BMI have been found more likely to be at risk from overweight or obesity in adulthood, highlighting the use of tracking BMI through childhood and adolescence in order to identify populations at risk.

Furthermore, for infants aged less than two years there is currently no definitive or widely accepted measure of excess adiposity (overweight and obesity) despite the fact that the WHO provides recommended BMI standards for children (Roy et al., 2016). Total body fat in infancy is sometimes measured using skinfold thickness tests at two sites (subscapular and triceps), where data is available (WHO, 2007). As it stands, weight-for-length (WFL) is the global default standard to measure excess adiposity in infancy as well as being the recommended standard by the American Academy of Pediatrics (Roy et al., 2016). However, after conducting a comparative examination of WFL and BMI use for measuring overweight and obesity in healthy infants, Roy et al., (2016) confirmed that elevated BMI during early infancy was a stronger predictor of childhood obesity than WFL, confirming the value of BMI as a measure of adiposity in early infancy. Similar results verifying a positive correlation between weight-for-length and BMI-for-age were also confirmed by Furlong et al., (2016).

In addition to the aforementioned arguments for the use of BMI as a measure of young child adiposity, BMI was also the preferred child growth standard for this study because with the exception of height-for-age, BMI-for-age is the only indicator with WHO child growth references up until 19 years of age, meaning it could be consistently measured in each wave of the IFLS. For a more in-depth discussion of indicators of child nutritional status, please refer to Chapter 3.2.

3.4.6 Independent variables

Table 3.11 Definition and coding of independent variables for the third analysis

Variable	Definition and coding
Inherent (biological) factors	
Child's age	Continuous variable
Sex	Coded as (1) male; (2) female
Birth weight	Child's birth weight was grouped as (1) <2.5kg; (2) 2.5kg<4.0kg; (3) ≥4.0kg; (4) missing
Height-for-age	Coded as (1) normal height; (2) stunted
Weight-for-age	Coded as (1) normal weight; (2) underweight
BMI-for-age	Coded as (1) underweight; (2) normal; (3) overweight/obese
Maternal BMI	Coded as (1) normal; (2) underweight; (3) overweight/obese; (4) missing
Maternal stature	Mother's height was categorised as (1) normal stature; (2) short stature; (3) missing
Proximate factors	
Duration of exclusive breastfeeding[A]	Calculated for this study and coded as (1) <3 months; (2) ≥3 months
Introduction of complementary foods	Categorised as (1) <6 months; (2) 6-8 months; (3) ≥8 months; (4) missing
Duration of continued breastfeeding[A]	Calculated for this study and coded as (1) <6 months; (2) ≥6 months; (3) never breastfed; (4) missing
Colostrum given to baby	Coded as (0) no; (1) yes; (2) missing
Intermediate factors	
Check-up during pregnancy	Coded as (0) no; (1) yes; (2) missing
Mother's age at IFLS-1 (1993)	Re-categorised as (1) 35+ years; (2) 25-34 years; (3) 15-24 years

Variable	Definition and coding
Distal (underlying) factors	
Mother's highest educational level	Coded as (1) no education/primary; (2) middle school; (3) secondary & higher; (4) missing
Maternal employment at IFLS-1	Coded as (1) did not work for wages in past 7 days; (2) worked for wages in past 7 days; (3) missing
Religion	Re-categorised as (1) Muslim; (2) Hindu, Buddhist, Protestant, other
Household wealth index[A]	This variable was a composite measure of household living standards, stratified by urban/rural residence and computed especially for this study using principle component analysis. Coded as (1) poorest; (2) middle; (3) richest; (4) missing
Place of residence	Coded as (1) rural; (2) urban

[A]Variables computed especially for this study (see section 3.4.6.1)

3.4.6.1 Computation of key Independent Variables of interest

Duration of exclusive breastfeeding and duration of continued breastfeeding

Mothers interviewed in the IFLS were asked retrospectively at what age their child stopped breastfeeding. Firstly, it should be considered that retrospective reports of duration are often beset with recall bias as respondents may fail to accurately recall a behaviour that occurred in the past (Lesthaeghe and Page, 1980; Grummer-Strawn, 1993). A study using the Malaysian Family Life Survey (MFLS) also noted that retrospective data on breastfeeding duration was heaped around 6, 12, 18 and 24 months as respondents are likely to approximate an estimate of past behaviours (Mokhtar, Ibrahim and Mohamed, 2008). Mothers were asked in IFLS-1 and IFLS-2 about how long they breastfed their child as some children were still being breastfed at the time of IFLS-1 and so to minimise recall bias, the first response was always taken to be the final observation. An additional check was made to ensure that there were also no cases where breastfeeding duration exceeded the age of the child at the time of survey. The duration of continued breastfeeding was coded as <6 months and ≥6 months, in line with the classification used by Rachmi and colleagues (2016) in their study using IFLS data.

Age at which was the child was introduced to complementary foods (including any liquids or solids) was used to calculate the duration of exclusive breastfeeding among mothers who reported ever breastfeeding their child. Although the recommended duration of exclusive breastfeeding is six months (WHO, 2010), the duration of exclusive breastfeeding was categorised as <3 months and ≥3 months because of the large proportion of children who had already ceased exclusive breastfeeding by this age.

Household wealth index

Although the IFLS included data on household expenditure, income, household-owned agricultural and non-agricultural businesses and household assets (Frankenberg and Karoly, 1995), there was no composite measure of household wealth using household consumer durables or assets. Therefore, a household wealth index was computed for this study using a household asset index approach, similar to the methodology reported by Rachmi et al., (2016) in their research using IFLS data. However, to build on the wealth index methodology reported by this aforementioned paper, household characteristics were also included in the variable computation, in addition to assets. Composite measures of household living standards are preferable over direct measures of wealth (such as income or expenditure), as they are less susceptible to short-term fluctuations and therefore an appropriate measure of longer-term living standards (O'Donnell et al., 2008). Firstly, household weights were assigned to seventeen household assets and characteristics including household ownership, WASH facilities (toilet, water source), floor/wall/roof material, vehicle ownership (cars, boats, bicycles, motorbikes), appliance ownership (refrigerator, washing machine, radio, television), savings, deposits, stocks, jewellery and livestock. Following principle components analysis, the index was created from the sum of weighted scores for each item included in the analysis and households were ranked relative to urban and rural areas, to distinguish the poorest of the poor in rural areas. This index was categorised into terciles (poorest, middle and richest), similar to the approach noted by Rachmi et al., (2016).

3.4.7 Analytical methods

The main dependent variable in this study was children's BMI-for-age, and relevant independent variables were selected based on the conceptual framework presented at the beginning of this thesis (Chapter 2.2, p.55). The first stage of analysis involved fitting GBTM models to the longitudinal data to identify distinctive BMI trajectories over the selected survey period (1993-2007), from age 6 months, through childhood and adolescence. Two distinct BMI trajectories were identified in the sample: one trajectory where children followed approximately normal growth over the study period and the other trajectory where children followed an elevated BMI pathway characterised by children already experiencing overweight/obesity[28], or those at risk of becoming overweight. The trajectory groups were transformed into one dichotomous outcome variable, and bivariate analysis was conducted using Chi-square tests of association, in order to

[28] For children 0-5 years: +2SD (overweight), +3SD (obese). For children 5-19 years: +1SD (overweight), +2SD (obese) (WHO, 2016)

reveal potential association between trajectory group membership and selected independent variables. Factors that were significantly associated with the outcome were retained in the final binary logistic regression models which examined the early life factors and socio-demographic characteristics associated with trajectory group membership. The application of GBTM and logistic regression for this study is discussed in more detail below.

3.4.7.1 Group-based trajectory modelling (GBTM)

BMI development during childhood and adolescence is characterised by dynamic changes according to age or time, and influenced by environmental factors that may alter these developmental paths. To date, the majority of research that examines body weight in childhood, focuses on cross-sectional analysis of BMI or weight-for-height (WHZ) at one point in time, which does not account for temporal changes or conditional growth from one time point to the next. However, in reality children follow heterogeneous developmental pathways which may lead to adverse health outcomes such as incidence of overweight and obesity, highlighting the value of being able to group children who follow similar BMI trajectories in order to identify sub-populations most at risk.

GBTM is a form of semiparametric mixture modelling which identifies latent distinct groups in the population based on a maximum likelihood probability distribution (Nagin, 2005). Essentially GBTM provides two main functions: (1) it defines distinctive growth trajectories using polynomial functions of age or time and (2) it assigns individuals to the most likely trajectory based on estimated posterior group-membership probabilities (Nagin and Odgers, 2010). A novel feature of GBTM, compared to other forms of longitudinal analysis of repeated measures, is that it assumes conditional independence between the outcome at each time point, such that the measurement at a later stage is not dependent on a prior measurement (Nagin, 2014).

The Likelihood Function of GBTM can be expressed as follows:

$$P(Y_i) = \sum_j \pi_j\ (x_i)\ P^j(Y_i)$$

Y_i= trajectory data for subject *i*

$P^j(Y_i)$ = probability of Y_i of belonging to group *j*

$\pi_j\,(x_i)$ = probability of belonging to group *j* for covariates (risk) x^i

GBTM fits models using maximum likelihood estimation which means that as long as data is missing at random (MAR), all available information can be used (Nagin and Odgers, 2010). Therefore, the decision was made that all children with information at IFLS-1 and who were followed up on at least one occasion would be included in the analysis i.e. children who had two or more measurements.

GBTM was conducted in Stata 15 SE using Stata program *traj*, which was developed by Jones and Nagin (2012). Although GBTM allows for the modelling of different distributions, exploration of the distribution of BMI in this study sample confirmed that BMI was approximately normal, thus it was decided that a censored normal distribution should be applied. In order to determine the optimum number and shape of trajectories, a step-wise approach was adopted, beginning with a one trajectory model up to a maximum of four trajectories. During the initial phases of model development, different polynomial functions and orders were tested such as linear and quadratic, however it was decided only to use cubic polynomial function to represent the multiple inflections in BMI over age. This is further confirmed by theory that suggests that adiposity development during childhood is not linear, usually characterised by a nadir in BMI around one year and an ‘adiposity rebound’ between the ages of five and seven years (Rolland-Cachera et al., 1984; Siervogel et al., 1991). Based on a wealth of research since Rolland-Cachera and colleagues first identified this ‘adiposity rebound’, it is theorised that early ‘adiposity rebound’ may in fact predict a BMI pathway associated with adulthood overweight and obesity (Rolland-Cachera et al., 2006; Prokopec and Bellisle., 1993; Whitaker et al., 1998; Koyama et al., 2014).

To select the best and most parsimonious model fitted to the data, a step-wise approach was adopted, beginning with a one trajectory model and modelling a maximum of four trajectories. Bayesian Information Criteria (BIC) was used to assess the optimum number and shape of trajectories; a lower BIC value signifying a better fitting model (Nagin and Odgers, 2010). Second, in order to assess how well the model predicted group membership, average posterior probability estimates were examined to ensure that probability exceeded the minimum threshold of 0.7 for each group (as defined by Nagin and Odgers (2010)). Finally, perhaps the most important criteria for model fit was the biological plausibility of the trajectories, based on previous empirical research and theories of childhood BMI development. In order to assess this final criterion, predicted trajectories were compared to WHO BMI growth curves based on WHO MGRS growth standards (WHO, 2006) and to recently developed national synthetic growth references for infants, children and adolescents in Indonesia (Pulungan et al., 2018).

GBTM were estimated for children who had valid anthropometric information at IFLS-1 and were followed up at least once during the subsequent three waves, after having confirmed that data was missing at random (see Appendix A, p.228). Although trajectory models were also estimated separately for each sex to assess differences in growth patterns, data on males and females were combined due to similar BMI growth curves and the small sample sizes by sex. Instead, the final logistic regression model also controlled for sex.

GBTM models were computed using cubic polynomial function as BMI-for-age did not follow a linear trend and a step-wise approach was taken to the number of trajectory groups that the model predicted, adding incrementally to assess change in BIC estimate. Finally, a two-group trajectory model was identified which was characterised by a group of children following a normal BMI trajectory, and then a group who represented an elevated BMI trajectory, characterised by children who were already experiencing overweight and obesity in IFLS-3 and/or IFLS-4 or were considered at risk of. Details of the model selection and application to children's BMI-for-age is discussed in the results section (Chapter 6.3.3, p.188).

3.4.7.2 Binary logistic regression

The next stage of analysis involved analysis of early life and socio-demographic factors associated with the BMI growth trajectories predicted by GBTM. The dichotomous dependent variable was defined as 0=Low-stable group and 1=Elevated (at risk) group. Bivariate analysis using Chi Square tests were conducted in order to assess significant bivariate associations between risk factors and the outcome variable. Only those explanatory variables that presented significant ($p=<0.05$) were retained in the final multivariable logistic regression models, which also adjusted for sex and birth weight. Furthermore, variables that had been excluded on the basis of insignificant (> 0.05) P-values in bivariate analysis were entered individually into the logistic regression model to assess any change in model estimates. In addition, variables that changed direction of association or became insignificant when added to the adjusted model were tested for collinearity with other variables using variance inflation factors (Craney and Surles, 2002) and interactions were tested in the model to account for any potential confounding. Three multivariable models were assessed: the first included variables that were significant in univariable analysis or were theoretically relevant, the second included an interaction term between household wealth and urban/rural residence and the third model included an interaction term between maternal employment and household wealth. Although the results of all three multivariable models are presented in the analysis chapter (Table 6.5, p.195), the third model was selected as the optimum model on the basis that it revealed a significant interaction between maternal employment and household wealth and this is the model which is interpreted in the results section. The final logistic regression analyses which predict factors associated with membership in the ‘elevated (at risk)’ BMI trajectory group, are presented in odds ratios with 95% confidence intervals.

Chapter 4 Demographic and socioeconomic factors associated with infant and young child feeding practices in Cambodia, Myanmar and Indonesia[29]

4.1 Introduction

The first two years of a child's life are the most sensitive to growth faltering (Uauy et al., 2011; Victora et al., 2010; Shrimpton et al., 2001) and the time in which Infant and Young Child Feeding (IYCF) practices should adapt in line with the evolving nutritional needs of growing children. The WHO advises that from the first hour of life, breastfeeding is initiated and from then on exclusive breastfeeding is recommended for the first six months of life (WHO, 201). However, previous evidence from Southeast Asia and other LMICs suggests that improvements in socioeconomic status at the individual and community level has a deleterious effect on rates of exclusive breastfeeding (Senarath et al., 2010; Sasaki et al., 2010; Victora et al., 2016), with formula feeding preferable amongst wealthier, urban and working mothers. Although most infants in Southeast Asia receive some breast milk in the first six months of life (Walters et al., 2016), rates of exclusive breastfeeding range from 24% in Thailand to 65% in Cambodia (UNICEF, 2018). In a cost-benefit analysis of breastfeeding in Southeast Asia, Walters and colleagues (2016) estimated that suboptimal breastfeeding practices contribute to more than 12,400 child and maternal deaths annually in the region, highlighting the life-saving potential of breastfeeding as a population health intervention.

Continued breastfeeding is recommended beyond the first six months, alongside appropriate complementary feeding practices between the ages of 6-23 months (WHO, 2018). Adequate dietary diversity increases the intake of micronutrients and energy in young children (Onyango et al., 1998; Zhao et al., 2017) and there is evidence to suggest that it has the potential to influence later taste preference and dietary choice throughout adolescence and early adulthood (Beauchamp and Mennella, 2009; Nicklaus et al., 2005). Although, 60% of children aged 6-23 months in Southeast Asia meet the minimum dietary diversity (MDD) as defined by the WHO, the

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[29] This chapter is an extended version of a paper that was published earlier, Harvey CM, Newell ML and Padmadas SP (2018). *Socio-economic differentials in minimum dietary diversity among young children in South-East Asia: evidence from Demographic and Health Surveys.* Public Health Nutrition, pp. 3048-3057. See Appendix B (p.231) for citation details and co-author contributions.

dietary diversity inequality by socioeconomic status is perhaps the starkest globally (UNICEF, 2016). Furthermore, dietary diversity amongst young children in Southeast Asia is a particular concern due to the traditionally rice-based and sometimes vegetarian diets that potentially exacerbate micronutrient deficiencies such as iron, zinc, vitamin A, iodine and calcium deficiencies (Chaparro et al., 2014).

A breadth of previous empirical evidence has detected the strong association between socioeconomic status and growth during early childhood (Srinivasan et al., 2013; Van de Poel et al., 2008), suggesting that children from richer and urban households typically exhibit better linear growth. However, less is known about the intra-urban and intra-rural socioeconomic disparities across wealth quintiles within urban and rural areas, in terms of IYCF practices and child nutrition. This is an important factor to consider, in light of the fact that by 2050, 64% of the region's population is predicted to live in urban areas (United Nations, 2014), which may only lead to further exaggeration of intra-urban socioeconomic inequality in child nutritional status. Adding to this is the fact that over two-thirds of females in Southeast Asia actively participate in employment (ILOSTAT, 2018); a fact which should be considered in conjunction with rapid urban transformation and the possible implications for IYCF practices.

Therefore, this present study aimed to examine factors associated with two important IYCF practices: exclusive breastfeeding in 0 to <6 month olds, and minimum dietary diversity in 6 to < 23 month olds in three economically diverse countries of Southeast Asia. The analysis pays particular attention to the underlying socioeconomic conditions that are associated with exclusive breastfeeding and dietary diversity, in order to highlight sub-populations where more progress needs to be made in order to meet the WHO Global Nutrition targets by 2025 (WHO, 2014).

Exclusive breastfeeding and minimum dietary diversity were defined in this study using the WHO (2008) IYCF indicators, and they refer to a current-status indicator measuring whether the child was exclusively breastfed[30] or if they received the minimum dietary diversity[31] in the 24 hours prior to survey. Using demographic and health survey (DHS) data from Cambodia, Myanmar and Indonesia, this analysis employed logistic regression models to examine the demographic and socioeconomic factors associated with (1) exclusive breastfeeding in children 0 to <6 months and (2) minimum dietary diversity in children 6 to <24 months.

[30] Proportion of children aged 0 to <6 months fed exclusively on breast milk in 24 hr recall.
[31] Proportion of children aged 6 to <24 months fed ≥4 food groups, out of a total 7.

4.1.1 Research Questions

1. Are there clear socioeconomic differentials in achievement of the WHO recommendation of exclusive breastfeeding status in Cambodia, Myanmar and Indonesia and do these associations vary by country?
2. Are there clear socioeconomic differentials in achievement of the WHO recommendation for minimum dietary diversity in Cambodia, Myanmar and Indonesia and do these associations vary by country?
3. What conclusions can be drawn about the effect of overall improvements in socioeconomic conditions on exclusive breastfeeding and dietary diversity in Southeast Asia?

4.2 Results: Exclusive breastfeeding amongst children aged 0-< 6 months

4.2.1 Descriptive analysis

Of the total 2,848 children aged 0 to < 6 months (Table 4.1), approximately half were girls (52% in Cambodia, 47% in Myanmar and 50% in Indonesia). More than three quarters of children in this sample from Cambodia and Indonesia had a birth weight within the normal range (2.5 < 4.0kg), with just 5% of Cambodian children having a low birth weight (< 2.5kg) and 8% of Indonesian children. Nearly half of birthweight data was missing in Myanmar, but among the 225 children with birthweight information, 82.9% were within the normal range, and 8.6% were of low and 8.5% of high birthweight. There were approximately equal proportions of children aged <3 months and ≥3 months in all three countries.

In Cambodia, 29% of children had reportedly consumed pre-lacteal feeds during the first 3 days following birth and in Indonesia 59%. Again there was a significant proportion of missing data for this variable in Myanmar. The proportion of children exhibiting any symptoms of morbidity in the two weeks prior to survey (diarrhoea, fever, coughing), ranged from 16% in Myanmar, 26% in Cambodia and 31% in Indonesia. Approximately 40% of children in each country were first-order births and in more than three quarters were delivered vaginally (non-caesarean section). Myanmar had the highest proportion of caesarean section deliveries (24%), yet also conversely, the highest proportion of home births (55%). In all three countries, the majority of mothers were married or co-habiting with their partners and were aged between 25 and 34, however, the proportion of mothers in the youngest age category (15-24) was also significant, ranging from

30% in Myanmar, 38% in Indonesia to 45% in Cambodia. The percentage of mothers who had achieved secondary or higher education was significantly larger in Indonesia (70%), compared with Myanmar (42%) and Cambodia (39%). Just over half of women in Myanmar and Indonesia reported not having worked in the past 12 months, but in all three countries, more than 20% of women were identified as having a high level of active participation in the labour force. In Indonesia, the proportion of children from rural households was approximately equal to those from urban households (52% and 48% respectively), whereas in Cambodia and Myanmar, the majority of children were from rural households (86% and 75% respectively).

Table 4.1 Characteristics of the study sample (adjusted percentages and 95% CI) of Southeast Asian children (n 2,848) aged 0-5 months from Cambodia, Myanmar and Indonesia*

	Cambodia (*n 688)*			Myanmar (*n* 468)			Indonesia (*n* 1, 686)		
Characteristics	***N***	**%**	**95% CI**	***N***	**%**	**95% CI**	***N***	**%**	**95% CI**
Inherent (biological) factors									
Age (months)									
<3	341	47.6	(42.9, 52.3)	165	41.3	(36.0, 46.9)	727	45.6	(42.2, 49.1)
≥3	376	52.4	(47.7, 57.2)	234	58.7	(53.1, 64.0)	866	54.4	(50.9, 57.8)
Sex									
Male	344	48.0	(43.3, 52.7)	214	53.5	(47.9, 59.0)	804	50.4	(47.0, 53.9)
Female	373	52.0	(47.3, 56.7)	185	46.5	(41.0, 52.1)	789	49.6	(46.1, 53.1)
Birth weight									
<2.5kg	38	5.3	(3.5, 7.9)	19	4.9	(3.0, 7.8)	122	7.7	(5.8, 10.0)
2.5kg < kg	626	87.4	(84.0, 90.2)	187	46.8	(41.3, 52.4)	1259	79.0	(76.2, 81.6)
≥4kg	14	1.9	(1.0, 3.8)	19	4.8	(2.9, 7.9)	81	5.1	(3.9, 6.7)
Missing/not weighed	39	5.4	(3.7, 7.8)	174	43.5	(38.1, 49.1)	131	8.2	(6.9, 9.8)
Proximate factors									
Received pre-lacteal feeds									
No	494	69.0	(64.3, 73.3)	-	-	-	593	37.2	(33.9, 40.7)
Yes	204	28.5	(24.2, 33.1)	83	20.8	(16.8, 25.5)	943	59.2	(55.7, 62.6)
Never breastfed	18	2.5	(1.5, 4.4)	2	0.6	(0.2, 2.1)	44	2.8	(1.8, 4.2)
Missing	1	0.0	-	314	78.6	(73.9, 82.7)	12	0.7	(0.4, 1.6)
Morbidity									
No symptoms	530	73.9	(69.3, 78.1)	336	84.2	(79.8, 87.7)	1108	69.6	(66.2, 72.7)
At least one symptom	187	26.1	(22.0, 30.7)	63	15.9	(12.3, 20.2)	485	30.5	(27.3, 33.8)
Intermediate factors									

Characteristics	Cambodia (*n 688)* N	%	95% CI	Myanmar (*n* 468) N	%	95% CI	Indonesia (*n* 1, 686) N	%	95% CI
Birth order									
First	305	42.6	(37.9, 47.4)	159	39.8	(34.5, 45.3)	676	42.4	(38.9, 46.0)
2-3	324	45.2	(40.6, 50.0)	174	43.7	(38.3, 49.3)	719	45.2	(41.7, 48.6)
4+	87	12.2	(9.4, 15.7)	66	16.5	(12.9, 21.0)	198	12.5	(10.5, 14.7)
Birth place									
At home	54	7.5	(5.6, 10.0)	219	54.9	(49.3, 60.3)	409	25.7	(23.1, 28.5)
Private facility	127	17.7	(14.2, 22.0)	29	7.2	(4.8, 10.7)	814	51.1	(47.6, 54.6)
Public facility	536	74.7	(70.3, 78.7)	151	37.9	(32.7, 43.5)	370	23.2	(20.4, 26.2)
ANC visits									
5+	406	56.6	(51.9, 61.2)	192	48.3	(42.7, 53.9)	1293	81.7	(79.2, 84.0)
2-4	257	35.9	(31.5, 40.6)	135	33.9	(28.8, 39.4)	215	13.6	(11.5, 15.9)
0-1	54	7.5	(5.4, 10.2)	71	17.8	(13.9, 22.5)	75	4.7	(3.8, 5.9)
Delivery by caesarean section									
No	641	89.6	(85.9, 92.3)	300	75.6	(70.4, 80.1)	1339	84.2	(81.5, 86.5)
Yes	75	10.5	(7.7, 14.1)	97	24.4	(19.9, 29.6)	252	15.8	(13.5, 18.5)
Mother's age									
35-49	49	6.9	(4.9, 9.7)	74	18.6	(14.6, 23.4)	250	15.7	(13.3, 18.4)
25-34	347	48.5	(43.8, 53.2)	206	51.6	(46.1, 57.2)	743	46.6	(43.2, 50.1)
15-24	320	44.6	(40.0, 49.4)	119	29.7	(24.9, 35.0)	600	37.7	(34.3, 41.2)
Distal (underlying) factors									
Marital status									
Married/co-habiting	698	97.4	(95.1, 98.6)	393	98.5	(96.8, 99.3)	1581	99.2	(98.4, 99.6)
Widowed/divorced/separated	19	2.6	(1.4, 4.9)	6	1.5	(0.7, 3.3)	12	0.8	(0.4, 1.6)

	Cambodia (*n 688)*			Myanmar (*n* 468)			Indonesia (*n* 1, 686)		
Characteristics	***N***	**%**	**95% CI**	***N***	**%**	**95% CI**	***N***	**%**	**95% CI**
Maternal education level									
No education/primary	434	60.6	(55.9, 65.1)	230	57.6	(52.1, 63.0)	473	29.7	(26.6, 33.0)
Secondary/higher	282	39.4	(34.9, 44.1)	169	42.4	(37.0, 47.9)	1120	70.3	(67.0, 73.4)
Maternal active labour force participation									
Not working (past 12 months)	295	41.3	(36.7, 46.0)	209	52.3	(46.7, 57.8)	897	56.5	(53.0, 59.9)
Low	218	30.4	(26.2, 35.0)	98	24.5	(19.9, 29.7)	353	22.2	(19.5, 25.1)
High	202	28.3	(24.2, 32.7)	93	23.3	(18.9, 28.3)	339	21.3	(18.6, 24.3)
Household wealth									
Poorest	147	20.9	(17.5, 24.8)	98	24.6	(20.2, 29.6)	258	16.2	(14.0, 18.7)
Poorer	149	21.2	(17.6, 25.2)	76	19.1	(15.2, 23.7)	306	19.2	(16.7, 22.0)
Middle	134	19.1	(15.5, 23.2)	80	20.1	(16.0, 25.1)	338	21.2	(18.5,24.2)
Richer	153	21.8	(17.9,26.3)	71	17.8	(13.9, 22.6)	343	21.5	(18.7, 24.6)
Richest	120	17.1	(13.7, 21.1)	73	18.4	(14.4, 23.2)	348	21.8	(18.9, 25.1)
Residence									
Rural	618	86.2	(83.3, 88.6)	299	75.0	(69.7, 79.6)	823	51.7	(48.1, 55.2)
Urban	99	13.8	(11.4, 16.7)	100	25.0	(20.4, 30.3)	770	48.3	(44.9, 51.9)
Geographical region[a]									
Region 1	61	8.5	(6.3, 11.4)	64	16.0	(12.5, 20.4)	382	24.0	(21.7, 26.4)
Region 2	272	38.0	(33.2, 43.0)	51	12.9	(9.2, 17.7)	826	51.8	(48.4, 55.2)
Region 3	239	33.3	(29.1,37.8)	48	11.9	(9.7, 14.6)	106	6.7	(5.6, 7.9)
Region 4	47	6.5	(4.9, 8.5)	42	10.4	(8.0, 13.4)	100	6.3	(5.3, 7.3)
Region 5	99	13.8	(11.4, 16.7)	108	27.1	(22.1, 32.8)	122	7.6	(6.6, 8.8)
Region 6				86	21.6	(17.3, 26.6)	19	1.2	(1.0, 1.5)

Characteristics	Cambodia (*n 688)*			Myanmar (*n* 468)			Indonesia (*n* 1, 686)		
	N	**%**	**95% CI**	***N***	**%**	**95% CI**	***N***	**%**	**95% CI**
Region 7							39	2.5	(2.0, 3.1)

*Data from most recent DHS surveys in Cambodia (2014), Myanmar (2015-16) and Indonesia (2012).

[a] **Cambodia:** (1) Phnom Penh; (2) Plain; (3) Tonle Sap; (4) Coast; (5) Plateau/mountain. **Myanmar:** (1) North Myanmar; (2) East Myanmar; (3) South Myanmar; (4) West Myanmar; (5) Lower Myanmar; (6) Central Myanmar. **Indonesia:** (1) Sumatra; (2) Java; (3) Lesser Sunda Islands; (4) Kalimantan; (5) Sulawesi; (6) Maluku Islands; (7) New Guinea.

4.2.2 Bivariate and Multivariable logistic regression analysis

Factors associated with exclusive breastfeeding at the time of survey using 24-hour recall

Overall, the proportion of children aged 0-< 6 months reported to be exclusively breastfed, ranged from 42% in Indonesia, 51% in Myanmar and 65% in Cambodia (Table 4.2).

The Chi-square tests (Table 4.2, p.134) indicated that the inherent (biological) factors associated with exclusive breastfeeding were children's age in all three countries and sex of child in Myanmar. In terms of the proximate level factors, pre-lacteal feeding showed statistically significant, negative associations with exclusive breastfeeding in Cambodia and Indonesia, although this could not be measured in Myanmar due to missing information. Birth order, birth place, ANC visits and caesarean section delivery were identified in one or all of the countries as significant intermediate factors associated with exclusive breastfeeding. The significant distal (underlying) factors that were mainly representative of the socioeconomic conditions of the household, were maternal labour force participation, household wealth, urban-rural residence and geographical region. Although the results of bivariate analysis revealed no statistically significant differences in exclusive breastfeeding according to mothers age or level of education, these variables were retained in the final model because of their theoretical importance as key demographic characteristics.

Overall, results of adjusted pooled analysis (Appendix C, p.243) of data from all three countries showed that in comparison to Indonesia, children from Myanmar (aOR 2.13, 95%CI: 1.41, 3.21) and Cambodia (aOR 2.33, 95%CI: 1.82, 2.98) were more than twice as likely to have been exclusively breastfed. Across all countries, female children were more likely to be exclusively breastfed (aOR 1.34, 95%CI: 1.13, 1.58) and those who received pre-lacteal feeds were significantly less likely to be exclusively breastfed (aOR 0.33, 95%CI: 0.27, 0.40). Delivery by caesarean section was significantly and negatively associated with exclusive breastfeeding (aOR 0.71, 95%CI: 0.55, 0.92), as was the least amount of ANC visits (0-1 visits) (aOR 0.72, 95%CI: 0.52, 0.98) compared to those who received five or more ANC visits. In terms of the distal (underlying) factors associated with exclusive breastfeeding, a higher level of maternal education was positively associated with exclusive breastfeeding (aOR 1.26, 95%CI: 1.03, 1.55), whereas a high level of maternal labour force participation (aOR 0.71, 95%CI: 0.57, 0.89) and residing in an urban area (aOR 0.73, 95%CI: 0.60, 0.90) was associated with decreased odds of exclusively breastfeeding.

Results from the final multivariable models (Table 4.3, p.138) showed that being exclusively breastfed was less likely in older children aged three months or more in all three countries. In Myanmar, female infants were significantly more likely to be exclusively breastfed than boys (aOR 2.16, 95%CI: 1.42, 3.27); this association was of borderline significance in Cambodia (aOR 1.44, 95%CI: 0.99, 2.09) but was not significant in Indonesia (aOR 1.16, 95%CI: 0.93, 1.44, *p*=0.188). Although there was a substantial amount of missing data for pre-lacteal feeding in all countries, in both Cambodia and Indonesia the odds of being exclusively breastfed were significantly reduced for children who had received some form of pre-lacteal feeds in the first three days following birth (Cambodia aOR 0.50, 95%CI: 0.32, 0.79; Indonesia aOR 0.35, 95%CI: 0.28, 0.44).

In terms of the intermediate level factors associated with exclusive breastfeeding, children from second or third order births in Indonesia were 55% more likely to be exclusively breastfed than first born children (aOR 1.55, 95%CI: 1.16, 2.07). Although no statistically significant associations were noted between birth place and the outcome in the final multivariable analysis, univariable analysis (see Appendix D, p.245) showed that children born in a private health facility in Cambodia were 68% less likely to be exclusively breastfed than children born at home (uOR 0.32, 95%CI: 0.17, 0.62), however significance was lost after adjustment for other covariates such as delivery by caesarean section. With regards to contact with primary health care, a decreasing number of antenatal (ANC) visits was significantly associated with a reduced likelihood of exclusive breastfeeding in Myanmar for mothers who attended only 0-1 ANC visits (aOR 0.46, 95%CI: 0.23, 0.91) and for mothers in Indonesia who attended 2-4 visits (aOR 0.58, 95%CI: 0.42, 0.80), when compared to the reference of five or more ANC visits. Delivery by caesarean section was associated with decreased odds of exclusive breastfeeding amongst children in both Cambodia (aOR 0.49, 95%CI: 0.25, 0.94) and Indonesia (aOR 0.66, 95%CI: 0.46, 0.93). However, the association between maternal age and probability of being exclusively breastfed was not statistically significant in all three countries.

Regarding the distal (underlying) factors that represented the socioeconomic conditions of the mother and the household, increasing maternal education had a significant and positive association with exclusive breastfeeding only in Indonesia, where mothers with secondary or higher education were 33% more likely to be exclusively breastfeeding than mothers with no education or primary level (aOR 1.33, 95%CI: 1.01, 1.75). Conversely, a high level of maternal active labour force participation in Indonesia was associated with decreased odds of exclusive breastfeeding (aOR 0.61, 95%CI: 0.45, 0.83); a similar association was noted in Cambodia but there is was of only borderline significance. Results from univariable analysis (see Appendix D, p.245) suggested clear household wealth differentials in the likelihood of exclusive breastfeeding in all three countries. However, in Cambodia and Indonesia increasing household wealth was inversely associated with exclusively breastfeeding, whilst in Myanmar increasing household wealth was positively associated with the likelihood of being exclusively breastfed. Nonetheless, multivariable models revealed that only amongst the richer households in Indonesia there was a reduced probability of exclusive breastfeeding when compared to the poorest households (aOR 0.58, 95%CI: 0.39, 0.87). In all three countries, children residing in an urban area were less likely to be exclusively breastfed, although the effect was significant only in Cambodia (aOR 0.54, 95%CI: 0.33, 0.87).

Table 4.2 Proportion of children exclusively breastfed by demographic and socioeconomic characteristics, with Chi-square tests of association in Cambodia, Myanmar and Indonesia

	Cambodia (*n* 688)			**Myanmar (*n* 468)**			**Indonesia (*n* 1,686)**		
	Non-EBF	**EBF**	**P-value**	**Non-EBF**	**EBF**	**P-value**	**Non-EBF**	**EBF**	**P-value**
Characteristics	***N* (%)**	***N* (%)**		***N* (%)**	***N* (%)**		***N* (%)**	***N* (%)**	
Inherent (biological) factors									
Age (months)									
<3	77 (22.5)	264 (77.5)	<0.001	56 (34.2)	109 (65.8)	<0.001	364 (50.1)	363 (50.0)	<0.001
≥3	173 (45.9)	203 (54.1)		138 (59.1)	96 (41.0)		569 (65.7)	298 (34.3)	
Sex									
Male	135 (39.3)	209 (60.7)	0.061	125 (58.4)	89 (41.6)	<0.001	473 (58.8)	331 (41.2)	0.881
Female	114 (30.7)	259 (69.3)		70 (37.7)	116 (62.3)		(460 (58.3)	329 (41.7)	
Birth weight									
<2.5kg	14 (38.1)	23 (61.9)	0.969	13 (66.9)	6 (33.1)	0.117	67 (54.5)	56 (45.5)	0.291
2.5kg < kg	216 (34.4)	411 (65.6)		82 (44.0)	105 (56.0)		748 (59.4)	511 (40.6)	
≥4kg	6 (40.6)	8 (59.4)		6 (33.7)	13 (66.3)		38 (46.3)	44 (53.8)	
Missing/not weighed	14 (35.6)	25 (64.5)		93 (53.5)	81 (46.5)		80 (61.4)	50.7 (38.6)	
Proximate factors									
Received pre-lacteal feeds									
No	128 (25.9)	366 (74.1)	<0.001	- [A]	-	-	249 (42.0)	344 (58.0)	<0.001
Yes	103 (50.3)	101 (49.7)		-	-		628 (66.5)	316 (33.5)	
Never breastfed	18 (100.0)	0 (0.0)		-	-		44 (100.0)	0 (0.0)	
Missing	1 (100.0)	0 (0.0)					12 (93.9)	1 (6.1)	
Morbidity									
No symptoms	172 (32.5)	357 (67.5)	0.112	159 (47.4)	177 (52.6)	0.249	626 (56.5)	482 (43.5)	0.085

Characteristics	Cambodia (*n* 688) Non-EBF *N* (%)	Cambodia (*n* 688) EBF *N* (%)	P-value	Myanmar (*n* 468) Non-EBF *N* (%)	Myanmar (*n* 468) EBF *N* (%)	P-value	Indonesia (*n* 1,686) Non-EBF *N* (%)	Indonesia (*n* 1,686) EBF *N* (%)	P-value
At least one symptom	77 (41.2)	110 (58.8)		36 (56.2)	28 (43.8)		307 (63.3)	178 (36.8)	
Intermediate factors									
Birth order									
First	115 (37.8)	190 (62.2)	0.420	76 (48.1)	82 (51.9)	0.508	431 (63.8)	245 (36.2)	0.021
2-3	102 (31.5)	222 (68.5)		81 (46.6)	93 (53.4)		385 (53.6)	334 (46.4)	
4+	32.0 (36.6)	55 (63.4)		37 (55.9)	29 (44.1)		116 (58.6)	82 (41.4)	
Birth place									
At home	18 (33.6)	36 (66.5)	<0.001	109 (49.9)	110 (50.1)	0.907	251 (61.3)	158 (38.7)	0.573
Private facility	70 (55.1)	57 (44.9)		14 (48.4)	15 (51.6)		474 (58.2)	341 (41.8)	
Public facility	161 (30.1)	374 (69.9)		71 (47.2)	80 (52.8)		208 (56.4)	161 (43.6)	
ANC visits									
5+	149 (36.7)	257 (63.3)	0.024	88 (46.1)	103 (53.9)	0.130	718 (55.5)	575 (44.5)	<0.001
2-4	92 (35.9)	165 (64.1)		62 (46.2)	72 (53.8)		160 (74.2)	55 (25.8)	
0-1	8 (14.9)	46 (85.1)		43 (61.2)	27 (38.8)		50 (67.0)	25 (33.0)	
Delivery by caesarean section									
No	210 (32.8)	430 (67.2)	0.020	149 (49.8)	150 (50.2)	0.419	760 (56.7)	579 (43.3)	0.022
Yes	39 (51.9)	36 (48.1)		43 (44.4)	54 (55.6)		172 (68.2)	80 (31.8)	
Mother's age									
35-49	24 (48.2)	26 (51.8)	0.271	38 (50.4)	37 (49.6)	0.534	139 (55.4)	112 (44.6)	0.618
25-34	115 (33.2)	232 (66.9)		94 (45.8)	112 (54.2)		431 (58.0)	312 (42.0)	
15-24	110 (34.5)	209 (65.5)		63(52.9)	56 (47.1)		363 (60.5)	237 (39.5)	
Distal (underlying) factors									

Characteristics	Cambodia (*n* 688) Non-EBF *N* (%)	Cambodia EBF *N* (%)	P-value	Myanmar (*n* 468) Non-EBF *N* (%)	Myanmar EBF *N* (%)	P-value	Indonesia (*n* 1,686) Non-EBF *N* (%)	Indonesia EBF *N* (%)	P-value
Marital status									
Married/co-habiting	243 (34.8)	455 (65.2)	0.918	189 (48.1)	204 (51.9)	0.002	926 (58.6)	655 (41.4)	0.725
Widowed/divorced/separated	6 (33.3)	12 (66.8)		5 (90.2)	1 (9.8)		6 (52.2)	6 (47.8)	
Maternal education level									
No education/primary	140 (32.3)	294 (67.8)	0.165	120 (52.1)	110 (48.0)	0.176	281 (59.3)	193 (40.7)	0.775
Secondary/higher	109 (38.7)	173 (61.3)		75 (44.3)	94 (55.7)		652 (58.2)	468 (41.8)	
Maternal active labour force participation									
Not working (past 12 months)	94 (32.0)	201 (68.0)	0.004	105 (50.5)	103 (49.5)	0.770	500 (55.7)	397 (44.3)	0.143
Low	60 (27.4)	158 (72.6)		44 (45.4)	53 (54.6)		216 (61.4)	135 (38.6)	
High	94 (46.7)	108 (53.3)		45 (48.4)	48 (51.6)		216 (63.6)	123 (36.4)	
Household wealth									
Poorest	41 (28.2)	105 (71.8)	0.057	53 (54.1)	45 (45.9)	0.284	150 (58.1)	108 (41.9)	0.027
Poorer	41 (27.9)	107 (72.1)		37 (49.0)	39 (51.0)		158 (51.5)	149 (48.5)	
Middle	48 (35.6)	86 (64.4)		45 (55.5)	36 (44.5)		211 (62.5)	127 (37.5)	
Richer	57 (37.0)	96 (63.0)		32 (44.5)	39 (55.5)		229 (66.8)	114 (33.2)	
Richest	57 (47.7)	63 (52.3)		28 (38.1)	45 (61.9)		185 (53.1)	163 (46.9)	
Residence									
Rural	189 (30.6)	429 (69.4)	<0.001	146 (48.9)	153 (51.1)	0.917	473 (57.5)	350 (42.5)	0.541
Urban	60 (61.1)	38 (38.9)		48 (48.2)	52 (51.8)		460 (59.7)	311 (40.3)	
Geographical region									
Region 1	42 (68.9)	19 (31.1)	<0.001	32 (49.2)	32 (50.8)	0.598	258 (67.7)	123 (32.3)	<0.001
Region 2	108 (39.6)	164 (60.4)		23 (44.9)	28 (55.1)		453 (54.9)	373 (45.1)	

Characteristics	Cambodia (*n* 688) Non-EBF *N* (%)	EBF *N* (%)	P-value	Myanmar (*n* 468) Non-EBF *N* (%)	EBF *N* (%)	P-value	Indonesia (*n* 1,686) Non-EBF *N* (%)	EBF *N* (%)	P-value
Region 3	60 (25.1)	179 (74.9)		27 (57.5)	20 (42.5)		47 (44.5)	59 (55.5)	
Region 4	9 (19.9)	37 (80.1)		24 (58.1)	17 (41.9)		71 (71.4)	29 (28.6)	
Region 5	31 (31.1)	68 (68.9)		48 (44.8)	60 (55.3)		61 (50.6)	60 (49.5)	
Region 6				40 (46.4)	46 (53.6)		11 (59.3)	8 (40.7)	
Region 7							30.3 (76.8)	9 (23.2)	
TOTAL	249 (34.8)	467 (65.2)		195 (48.8)	205 (51.2)		933 (58.5)	660 (41.5)	

[A] 79% of data on pre-lacteal feeding was missing from Myanmar, so this variable was excluded from the Myanmar analysis but retained in the other country models as it was theorised to be an important variable.

[a] **Cambodia:** (1) Phnom Penh; (2) Plain; (3) Tonle Sap; (4) Coast; (5) Plateau/mountain. **Myanmar:** (1) North Myanmar; (2) East Myanmar; (3) South Myanmar; (4) West Myanmar; (5) Lower Myanmar; (6) Central Myanmar. **Indonesia:** (1) Sumatra; (2) Java; (3) Lesser Sunda Islands; (4) Kalimantan; (5) Sulawesi; (6) Maluku Islands; (7) New Guinea

Table 4.3 Adjusted odds ratios (95% CI) of factors associated with exclusive breastfeeding in Cambodia, Myanmar and Indonesia

	Cambodia (*n* 668)			Myanmar (*n* 460)			Indonesia (*n* 1,665)		
Characteristics	**AOR**	**95% CI**	***P***	**AOR**	**95% CI**	***P***	**AOR**	**95% CI**	***P***
Inherent (biological) factors									
Age (months)									
<3	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
≥3	0.31	0.21, 0.46	<0.001	0.31	0.20, 0.46	<0.001	0.37	0.30, 0.46	<0.001
Sex									
Male	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Female	1.44	0.99, 2.09	0.056	2.16	1.42, 3.27	<0.001	1.16	0.93, 1.44	0.188
Proximate factors									
Received pre-lacteal feeds									
No	1.00	Ref.	-	-	-	-	1.00	Ref.	-
Yes	0.50	0.32, 0.79	0.003	-	-	-	0.35	0.28, 0.44	<0.001
Never breastfed	- [A]	-	-	-	-	-	- [A]	-	-
Missing	- [A]	-	-	-	-	-	0.16	0.03, 0.77	0.023
Intermediate factors									
Birth order									
First	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
2-3	0.99	0.63, 1.54	0.948	1.18	0.71, 1.99	0.520	1.55	1.16, 2.07	0.003
4+	0.72	0.35, 1.51	0.385	1.32	0.62, 2.81	0.464	1.38	0.88, 2.15	0.159
Birth place									
At home	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Private facility	0.99	0.40, 2.47	0.987	0.48	0.17, 1.40	0.180	1.14	0.82, 1.58	0.435

	Cambodia (*n* 668)			Myanmar (*n* 460)			Indonesia (*n* 1,665)		
Characteristics	**AOR**	**95% CI**	***P***	**AOR**	**95% CI**	***P***	**AOR**	**95% CI**	***P***
Public facility	1.34	0.62, 2.87	0.457	0.87	0.49, 1.55	0.648	1.17	0.85, 1.61	0.324
ANC visits									
5+	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
2-4	0.73	0.48, 1.09	0.125	1.11	0.67, 1.85	0.675	0.58	0.42, 0.80	0.001
0-1	1.32	0.57, 3.04	0.514	0.46	0.23, 0.91	0.026	0.79	0.50, 1.24	0.299
Delivery by caesarean section									
No	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Yes	0.49	0.25, 0.94	0.032	1.04	0.56, 1.94	0.904	0.66	0.46, 0.93	0.017
Mother's age									
35-49	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
25-34	1.04	0.49, 2.21	0.923	1.18	0.65, 2.14	0.583	1.17	0.83, 1.66	0.369
15-24	0.93	0.41, 2.15	0.870	0.94	0.45, 1.95	0.860	1.18	0.77, 1.81	0.438
Distal (underlying) factors									
Maternal education level									
No education/primary	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Secondary/higher	1.01	0.66, 1.55	0.954	1.60	0.97, 2.64	0.068	1.33	1.01, 1.75	0.043
Maternal active labour force participation									
Not working (past 12 months)	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Low	1.10	0.67, 1.83	0.701	1.28	0.78, 2.10	0.329	0.84	0.64, 1.11	0.213
High	0.66	0.43, 1.03	0.067	1.46	0.85, 2.50	0.170	0.61	0.45, 0.83	0.002
Household wealth									
Poorest	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Poorer	1.27	0.72, 2.24	0.413	0.86	0.45, 1.63	0.640	1.31	0.92, 1.86	0.130

	Cambodia (*n* 668)			Myanmar (*n* 460)			Indonesia (*n* 1,665)		
Characteristics	**AOR**	**95% CI**	***P***	**AOR**	**95% CI**	***P***	**AOR**	**95% CI**	***P***
Middle	0.81	0.44, 1.47	0.487	1.39	0.75, 2.57	0.291	0.77	0.53, 1.12	0.171
Richer	0.67	0.36, 1.25	0.208	1.21	0.60, 2.43	0.594	0.58	0.39, 0.87	0.007
Richest	1.07	0.52, 2.18	0.854	1.48	0.71, 3.06	0.297	0.84	0.55, 1.27	0.402
Residence									
Rural	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Urban	0.54	0.33, 0.87	0.012	0.90	0.50, 1.62	0.725	0.80	0.61, 1.03	0.084
Geographical region									
Region 1	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Region 2	1.91	0.80, 4.58	0.145	0.87	0.40, 1.91	0.733	1.45	1.05, 1.99	0.023
Region 3	3.55	1.50, 8.38	0.004	0.54	0.27, 1.07	0.077	1.66	1.09, 2.54	0.018
Region 4	5.07	1.84, 13.98	0.002	0.77	0.38, 1.57	0.468	0.73	0.49, 1.11	0.144
Region 5	2.53	1.03, 6.19	0.043	0.83	0.39, 1.75	0.621	1.46	1.03, 2.07	0.036
Region 6				0.89	0.43, 1.85	0.753	1.18	0.70, 2.00	0.540
Region 7							0.66	0.39, 1.11	0.117

[A] Variance in the outcome variable was 0 for these categories of pre-lacteal feeding, as these categories mostly consisted of children who were never breastfed in Cambodia and Indonesia. However, this variable was still retained to maintain consistency between models and retain sample size.

[a] **Cambodia:** (1) Phnom Penh; (2) Plain; (3) Tonle Sap; (4) Coast; (5) Plateau/mountain. **Myanmar:** (1) North Myanmar; (2) East Myanmar; (3) South Myanmar; (4) West Myanmar; (5) Lower Myanmar; (6) Central Myanmar. **Indonesia:** (1) Sumatra; (2) Java; (3) Lesser Sunda Islands; (4) Kalimantan; (5) Sulawesi; (6) Maluku Islands; (7) New Guinea

4.3 Results: Minimum dietary diversity amongst children aged 6 to < 24 months

4.3.1 Descriptive analysis

Of the total 8,659 children aged between 6 and 23 months, approximately half were female (49% in Cambodia, 46% in Myanmar and 49% in Indonesia) (Table 4.4, p.149). The proportion of children who were fourth or higher order births ranged from 13% in Indonesia, 16% in Cambodia to 21% in Myanmar and more than half of births in each country had a preceding birth interval of more than or equal to 24 months. Although approximately half of children in Myanmar had missing information for birth weight, more than 7% of children in Cambodia and 6% of children in Indonesia had a low birth weight (<2.5kg) and 3% of children in Cambodia and 6% in Indonesia exhibited a reported large birth weight (≥4kg). Just little under half of the children in Cambodia and Indonesia reported at least one symptom of morbidity (diarrhoea, fever, coughing) and approximately one third of children in Myanmar. In Myanmar, 85% of children were reported as still being breastfed at the time of survey but this estimate was lower in Indonesia (73%) and Cambodia (69%).

Cambodia had the highest proportion of mothers in the youngest age category between 15 and 24 years (35%), Myanmar had 25% of women aged 15-24 years and 28% in Indonesia. The majority of mothers in Indonesia had achieved secondary or higher level of education (68%), whilst this accounted for 40% of mothers in Myanmar and just 36% of mothers in Cambodia. Only a small proportion of mothers in each country were not married or cohabiting with their partner: 2% in Indonesia, 3% in Myanmar and 4% in Cambodia. Cambodia had the highest overall proportion of employed women (70%) which could be further disaggregated into those considered as having a low (36%) and high (34%) levels of active participation. In Myanmar 59% of mothers were employed, which is 46% in the case of Indonesia. The majority of children in Cambodia and Myanmar resided in rural areas, whereas this represented half of all children aged 6 to <24 months in Indonesia.

Table 4.4 Characteristics of the study sample (adjusted percentages and 95% CI) of Southeast Asian children (*n* 8,659) aged 6-23 months from Cambodia, Myanmar and Indonesia*

	Cambodia (*n 2, 127)*			**Myanmar (*n* 1,339)**			**Indonesia (*n 5,193*)**		
Characteristics	***N***	**%**	**95% CI**	***N***	**%**	**95% CI**	***N***	**%**	**95% CI**
Inherent (biological) factors									
Age (months)									
6-11	745	34.8	(32.3, 37.4)	399	32.6	(29.6, 35.8)	1806	36.1	(34.2, 38.1)
12-17	673	31.4	(29.0, 34.0)	454	37.2	(34.0, 40.4)	1635	32.7	(30.9, 34.6)
18-23	724	33.8	(31.3, 36.4)	369	30.2	(27.3, 33.3)	1558	31.2	(29.4, 33.0)
Sex									
Male	1086	50.7	(48.0, 53.4)	658	53.9	(50.6, 57.1)	2576	51.5	(49.5, 53.5)
Female	1057	49.3	(46.6, 52.0)	564	46.2	(42.9, 49.4)	2423	48.5	(46.5, 50.5)
Birth weight									
<2.5kg	140	6.5	(5.5, 7.9)	55	4.5	(3.3, 6.2)	284	5.7	(4.9, 6.6)
2.5kg <4kg	1788	83.5	(81.5, 85.3)	511	41.8	(38.6, 45.1)	4014	80.3	(78.8, 81.7)
≥4kg	69	3.2	(2.5, 4.3)	81	6.6	(5.2, 8.5)	310	6.2	(5.3, 7.2)
Missing/not weighed	145	6.8	(5.6, 8.1)	574	47.0	(43.8, 50.3)	392	7.8	(7.0, 8.7)
Proximate factors									
Breastfeeding status									
Not currently breastfed	655	30.6	(28.2, 33.1)	189	15.5	(13.2, 18.1)	1342	26.8	(25.2, 28.6)
Currently breastfed	1488	69.4	(66.9, 71.8)	1033	84.5	(81.9, 86.8)	3657	73.2	(71.4, 74.8)
Morbidity									
No symptoms	1219	56.9	(54.2, 59.6)	823	67.3	(64.2, 70.3)	2584	51.7	(49.7, 53.7)
At least one symptom	924	43.1	(40.4, 45.8)	399	32.7	(29.7, 35.8)	2415	48.3	(46.3, 50.3)
Intermediate factors									
Birth interval (months)									
No previous birth	862	40.2	(37.6, 42.9)	442	36.2	(33.1, 39.4)	1935	38.7	(36.8, 40.7)
<24	166	7.8	(6.4, 9.4)	90	7.3	(5.8, 9.2)	277	5.5	(4.8, 6.4)

Characteristics	Cambodia (*n 2, 127)*			Myanmar (*n* 1,339)			Indonesia (*n 5,193*)		
	N	**%**	**95% CI**	***N***	**%**	**95% CI**	***N***	**%**	**95% CI**
≥24	1115	52.0	(49.3, 54.7)	690	56.5	(53.2, 59.7)	2786	55.7	(53.8, 57.7)
Birth order									
First	857	40.0	(37.4, 42.7)	434	35.5	(32.4, 38.8)	1915	38.3	(36.4, 40.3)
2-3	946	44.1	(41.5, 46.8)	426	43.1	(39.9, 46.3)	2447	49.0	(47.0, 51.0)
4+	340	15.9	(13.9, 18.0)	262	21.4	(18.9, 24.1)	637	12.7	(11.6, 13.9)
Maternal age (years)									
35-49	260	12.1	(10.4, 14.0)	281	23.0	(20.4, 25.8)	982	19.6	(18.1, 21.3)
25-34	1135	53.0	(50.3, 55.7)	634	51.8	(48.6, 55.1)	2612	52.2	(50.3, 54.2)
15-24	748	34.9	(32.4, 37.5)	308	25.2	(22.4, 28.2)	1405	28.1	(26.4, 29.9)
Distal (underlying) factors									
Marital Status									
Married/cohabiting	2058	96.0	(94.9, 96.9)	1182	96.7	(95.3, 97.7)	4888	97.8	(97.1, 98.3)
Widowed/divorced/separated	85	4.0	(3.1,5.1)	40	3.3	(2.3, 4.7)	111	2.2	(1.7, 2.9)
Exposure to media									
Frequent	838	39.1	(36.5, 41.8)	424	34.7	(31.6, 37.9)	1794	36.0	(34.1, 37.9)
Moderate	685	32.0	(29.5, 34.6)	461	37.8	(34.6, 41.0)	1567	31.4	(29.6, 33.3)
Limited	619	28.9	(26.6, 31.4)	337	27.6	(24.8, 30.6)	1630	32.7	(30.8, 34.5)
Maternal educational level									
No education/primary	1367	63.8	(61.2, 66.3)	731	59.8	(56.6, 63.0)	15.9	31.8	(29.9, 33.7)
Secondary/higher	776	36.2	(33.7, 38.8)	491	40.2	(37.0, 43.4)	34.1	68.2	(66.3, 70.1)
Maternal active labour force participation									
Not working (past 12 months)	650	30.4	(27.9, 33.0)	503	41.3	(38.1, 44.6)	2705	54.2	(52.2, 56.2)
Low	771	36.1	(33.6, 38.6)	368	30.2	(27.2, 33.3)	1396	28.0	(26.3, 29.8)
High	718	33.6	(31.1, 36.1)	347	28.5	(25.6, 31.6)	890	17.8	(16.3, 19.4)
Household wealth									

Characteristics	Cambodia (*n 2, 127)* N	%	95% CI	Myanmar (*n* 1,339) N	%	95% CI	Indonesia (*n 5,193*) N	%	95% CI
Poorest	504	23.8	(21.7, 26.2)	326	26.6	(23.9, 29.6)	816	16.3	(15.0, 17.7)
Poorer	384	18.2	(16.3, 20.2)	280	22.9	(20.3, 25.8)	1041	20.8	(19.3, 22.5)
Middle	417	19.7	(17.6, 22.0)	246	20.1	(17.6, 22.9)	1034	20.7	(19.1, 22.4)
Richer	384	18.2	(16.1, 20.5)	189	15.5	(13.3, 18.0)	1121	22.4	(20.8, 24.2)
Richest	425	20.1	(17.9, 22.4)	182	14.9	(12.7, 17.4)	987	19.7	(18.2, 21.4)
Sex of HH head									
Male	1661	77.5	(75.2, 79.7)	1050	85.9	(83.5, 88.0)	4568	91.4	(90.2, 92.5)
Female	482	22.5	(20.4, 24.8)	172	14.1	(12.0, 16.5)	431	8.6	(7.5, 9.9)
Residence									
Rural	1842	86.0	(84.3, 87.5)	912	74.6	(71.6, 77.5)	2539	50.8	(48.8, 52.8)
Urban	300	14.0	(12.5, 15.7)	310	25.4	(22.6, 28.4)	2460	49.2	(47.2, 51.2)
Geographical region									
Region 1	186	8.7	(7.3, 10.3)	156	12.8	(10.9, 15.0)	1171	23.4	(22.1, 24.8)
Region 2	769	35.9	(33.2, 38.7)	189	15.5	(13.1, 18.3)	2670	53.4	(51.5, 55.3)
Region 3	716	33.4	(31.0, 36.0)	120	9.8	(8.6, 11.2)	285	5.7	(5.2, 6.3)
Region 4	128	6.0	(5.1, 7.0)	102	8.3	(7.0, 9.8)	331	6.6	(6.1, 7.2)
Region 5	344	16.0	(14.5, 17.8)	417	34.1	(30.9, 37.5)	393	7.9	(7.3, 8.5)
Region 6				238	19.5	(17.0, 22.2)	60	1.2	(1.1, 1.4)
Region 7							89	1.8	(1.5, 2.1)

*Data from most recent DHS surveys in Cambodia (2014), Myanmar (2015-16) and Indonesia (2012).

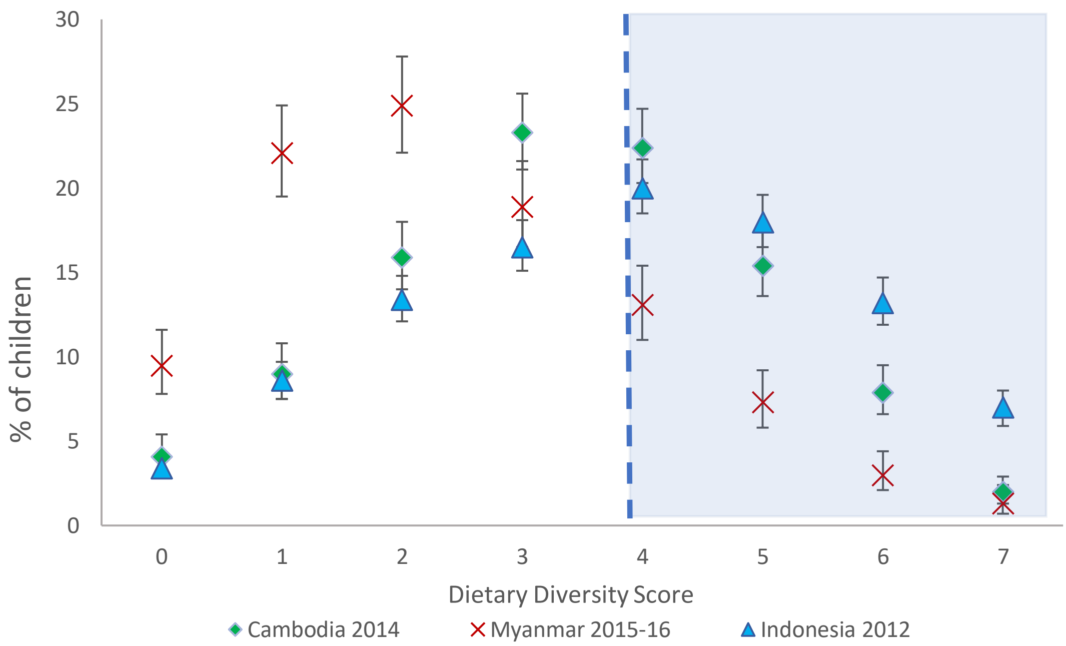
[a] **Cambodia:** (1) Phnom Penh; (2) Plain; (3) Tonle Sap; (4) Coast; (5) Plateau/mountain. **Myanmar:** (1) North Myanmar; (2) East Myanmar; (3) South Myanmar; (4) West Myanmar; (5) Lower Myanmar; (6) Central Myanmar. **Indonesia:** (1) Sumatra; (2) Java; (3) Lesser Sunda Islands; (4) Kalimantan; (5) Sulawesi; (6) Maluku Islands; (7) New Guinea.

4.3.2 Bivariate and multivariable logistic regression analysis

Dietary Diversity

Of the total sample of 8,659 children aged 6-<24 months, the proportion reported to be receiving MDD (four or more food groups) ranged from 25% in Myanmar, 48% in Cambodia to 58% in Indonesia which is represented by the area within the shaded section in Figure 4.1.

Figure 4.1 Percentage of children aged 6-<24 months by number of food groups received



Food types consisting of grains, roots and tubers were a staple in the diets of children in all three countries with more than half of children in Cambodia and Myanmar receiving this type of food at six or seven months respectively and over 83% of children in Indonesia, by age six months (Figure 4.2, p.146; Figure 4.3, p.146; Figure 4.4, p.147). Animal source protein such as meat and poultry, featured in the diets of more than half of Cambodian children aged 6-11 months, which increased to 94% between the ages of 18 and 23 months. In Myanmar and Indonesia, approximately one third of children aged 6-11 months consumed meat, poultry or fish, increasing to 60% in Myanmar and 70% in Indonesia by age 18-23 months.

Figure 4.2 Percentage of children aged 6-<24 months by food group consumption, Cambodia (2014)

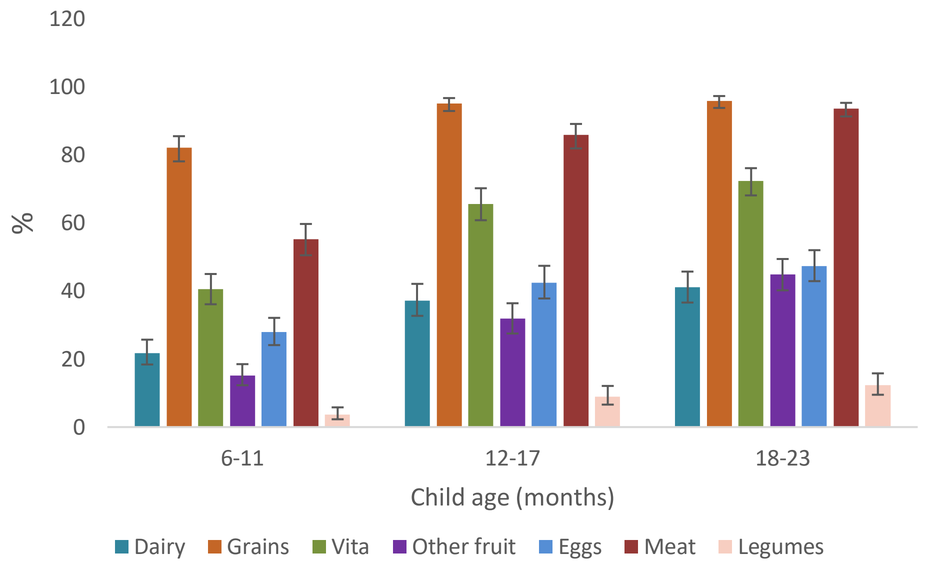


Figure 4.3 Percentage of children aged 6-<24 months by food group consumption, Myanmar (2015-16)

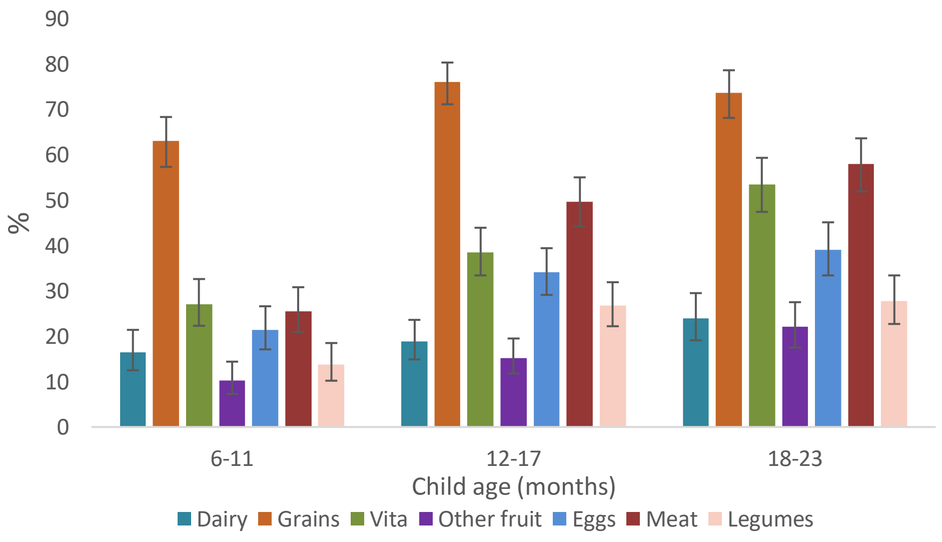
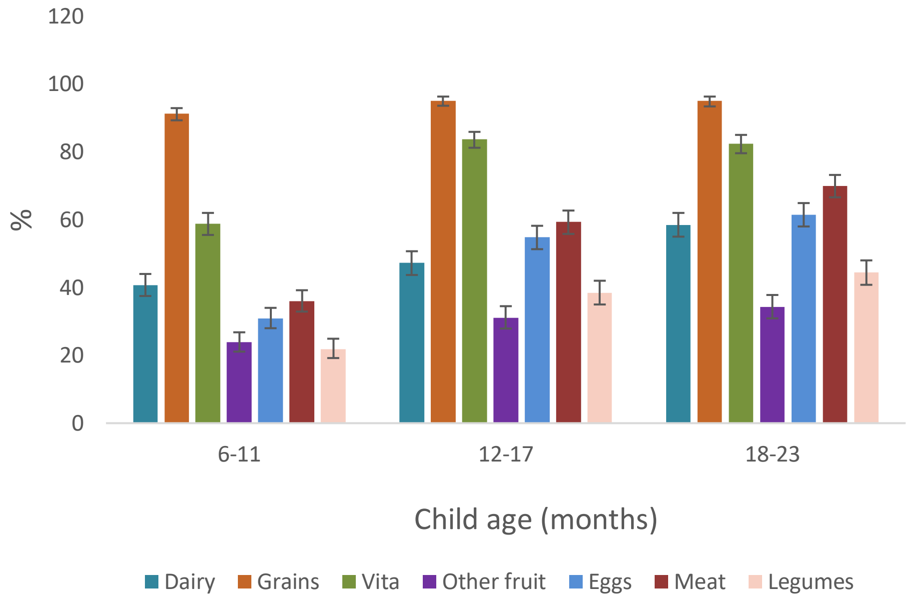


Figure 4.4 Percentage of children aged 6-<24 months by food group consumption, Indonesia (2012)



Factors associated with minimum dietary diversity

In pooled analysis of data from Cambodia, Myanmar and Indonesia, where Cambodia was used as the reference category (see Appendix E, p.248), the odds of meeting MDD was 68% lower in Myanmar (aOR 0.32, 95%CI: 0.27, 0.38) and 22% higher in Indonesia (aOR 1.22, 95%CI: 1.08, 1.38). There seemed to be clear socioeconomic differentials consistent across countries, with children from the richest households (aOR 2.78, 95%CI: 2.36, 2.79) and those residing in urban areas (aOR 1.83, 95%CI: 1.64, 2.04) having increased odds of meeting MDD. Results from pooled analysis also indicated that in the sub-region overall (represented by Cambodia, Myanmar and Indonesia), high level of maternal labour force participation was associated with a 25% increased odds of meeting MDD (aOR 1.25, 95%CI: 1.10, 1.42).

In multivariable analyses stratified by country (Table 4.5, p.153), female children in Myanmar were significantly less likely to receive MDD (aOR 0.70, 95%CI: 0.52, 0.93) than their male counterparts, a finding not observed in Cambodia and Indonesia. In all three countries there was a statistically significant positive relationship between increasing age of child and meeting MDD; with children aged 18-23 months over three times more likely to receive MDD than those aged 6-11 months.

In terms of proximate level factors associated with MDD, children in all three countries were consistently less likely to meet MDD if they were still being breastfed at the time of survey (Cambodia aOR 0.73, 95%CI: 0.58, 0.92; Myanmar aOR 0.61, 95%CI: 0.42, 0.89; Indonesia aOR 0.49, 95%CI: 0.42, 0.56). In Indonesia, experiencing at least one morbidity symptom in the two weeks prior to survey was significantly associated with increased odds of meeting MDD (aOR 1.25, 95%CI: 1.10, 1.42). Consistent across all three countries, children of mothers in the youngest age category (15-24 years) were most at risk for not meeting MDD when compared to children of older mothers (35-49 years). A short preceding birth interval (<24 months) was associated with decreased odds of the child receiving MDD in both Cambodia and Myanmar, by approximately half but this result was not observed in Indonesia.

With reference to distal (underlying) factors associated with MDD, there was a clear positive relationship between increasing household wealth and likelihood of meeting MDD, with children from the richest households in all three countries experiencing increased odds of MDD, by approximately two-fold or more in Cambodia (aOR 2.37, 95%CI: 1.65, 3.39), Myanmar (aOR 1.81, 95%CI: 1.10, 2.96) and Indonesia (aOR 1.98, 95%CI: 15.8, 2.48). Similarly, children living in urban areas consistently experienced better odds of receiving MDD in all three countries. As it had been previously hypothesised that despite the urban advantage, intra-urban socioeconomic disparities exist, further exploration of the predicted probabilities for children receiving MDD across household wealth quintile, by urban/rural residence was conducted (see Appendix F, p.250). There was stark socioeconomic inequality in MDD achievement in both urban and rural areas, but the rural poor were consistently disadvantaged compared to the urban poor.

In both Myanmar and Indonesia, children of mothers with secondary education or higher were 39% and 37% more likely to meet MDD, although this association did not quite meet statistical significance in Myanmar. Maternal labour force participation was only significantly associated with MDD in Indonesia, as children to mothers who were considered to have a high level of participation in employment experienced increased odds of meeting MDD (aOR 1.28, 95%CI: 1.06, 1.53) compared to children of mothers who had reported not working in the past 12 months. Although this association appeared to be in the same direction in both Cambodia and Myanmar, it did not reach statistical significance. Association between a composite measure of maternal exposure to media and media revealed contrasting results in Cambodia and Indonesia: with limited exposure reducing the odds of meeting MDD by 40% in Cambodia and increasing the odds by 58% in Indonesia.

Table 4.4 Proportion of children who received the minimum dietary diversity by demographic and socioeconomic characteristics, with Chi-square tests of association in Cambodia, Myanmar and Indonesia

	Cambodia (*n* 2,127)			**Myanmar (*n 1,339*)**			**Indonesia (*n 5,193*)**		
Characteristics	**No MDD *N* (%)**	**MDD *N* (%)**	**P-value**	**No MDD *N* (%)**	**MDD *N* (%)**	**P-value**	**No MDD *N* (%)**	**MDD *N* (%)**	**P-value**
Inherent (biological) factors									
Age (months)									
6-11	536 (72.0)	209 (28.0)	<0.001	349 (87.4)	50 (12.6)	<0.001	1116 (61.8)	690 (38.2)	<0.001
12-17	304 (45.1)	370 (54.9)		329 (72.5)	125 (27.6)		580 (35.5)	1055 (64.5)	
18-23	280 (38.7)	444 (61.4)		244 (65.9)	126 (34.1)		396 (25.4)	1163 (74.6)	
Sex									
Male	562 (51.8)	524 (48.2)	0.713	475 (72.2)	183 (27.8)	0.018	1113 (43.2)	1464 (56.8)	0.166
Female	558 (52.8)	499 (47.2)		446 (79.1)	118 (20.9)		979 (40.4)	1443 (59.6)	
Birth weight									
<2.5kg	67 (47.5)	74 (52.5)	<0.001	40 (72.4)	15 (27.6)	<0.001	106 (37.3)	178 (62.7)	<0.001
2.5kg < kg	908 (50.8)	880 (49.2)		347 (67.9)	164 (32.1)		1588 (39.6)	2426 (60.4)	
≥4kg	41 (58.9)	29 (41.1)		62 (75.8)	20 (24.2)		136 (44.0)	174 (56.1)	
Missing/not weighed	105 (72.2)	40 (27.9		472 (82.2)	102 (17.8)		263 (67.0)	129 (33.0)	
Proximate factors									
Breastfeeding status									
Not currently breastfed	231 (35.2)	424 (64.8)	<0.001	109 (57.6)	80 (42.4)	<0.001	329 (24.5)	1013 (75.5)	<0.001
Currently breastfed	890 (59.8)	598 (40.2)		812 (78.6)	221 (21.4)		1763 (48.2)	1894 (51.8)	
Morbidity									
No symptoms	621 (51.0)	598 (49.1)	0.270	623 (75.8)	199 (24.2)	0.680	1125 (43.6)	1458 (56.4)	0.077
At least one symptom	499 (54.0)	425 (46.0)		298 (74.5)	102 (25.5)		967 (40.0)	1449 (60.0)	

	Cambodia (*n* 2,127)			Myanmar (*n 1,339*)			Indonesia (*n 5,193*)		
	No MDD	MDD	P-value	No MDD	MDD	P-value	No MDD	MDD	P-value
Characteristics	***N* (%)**	***N* (%)**		***N* (%)**	***N* (%)**		***N* (%)**	***N* (%)**	
Intermediate factors									
Birth interval (months)									
No previous birth	430 (50.0)	431 (50.1)	0.009	313 (70.7)	130 (29.3)	0.009	775 (40.1)	1160 (59.9)	0.318
<24	110 (66.3)	56 (33.7)		77 (86.3)	12 (13.8)		121 (43.7)	156 (56.3)	
≥24	580 (52.0)	535 (48.0)		531 (77.0)	159 (23.1)		1196 (42.69)	1591 (57.1)	
Birth order									
First	429 (50.1)	428 (49.9)	0.338	309 (71.2)	125 (28.8)	0.017	764 (39.9)	1151 (60.1)	<0.001
2-3	501 (52.9)	445 (47.1)		396 (75.3)	130 (24.7)		1000 (40.8)	1448 (59.2)	
4+	190 (55.9)	150 (44.1)		216 (82.4)	46 (17.6)		328 (51.6)	309 (48.4)	
Maternal age (years)									
35-49	128 (49.4)	132 (50.7)	0.004	204 (72.6)	77 (27.4)	0.473	412 (42.0)	570(58.0)	0.038
25-34	554 (48.8)	581 (51.2)		478 (75.5)	155 (24.5)		1037 (39.7)	1574 (60.3)	
15-24	438 (58.6)	310 (41.4)		239 (77.7)	69 (22.3)		642 (45.7)	763 (54.3)	
Distal (underlying) factors									
Marital Status									
Married/cohabiting	1085 (52.8)	972 (47.3)	0.070	887 (75.0)	295 (25.0)	0.259	2034 (41.6)	2854 (58.4)	0.148
Widowed/divorced/separated	35 (40.9)	50 (59.1)		34 (84.8)	6 (15.2)		58 (52.0)	53 (48.1)	
Exposure to media									
Frequent	355 (42.3)	484 (57.7)	<0.001	295 (69.6)	129 (30.4)	0.002	933 (52.0)	862 (48.0)	<0.001
Moderate	372 (54.3)	313 (45.7)		348 (75.4)	114 (24.6)		607 (38.7)	961 (61.3)	
Limited	394 (63.6)	226 (36.4)		278 (82.6)	59 (17.4)		549 (33.7)	1081 (66.3)	
Maternal educational level									

Characteristics	Cambodia (*n* 2,127) No MDD *N* (%)	Cambodia MDD *N* (%)	Cambodia P-value	Myanmar (*n 1,339*) No MDD *N* (%)	Myanmar MDD *N* (%)	Myanmar P-value	Indonesia (*n 5,193*) No MDD *N* (%)	Indonesia MDD *N* (%)	Indonesia P-value
No education/primary	791 (57.9)	576 (42.2)	<0.001	588 (80.5)	143 (19.6)	<0.001	859 (54.1)	730 (45.9)	<0.001
Secondary/higher	330 (42.5)	447 (57.5)		333 (67.8)	158 (32.2)		1233 (36.2)	2177 (63.8)	
Maternal active labour force participation									
Not working (past 12 months)	366 (56.3)	284 (43.7)	<0.001	399 (79.4)	104 (206)	0.007	1237 (45.7)	1468 (54.3)	<0.001
Low	461 (59.8)	310 (40.2)		282 (76.7)	86 (23.3)		581 (41.6)	815 (58.4)	
High	292 (40.6)	426 (59.4)		237 (68.4)	110 (31.6)		269 (30.2)	621 (69.8)	
Household wealth									
Poorest	334 (66.2)	170 (33.8)	<0.001	262 (80.4)	64 (19.6)	<0.001	457 (56.0)	359 (44.0)	<0.001
Poorer	223 (58.1)	161 (41.9)		229 (82.0)	51 (18.1)		510 (48.9)	532 (51.1)	
Middle	202 (48.5)	215 (51.5)		182 (74.1)	64 (25.9)		433 (41.8)	601 (58.2)	
Richer	203 (52.9)	181 (47.1)		135 (71.2)	54 (28.8)		368 (32.9)	753 (67.1)	
Richest	148 (34.8)	277 (65.3)		113 (62.1)	69 (38.0)		325 (32.9)	662 (67.1	
Sex of HH head									
Male	875 (52.7)	786 (47.3)	0.571	783 (74.5)	267 (25.5)	0.141	1910 (41.8)	2658 (58.2)	0.925
Female	245 (50.9)	240 (49.2)		138 (80.4)	34 (19.6)		182 (42.2)	249 (57.8)	
Residence									
Rural	1031 (56.0)	812 (44.1)	<0.001	715 (78.4)	197 (21.6)	<0.001	1230 (48.5)	1308 (51.5)	<0.001
Urban	89 (29.7)	211 (70.3)		206 (66.5)	104 (33.5)		862 (35.0)	1599 (65.0)	
Geographical region									
Region 1	32 (17.4)	154 (82.6)	<0.001	131 (83.8)	25 (16.2)	<0.001	463 (39.5)	708 (60.5)	<0.001
Region 2	450 (58.5)	319 (41.5)		132 (69.6)	57 (16.6)		1048 (39.3)	1622 (60.7)	
Region 3	364 (50.8)	352 (49.2)		100 (83.4)	20 (16.6)		152 (53.3)	133 (46.8)	

Characteristics	Cambodia (*n* 2,127) No MDD *N* (%)	MDD *N* (%)	P-value	Myanmar (*n 1,339*) No MDD *N* (%)	MDD *N* (%)	P-value	Indonesia (*n 5,193*) No MDD *N* (%)	MDD *N* (%)	P-value
Region 4	71.4 (55.7)	57 (44.4)		85 (83.8)	16 (16.2)		146 (44.1)	185 (55.9)	
Region 5	203 (59.1)	141 (41.0)		333 (79.9)	84 (20.1)		197 (50.1)	196 (49.9)	
Region 6				140 (58.8)	98 (41.2)		34 (56.0)	27 (44.0)	
Region 7							53 (59.4)	36 (40.6)	
TOTAL	1120 (52.3)	1023 (47.7)		921 (75.4)	301 (24.6)		2092 (41.9)	2907 (58.2)	

[a] **Cambodia:** (1) Phnom Penh; (2) Plain; (3) Tonle Sap; (4) Coast; (5) Plateau/mountain. **Myanmar:** (1) North Myanmar; (2) East Myanmar; (3) South Myanmar; (4) West Myanmar; (5) Lower Myanmar; (6) Central Myanmar. **Indonesia:** (1) Sumatra; (2) Java; (3) Lesser Sunda Islands; (4) Kalimantan; (5) Sulawesi; (6) Maluku Islands; (7) New Guinea

Table 4.5 Adjusted odds ratios (95% CI) of factors associated with minimum dietary diversity

	Cambodia (*n* 2,096)			Myanmar (*n* 1,336)			Indonesia (*n* 5,160)		
Characteristics	**AOR**	**95% CI**	***P***	**AOR**	**95% CI**	***P***	**AOR**	**95% CI**	***P***
Inherent (biological) factors									
Age (months)									
6-11	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
12-17	3.29	2.59, 4.18	<0.001	3.28	2.22, 4.84	<0.001	3.21	2.77, 3.72	<0.001
18-23	3.38	2.60, 4.40	<0.001	4.51	2.98, 6.84	<0.001	4.74	4.05, 5.55	<0.001
Sex									
Male	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Female	0.96	0.80, 1.16	0.698	0.70	0.52, 0.93	0.013	1.00	0.88, 1.13	0.999
Proximate factors									
Breastfeeding status									
Not currently breastfed	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Currently breastfed	0.73	0.58, 0.92	0.009	0.61	0.42, 0.89	0.010	0.49	0.42, 0.56	<0.001
Morbidity									
No symptoms	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
At least one symptom	0.83	0.69, 1.01	0.065	1.15	0.86, 1.54	0.355	1.25	1.10, 1.42	<0.001
Intermediate factors									
Birth interval (months)									
No previous birth	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
<24	0.60	0.40, 0.89	0.011	0.54	0.30, 1.00	0.048	0.94	0.72, 1.22	0.650
≥24	0.76	0.60, 0.97	0.025	0.70	0.49,0.98	0.041	0.83	0.71, 0.98	0.031

Characteristics	Cambodia (*n* 2,096) AOR	95% CI	*P*	Myanmar (*n* 1,336) AOR	95% CI	*P*	Indonesia (*n* 5,160) AOR	95% CI	*P*
Maternal age (years)									
35-49	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
25-34	0.96	0.70, 1.30	0.773	0.57	0.40, 0.82	0.002	0.84	0.71, 1.00	0.045
15-24	0.69	0.48, 0.98	0.039	0.50	0.32, 0.80	0.003	0.73	0.58, 0.90	0.004
Distal (underlying) factors									
Exposure to media									
Frequent	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Moderate	0.70	0.56, 0.89	0.004	0.90	0.65, 1.26	0.544	1.47	1.26, 1.72	<0.001
Limited	0.60	0.46, 0.79	<0.001	0.74	0.49, 1.11	0.147	1.58	1.35, 1.85	<0.001
Maternal educational level									
No education/primary	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Secondary/higher	1.13	0.90, 1.42	0.277	1.39	1.00, 1.94	0.050	1.37	1.18, 1.59	<0.001
Maternal active labour force participation									
Not working (past 12 months)	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Low	1.00	0.78, 1.29	0.999	1.11	0.78, 1.59	0.550	1.08	0.94, 1.25	0.284
High	1.10	0.85, 1.41	0.475	1.17	0.82, 1.66	0.382	1.27	1.05, 1.52	0.012
Household wealth									
Poorest	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Poorer	1.26	0.96, 1.66	0.100	0.99	0.64, 1.53	0.970	1.27	1.05, 1.54	0.014
Middle	1.73	1.28, 2.35	<0.001	1.24	0.80, 1.93	0.334	1.53	1.25, 1.87	<0.001
Richer	1.16	0.83, 1.62	0.377	0.53	0.96,2.45	0.075	1.89	1.53, 2.33	<0.001
Richest	2.37	1.65, 3.39	<0.001	1.81	1.10,2.96	0.019	1.98	1.58, 2.48	<0.001
Residence									

	Cambodia (*n* 2,096)			Myanmar (*n* 1,336)			Indonesia (*n* 5,160)		
Characteristics	**AOR**	**95% CI**	***P***	**AOR**	**95% CI**	***P***	**AOR**	**95% CI**	***P***
Rural	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Urban	1.43	1.10, 1.88	0.008	1.69	1.18, 2.42	0.004	1.66	1.45, 1.90	<0.001
Geographical region									
Region 1	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Region 2	0.31	0.18, 0.53	<0.001	1.24	0.74, 2.09	0.415	0.97	0.81, 1.16	0.732
Region 3	0.38	0.22, 0.65	<0.001	0.72	0.43, 1.21	0.220	0.63	0.49, 0.80	<0.001
Region 4	0.33	0.18, 0.60	<0.001	0.65	0.37, 1.14	0.131	0.83	0.67,1.03	0.090
Region 5	0.28	0.16, 0.48	<0.001	0.81	0.49, 1.34	0.417	0.55	0.46, 0.67	<0.001
Region 6				2.26	1.38, 3.71	<0.001	0.55	0.41, 0.73	<0.001
Region 7							0.56	0.41, 0.77	<0.001

[a] **Cambodia:** (1) Phnom Penh; (2) Plain; (3) Tonle Sap; (4) Coast; (5) Plateau/mountain. **Myanmar:** (1) North Myanmar; (2) East Myanmar; (3) South Myanmar; (4) West Myanmar; (5) Lower Myanmar; (6) Central Myanmar. **Indonesia:** (1) Sumatra; (2) Java; (3) Lesser Sunda Islands; (4) Kalimantan; (5) Sulawesi; (6) Maluku Islands; (7) New Guinea

4.4 Summary of Findings

This section summarises the results of the first analysis; the findings are discussed in Chapter seven of this thesis (Chapter 7.3.1, p. 207).

Exclusive breastfeeding in 0 to <6 month olds

- Results from pooled analysis suggested that children in Myanmar and Cambodia were twice as likely to be exclusively breastfed compared to children from Indonesia.
- In terms of the factors associated with exclusive breastfeeding, these varied by country context:
    - In both Cambodia and Indonesia, pre-lacteal feeding had a significant and negative association with reported exclusive breastfeeding as assessed by 24-hour recall.
    - Delivery by caesarean section was associated with a reduced likelihood of exclusive breastfeeding in Cambodia and Indonesia.
    - Mothers with secondary education or higher in Indonesia were more likely to exclusively breastfeed, compared to those with no education or primary level.
    - High level of maternal participation in the labour force was associated with reduced probability of exclusive breastfeeding in Indonesia; a similar but insignificant finding was also noted in Cambodia.

Minimum dietary diversity in 6 to <24 month olds

- Compared to Cambodia which was set as the reference category, the results from pooled analysis showed that likelihood of meeting minimum dietary diversity in Myanmar was significantly lower and the odds were significantly higher in Indonesia.
- Children residing in urban areas, from the richest households were most likely to have met the requirements for minimum dietary diversity with the poorest children in rural areas being the most disadvantaged. This result was consistent across all three countries. Country specific findings:
    - High level of maternal labour force participation was positively associated with meeting minimum dietary diversity in all three countries, although this association only reached significance in Indonesia.
    - Female children were significantly less likely to receive the minimum dietary diversity in Myanmar.

- Children of mothers with secondary or higher education were more likely to meet minimum dietary diversity in Indonesia; this result was borderline significant in Myanmar.
- Children whose mothers had limited exposure to different forms of media such as television, newspapers and radio were significantly less likely to meet minimum dietary diversity in Cambodia, compared to those who had frequent exposure. The opposite effect was observed in Indonesia where mothers with limited exposure to media were more likely to provide a diverse diet to their children.

Chapter 5 Socioeconomic status, dietary diversity, continued breastfeeding and height-for-age in young children in Cambodia

5.1 Introduction

Stunting of children under five year of age continues to pose a critical public health concern for Cambodia, with 32% of children being of low height-for-age (UNICEF, 2018). Prevalence of stunting in Cambodia is also characterized by distinct socioeconomic inequality, and associated with suboptimum feeding practices that often occur from 6 months of age, micronutrient deficiencies and recurrent infections (Black et al., 2013; Dewey and Mayers, 2011). Impaired linear growth has adverse long-term health consequences for cognitive and immune system development, and is associated with increased risk of overweight and its co-morbidities in later life (Black et al., 2008; Black et al., 2013; Victora et al., 2008). Unfortunately, in geographical contexts where short stature has been a normative outcome for multiple generations, stunting often goes unrecognised, which is further exacerbated by irregular or lack of routine health assessments (de Onis and Branca, 2016).

With reference to the conceptual framework used in this thesis (Figure 2.1, p.55), and from previous research, it is clear that the factors associated with children's height-for-age operate 'at different levels of causation' (Black et al., 2013, p.434). Limited dietary diversity has been previously reported as a significant risk factor for impaired linear growth (Krasevec, 2017), whereas the evidence for continued breastfeeding remains inconclusive with some studies even suggesting a negative association (Cetthakrikul et al., 2018; Marquis et al., 1997). However, it is unclear whether these early feeding practices are independently associated with height-for-age or whether they mediate the association between distal (underlying) factors and stunting. Under this hypothesis, dietary diversity and continued breastfeeding may be considered as endogenous factors and the underlying components of socioeconomic status as exogenous factors. Previous studies in Cambodia and other low- and middle-income countries have consistently reported that the socioeconomic factors responsible for inequalities in stunting prevalence include maternal education, household wealth and maternal employment (Black et al., 2013; Boyle et al., 2006; Caldwell, 1979; Caldwell, 1994; Popkin and Solon 1976; Smith, Ruel and Ndiaye, 2004). Similarly, these same socioeconomic factors are also associated with stark differentials in breastfeeding practices and dietary diversity within the

Southeast Asian context, as the results from Chapter 4 indicated. However, the effect of improved socioeconomic status on continued breastfeeding and dietary diversity is paradoxical, as improvements in socioeconomic status are congruent with declines in continued breastfeeding, whereas better socioeconomic status is positively associated with adequate dietary diversity, as household incomes increase. This phenomenon is representative of a nutrition transition (Popkin, Adair and Ng, 2013). Maternal employment is particularly relevant to the Cambodian context where approximately 75% of women participate in the labour force (ILOSTAT, 2018).

Only a few studies have examined the complex and inter-related nature of factors associated with children's height-for-age using a comprehensive modelling technique that accounts for the dynamic interactions between factors, disentangling direct effects from indirect effects with mediating variables (Hanieh et al., 2015; Lander et al., 2015; Cunningham et al., 2018). Moreover, there is no such study from the Cambodian context. Therefore, this chapter investigated hypothetical pathways to height-for-age Z-scores among children aged 6 to <24 months using cross-sectional DHS data from Cambodia in structural path analyses.

Bivariate analyses included adjusted Wald tests for joint hypothesis testing, to assess preliminary associations between explanatory variables and the continuous outcome variable (height-for-age Z-scores). Based on the associations observed in bivariate analysis, these explanatory variables were entered in univariable and multivariable linear regression, providing a theoretical base on which to iteratively build a structural path model. Structural path analysis was selected as the main preferred analytical method over multivariable linear regression as the underlying (socioeconomic) and proximate (infant feeding) factors are hypothesised to form complex and inter-related pathways to children's height for age. Structural path analysis facilitated the modelling of several multivariate hypotheses and their interdependencies, in addition to testing how well the overall conceptualised model represented a valid hypothesis i.e. to what extent the specified pathways are explained by the data (Grace and Bollen, 2005).

5.1.1 Research Questions

1) Is maternal education, household wealth and maternal employment associated with dietary diversity and continued breastfeeding

2) To what extent (if at all) do dietary diversity and continued breastfeeding mediating the association between socioeconomic factors and child stunting?

3) Are these aforementioned associations moderated by urban/rural residence?

5.2 Results

5.2.1 Sample Characteristics

Age of children at time of survey ranged from 6 to <24 months, with approximately one third of children aged between six and 12 months old and two thirds aged 12 months or more (Table 5.1, P.162). There were slightly more male children in the sample (52%), compared to female (48%) and 6% of children had a low birth weight (< 2.5kg). Little more than two-fifth of children in the sample was reported to have morbidity (44%) in the two weeks prior to interview which included symptoms related to acute respiratory infection, diarrhoeal disease or fever. In terms of the maternal biological characteristics, 5% of mothers were reported to have a short stature (< 145cm); 16% of women had low BMI and 15% high BMI. The majority of the mothers in the sample had achieved primary level education (56%) and only 12% reported no education at all. In terms of level of maternal participation in the labour force, approximately a third of women reported that they had not worked in the 12 months prior to survey, a third of women were considered to have a low level of participation in employment and a third with high participation. At the household level, 25% of children were from the poorest households and 19% from the richest quintile of households, the majority of households located in rural areas (86%). In terms of infant feeding practices, 70% of children aged 6-23 months were still being breastfed at the time of survey and 34% had been fed from a bottle. About 43% of children had a low dietary diversity compared to children of the same age, but 73% of children consumed the recommended meal frequency. However, when dietary diversity and meal frequency were combined to create the minimum acceptable diet indicator, just 32% were considered to have achieved this – indicating that dietary diversity was the main contributing factor to lack of achievement of minimum acceptable diet.

Table 5.1 Association between IYCF indicators, socio-demographic factors and mean height-for-age Z-scores in children aged 6-23 months in Cambodia (2014) (estimates adjusted for survey design using appropriate sample weights)

Indicator	**%**	**N**	**Mean HAZ**	**Std. deviation**	**95% CI for mean**	**Test statistic**
Inherent (biological) factors						
Age (months)						
6-8	17.5	242	-0.55	1.25	-0.75, -0.35	F(3, 1362)=22.20, *p*=<0.001
9-11	15.1	208	-0.92	1.48	-1.14, -0.70	
12-17	33.5	463	-1.41	1.23	-1.54, -1.28	
18-23	33.9	468	-1.46	1.32	-1.60, -1.31	
Gender						
Male	52.0	718	-1.28	1.34	-1.39, -1.16	F(1, 1364)=3.33, *p*=0.068
Female	48.0	663	-1.12	1.35	-1.24, -1.00	
Birth weight						
< 2.5kg	6.0	83	-1.48	1.50	-1.85, -1.11	F(3, 1362)=5.65, *p*=<0.001
2.5 < 4.0kg	83.4	1152	-1.16	1.33	-1.25, -1.07	
≥ 4.0kg	3.4	46	-0.82	1.10	-1.17, -0.46	
Missing/not weighed	7.2	100	-1.63	1.38	-1.91, -1.36	
Maternal Height						
Normal stature (≥145cm)	94.8	1308	-1.16	1.34	-1.25, -1.08	F(1, 1362)=20.26, *p*=<0.001
Short stature (<145cm)	5.2	71	-1.90	1.36	-2.21, -1.59	
Maternal BMI						
<18.5	15.6	215	-1.50	1.22	-1.68, -1.32	F(2, 1360)=5.72, *p*=0.003
18.5-24.99	69.2	952	-1.17	1.39	-1.27, -1.06	
≥ 25.0	15.2	209	-1.09	1.24	-1.31, -0.86	
Proximate factors						
Morbidity						
No	56.5	781	-1.16	1.40	-1.27, -1.05	F(1, 1364)=1.45, *p*=0.229
Yes	43.5	601	-1.26	1.28	-1.39, -1.13	
Breastfeeding						
No	29.9	413	-1.15	1.39	-1.30, -0.99	F(1, 1364)=0.66, *p*=0.4178
Yes	70.1	968	-1.22	1.33	-1.32, -1.12	
Bottle feeding						
No	66.0	911	-1.27	1.33	-1.38, -1.16	F(1, 1363)=5.39, *p*=0.020
Yes	34.0	469	-1.07	1.37	-1.20, -0.93	
Dietary Diversity Tercile						
Low	43.2	596	-1.30	1.20	-1.42, -1.17	F(2, 1363)=7.80, *p*=<0.001
Middle	33.8	467	-1.29	1.46	-1.44, -1.13	
High	23.1	318	-0.90	1.41	-1.07, -0.73	
Minimum meal frequency						
No	27.4	378	-1.32	1.38	-1.48, -1.16	F(1, 1364)=2.93, *p*=0.087

Indicator	%	N	Mean HAZ	Std. deviation	95% CI for mean	Test statistic
Yes	72.6	1003	-1.16	1.33	-1.25, -1.06	
Minimum acceptable diet						
No	68.4	945	-1.23	1.32	-1.33, -1.13	F(1, 1364)=1.13, *p*=0.287
Yes	31.6	436	-1.13	1.41	-1.29, -0.98	
Distal (underlying) factors						
Highest education level						
No education	12.0	166	-1.26	1.45	-1.50, -1.02	F(1, 1364)=6.90, *p*=0.009
Primary	55.6	768	-1.28	1.27	-1.40, -1.16	
Secondary/Higher	32.4	447	-1.04	1.42	-1.18, -0.91	
Labour force participation						
Not working	30.5	421	-1.19	1.22	-1.34, -1.04	F(2, 1359)=8.34, *p*=<0.001
Low	37.5	517	-1.40	1.42	-1.54, -1.26	
High	32.0	441	-0.98	1.34	-1.12, -0.84	
Household Wealth Index						
Poorest	25.4	345	-1.48	1.49	-1.65, -1.32	F(4, 1347)=7.53, *p*=<0.001
Poorer	18.2	248	-1.32	1.41	-1.50, -1.14	
Middle	19.9	271	-1.23	1.18	-1.41, -1.05	
Richer	17.7	241	-1.00	1.21	-1.20, -0.80	
Richest	18.8	256	-0.86	1.17	-1.04, -0.67	
Urban/rural residence						
Rural	86.4	1193	-1.25	1.23	-1.34, -1.16	F(1,1364)=13.04, *p*=<0.001
Urban	13.6	188	-0.88	1.97	-1.06, -0.70	
Sex of household head						
Male	77.0	1064	-1.20	1.33	-1.29, -1.10	F(1, 1364)=0.01, *p*=0.920
Female	23.0	317	-1.21	1.39	-1.40, -1.02	

5.2.2 Bivariate analysis

In the sample of Cambodian children aged 6 to <24 months, mean HAZ was -1.20 and 26% of children were considered to be stunted from the total sample (Table 5.2, p.164). Furthermore, it was also observed that mean HAZ deteriorated with age of the child and hence the proportion of children stunted increased with age, in line with a finding by Shrimpton et al., (2001) in their study of 39 LMICs. This difference in mean HAZ between children's age groups was statistically significant (p<0.001) (Table 5.1, p.162). Mean HAZ score was slightly worse among boys, however this difference did not reach was not statistical significance (p=0.068). There were clear, statistically significant differences in mean HAZ by birth weight classification, where children whose birth weight was considered low (< 2.5kg) exhibiting the lowest mean HAZ score at -1.48, compared to normal and high birth weight children (*p*<0.001). There were no significant differences in mean HAZ between children who had experienced any morbidity in the two weeks prior to survey and those who had not. In terms of the maternal biological characteristics, children whose mothers had a short stature (< 145 cm) reported lower mean HAZ scores (-1.90, *p*<0.001) and similarly, children of mothers who were considered underweight by BMI classification reported worse mean HAZ scores (*p*=0.003). Children whose mothers had achieved secondary/higher level of education had higher mean HAZ scores compared to those with no education or primary level (*p*=0.009). Differences in mean HAZ by level of maternal participation in the labour force revealed some interesting results: children of mothers who were considered to have a high level of participation in employment had the higher mean HAZ scores than children of mothers who were not working or had low levels of participation (-0.98, *p*<0.001). Household wealth was positively associated with higher mean HAZ scores (*p*<0.001), suggesting children from the poorest households were the most disadvantaged in terms of nutrition. Residence in an urban area also offered advantage over rural areas as mean HAZ was significantly higher in urban areas (-0.88) compared to rural (-1.25) (*p*<0.001). There was no significant difference in mean HAZ by breastfeeding status, but among children who consumed a diet high in diversity compared to other children of the same age, the mean HAZ was higher (*p*<0.001). In terms of minimum meal frequency, there were no statistically significant differences in mean HAZ between children who received the minimum meal frequency and those who did not.

Explanatory variables that explained significant differences in mean HAZ scores in adjusted Wald tests (Table 5.1, p.162) were considered for inclusion in the structural path models.

Table 5.2 Mean height-for-age Z-scores by age, for children aged 6 to <24 months, adjusted estimates for Cambodia (2014)

	Age in months (*n* = 1,381)				
Age (months)	6-8	9-11	12-17	18-23	**6-23**
N	242	208	463	468	**1381**
Height-for-age z-score (Mean ± SD)	-0.55 ± 1.25	-0.92 ± 1.48	-1.41 ± 1.23	-1.46 ± 1.32	**-1.20 ± 1.35**
Prevalence of stunting (%, 95%CI)	13.9	18.5	29.2	32.4	**26.0**

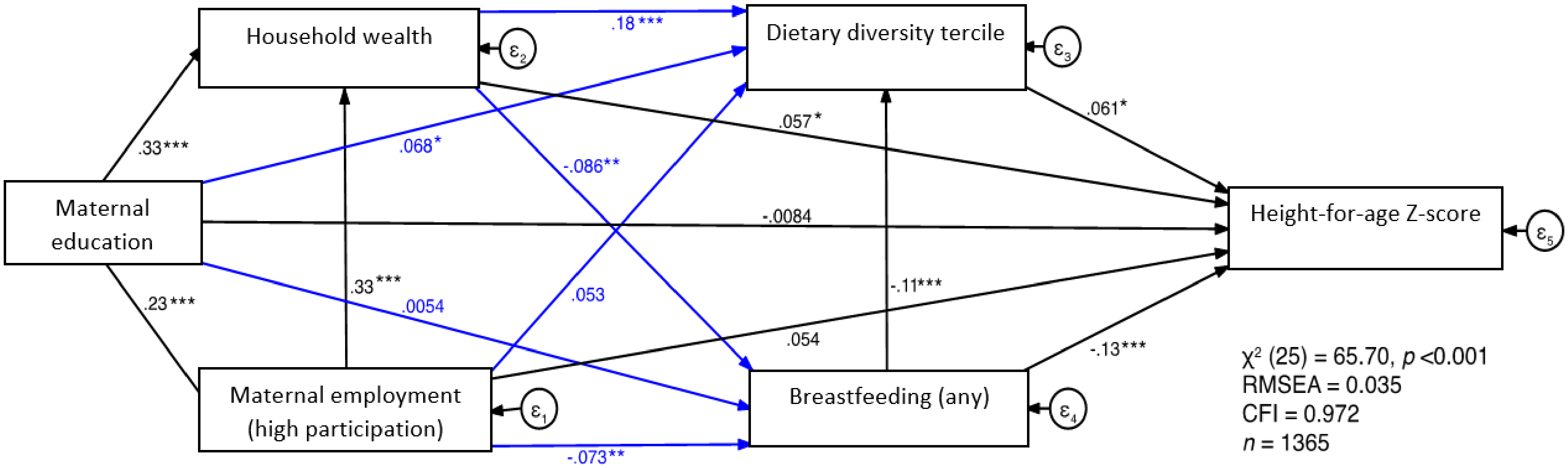
5.2.3 Structural Path Analysis

Is maternal education, household wealth and maternal employment associated with dietary diversity and continued breastfeeding?

Figure 5.1 (p.166) represents the full structural path model, highlighting the standardized path coefficients that are relevant to the first research question for this study which explores whether maternal education, household wealth and maternal employment are associated with dietary diversity and breastfeeding. The full standardized and unstandardized coefficients are presented in Table 6. Overall the fit of the model according to RMSEA (< 0.05) and CFI (>0.950) was good (Schreiber et al., 2006) and the model explains approximately 44% of the variance in Cambodian children's HAZ scores (R^2=0.44).

Maternal education was significantly and positively associated with dietary diversity tercile (Figure 5.1, p.166; Table 5.3, p.167). One SD increase in maternal education was associated with a 0.07 SD increase in dietary diversity (β = 0.07; *p* <0.05), but no notable effect on breastfeeding status. Similarly, household wealth had a positive impact on dietary diversity tercile which was statistically significant as a 1 SD increase in household wealth was associated with a 0.18 SD increase in dietary diversity tercile (β = 0.18; *p* <0.001). However, increasing household wealth had an inverse relationship with breastfeeding status, where a 1 SD increase in household wealth was associated with -0.09 SD decrease in breastfeeding. A high level of maternal participation in employment was associated with a positive, yet insignificant effect on dietary diversity tercile. In this Cambodian sample, high level of maternal participation in employment was characterised by mothers who reported working for somebody else or were self-employed, worked all year round, were paid in cash and involved in a range of occupations from clerical, sales, services and professional roles. On the other hand, a high level of maternal employment had a statistically significant, negative effect on breastfeeding status after adjusting for age of child (β=-0.07; *p*<0.01). This effect was confirmed amongst all younger age groups by Chi2 test in a decomposition analysis, but not the 18 to <24 month age group (Table 5.4, p.168).

Figure 5.1 Full structural path model, measuring how socioeconomic factors are associated with children's HAZ Z-scores directly and through mediators of dietary diversity and continued breastfeeding. Standardized coefficients. Cambodia (2014)



*p-value<0.05, **p-value<0.01, ***p-value<0.001

Note: Model is adjusted for age, sex, birth weight, maternal stature and urban/rural residence.

Table 5.3 Unstandardized and standardized results of the full structural path model, examining the association between selected socioeconomic factors, mediating feeding practices and child HAZ, Cambodia (2014)

Path	**Unstandardized (β)**	**Standardized (β)**	**R^2**
Maternal employment (high)			0.15
Maternal education	0.167***	0.234***	
Household wealth			0.24
Maternal employment (high)	0.993***	0.327***	
Maternal education	0.706***	0.326***	
Dietary diversity			0.11
Maternal employment (high)	0.088	0.053	
Household wealth	0.097***	0.176***	
Breastfeeding	-0.191***	-0.111***	
Maternal education	0.081*	0.068*	
Breastfeeding			0.24
Maternal employment (high)	-0.071**	-0.073**	
Household wealth	-0.027**	-0.086**	
Maternal education	0.004	0.005	
HAZ			0.12
Maternal employment (high)	0.168	0.054	
Household wealth	0.058*	0.057*	
Dietary diversity	0.113*	0.061*	
Breastfeeding	-0.413***	-0.129***	
Maternal education	-0.019	-0.008	
Overall R^2			0.44
χ^2 (df)	65.70 (25)		
RMSEA	0.035		
CFI	0.972		

*p-value<0.05, **p-value<0.01, ***p-value<0.001

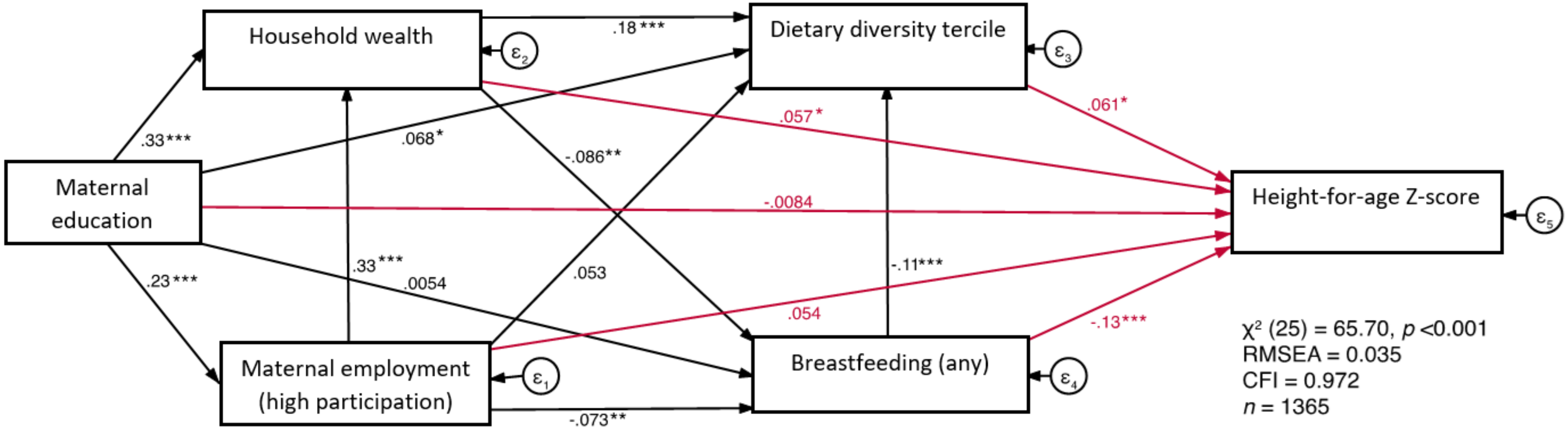
Table 5.4 Proportion of women who reported breastfeeding at time of survey, by level of maternal participation in employment and child age group, Cambodia (2014)

	Age in months (n=1,365)				
	6-8	**9-11**	**12-17**	**18-23**	**6-23**
Not working or maternal employment (low)	95.3	93.6	85.7	42.3	75.5
Maternal employment (high)	82.6	78.8	72.0	34.0	59.0
X^2 test	X^2=8.52(1), p=0.004	X^2=7.06(1), p=0.008	X^2=7.52(1), p=0.006	X^2=2.03(1), p=0.155	X^2=24.72(1), p<0.001

To what extent (if at all) do dietary diversity and continued breastfeeding mediate the association between socioeconomic factors and children's height-for-age Z-scores?

The same structural path model as was previously presented, is presented in Figure 5.2 with the pathways relevant to this research question highlighted. Both hypothesised mediating variables – dietary diversity tercile and breastfeeding status – were independently and significantly associated with child HAZ score, although having contrasting effects. One SD increase in dietary diversity tercile was associated with a 0.06 SD increase in HAZ (p<0.05), whereas continued breastfeeding was associated with a -0.13 decrease in HAZ (p<0.001) (Table 5.3, p.167). The only underlying socioeconomic factor that had a statistically significant direct association with HAZ was household wealth, where a 1 SD increase in household wealth was associated with a 0.06 SD increase in HAZ (p<0.05).

Figure 5.2 Full structural path model, measuring how socioeconomic factors are associated with children's HAZ Z-scores directly and through mediators of dietary diversity and continued breastfeeding. Standardized coefficients. Cambodia (2014).



*p-value<0.05, **p-value<0.01, ***p-value<0.001

Note: Model is adjusted for age, sex, birth weight, maternal stature and urban/rural residence.

In order to assess the role of dietary diversity and breastfeeding as mediators in the association between socioeconomic factors (maternal education, household wealth, maternal employment (high)) and HAZ, the indirect pathways were examined (Table 5.5, p.171; Table 5.6, p.171). In terms of maternal education, the standardized effects presented in Table 5.5 (p.171) present a case of 'inconsistent mediation' (MacKinnon et al., 2007), where the direct and indirect effects do not have the same consistent sign. Furthermore, whilst the indirect effect is significant (p<0.001), the direct effect is not and hence, the indirect effect is larger than the total effect meaning that the effect of maternal education on HAZ is completely due to the indirect path which operates through household wealth, maternal employment, dietary diversity and breastfeeding status.

The proportion of the total (direct) effect of high level of maternal employment on HAZ, after controlling for dietary diversity and breastfeeding status, is 57% (0.054/0.094=57), although this was not statistically significant. By contrast, the proportion of the total effect of high level of maternal employment which could be explained by the indirect effect was 41% (0.039/0.094=0.41), so it could be said that 41% of the effect of a high level of participation in maternal employment on HAZ was mediated by dietary diversity or breastfeeding status.

Household wealth was the only underlying (socioeconomic) factor that had a statistically significant direct effect on HAZ, with 71% of the total effect on HAZ estimated to be direct (0.057/0.080=0.71), after controlling for dietary diversity and breastfeeding status. This could of course be representative of the effect of household wealth on HAZ through other mediating factors not accounted for in this model, such as access to health care. By contrast, the indirect effect of household wealth on HAZ was calculated to be 28% (0.022/0.080=0.28), so 28% of the effect of household wealth on HAZ was mediated by dietary diversity or breastfeeding status.

Table 5.5 Standardized effects of maternal education, household wealth, maternal employment and child height-for-age Z-score with correlated residuals for dietary diversity and breastfeeding status.

Outcome	**Direct effect (β)**	**Indirect effect (β)**	**Total effect**
HAZ			
Dietary diversity -> HAZ	0.061*		0.061*
Breastfeeding -> HAZ	-0.129***	-0.007	-0.136***
Maternal Education -> HAZ	-0.008	0.051***	0.043
Maternal employment (high) -> HAZ	0.054	0.039***	0.094**
Household wealth -> HAZ	0.057*	0.022**	0.080**

The significance levels are for the unstandardized solution.

*p-value<0.05, **p-value<0.01, ***p-value<0.001

Further exploration of the specific indirect pathways between underlying (socioeconomic) factors and HAZ, through mediating variables of dietary diversity and breastfeeding, showed evidence of three indirect pathways that were statistically significant (Table 5.6). High level of maternal employment had a small but significant standardized effect on HAZ that was mediated by breastfeeding status of 0.01, z=2.30, p <0.05. Household wealth also had an even smaller but still statistically significant standardized effect on HAZ that was mediated by both dietary diversity and breastfeeding status (0.01, z=2.13, p<0.05; 0.01, z=2.58, p<0.01 respectively).

Table 5.6 Results of non-linear combinations for testing specific standardized indirect effects

Path	**Indirect Effect**			
	Coef.	**z**	**P-value**	**95% CI**
Maternal education -> Dietary diversity -> HAZ	0.004	1.63	0.104	(-0.00, 0.01)
Maternal education -> Breastfeeding -> HAZ	-0.001	-0.20	0.842	(-0.01, 0.01)
Maternal employment (high) -> Dietary diversity -> HAZ	0.003	1.41	0.159	(-0.00, 0.01)
Maternal employment (high) -> Breastfeeding -> HAZ	0.009	2.30	0.022	(0.00, 0.02)
Household wealth -> Dietary diversity -> HAZ	0.011	2.13	0.033	(0.00, 0.02)
Household wealth -> Breastfeeding -> HAZ	0.011	2.58	0.01	(0.00, 0.02)

5.2.4 Adjusting for the moderating effect of urban/rural residence

Are these aforementioned associations moderate by urban/rural residence?

It is clear that there are observed differences in mean height-for-age Z-scores between urban and rural areas, with children in rural areas in Cambodia generally fairing worse (Figure 5.3; Table 5.7, p.173). This has also been confirmed by numerous other studies conducted in low- and middle-income countries that found that children living in rural areas had worse nutritional outcomes, compared to their urban counterparts. Therefore, this part of the analysis examines whether the hypothetical paths presented in the structural path models are statistically different between urban and rural areas and whether the magnitude of association between specific variables increases or decreases. Two approaches were taken to assess urban-rural differences in the hypothesized pathways, both the unconstrained and constrained solution are presented in Table 5.8 (p.175). The unconstrained solution where all parameters were allowed to vary by urban-rural residence, provided a better fitting model than the constrained solution, however both sets of results were interpreted as the findings were notable.

Figure 5.3 Mean height-for-age Z-scores by child age group and urban/rural residence, (upper SD represented by error bar)

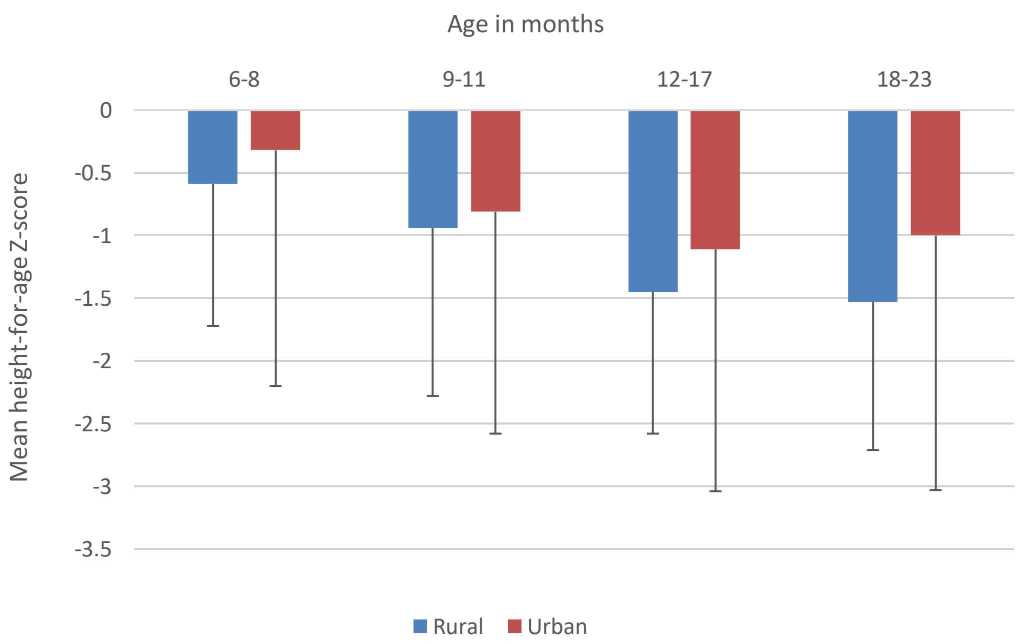


Table 5.7 Mean height-for-age Z-scores by child age group and urban/rural residence, Cambodia (2014)

	Age in months (*n* = 1,381)									
	6-8		**9-11**		**12-17**		**18-23**		**6-23**	
	Rural	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**
N	209	33	175	33	408	56	401	67	1193	188
Height-for-age z-score (Mean ± SD)	-0.59 ± 1.13	-0.32 ±1.88	-0.94 ± 1.34	-0.81 ± 1.77	-1.45 ± 1.13	-1.11 ± 1.93	-1.53 ± 1.18	-1.00 ± 2.03	-1.25 ± 1.23	-0.88 ± 1.97

Unconstrained solution

The unconstrained solution in which all parameters were allowed to vary, suggested that urban-rural residence had a significant moderating effect on some of the pathways in the hypothesised path analysis. Firstly, a 1 SD increase in maternal education in rural areas was associated with a 0.07 SD increase in dietary diversity in rural areas (*p*<0.05), but the association was not significant in urban areas. In terms of the underlying (socioeconomic) factors associated with breastfeeding, a high level of maternal employment was significantly, negatively associated with breastfeeding status in rural areas, where a 1 SD increase in maternal employment was associated with a -0.07 SD increase in breastfeeding (*p*<0.05), contrary to urban areas where this association was not significant. One of the most significant differences between urban and rural areas that was represented by the unconstrained solution was the effect of household wealth on breastfeeding. In urban areas, a 1 SD increase in household wealth was associated with a statistically significant decrease in breastfeeding by -0.26 SD (*p<0.01),* whereas there was no such observed association in rural areas, suggesting a strong moderating effect of urban-rural residence on this pathway. Finally, the results from the unconstrained solution suggested that both household wealth and dietary diversity were positively associated with HAZ through a statistically significant direct pathway, a finding which was not observed in urban areas (0.10, *p*<0.01; 0.07, *p*<0.05 respectively).

Constrained solution

Although the unconstrained solution which accounted for the moderating effect of urban-rural residence was the better fitting model, a constrained solution was also tested and the results presented in Table 12. After conducting a Wald test for the group invariance of parameters between urban-rural areas (Table 5.9, p.177), the only pathway that was found to be statistically different between urban and rural areas was the effect of household wealth on breastfeeding status (*p*<0.001). As a result, the constrained solution for assessing the moderating effect of urban-rural residence constrained all parameters to be identical except for the pathway between household wealth and breastfeeding status. The constrained solution did not offer a good fit to the data when compared to the unconstrained solution, and the difference in coefficient of the unconstrained pathway between urban-rural areas was very similar to the results obtained from the unconstrained solution.

Table 5.8 Summary table for multiple-group analysis, unstandardized (B) and standardized coefficients (β)

Path	**Unconstrained solution**				**Constrained solution**			
	Rural (*n*=1001)		**Urban (*n*=364)**		**Rural (*n*=1001)**		**Urban (*n*=364)**	
	B	**β**	**B**	**β**	**B**	**β**	**B**	**β**
Maternal employment (high)								
Maternal education	0.157***	0.231***	0.197***	0.245***	0.165***	0.243***	0.165***	0.208***
Household wealth								
Maternal employment (high)	1.091***	0.325***	0.780***	0.277***	0.989***	0.299***	0.989***	0.339***
Maternal education	0.711***	0.312***	0.686***	0.305***	0.706***	0.314***	0.706***	0.304***
Dietary diversity								
Maternal employment (high)	0.057	0.032	0.161	0.101	0.089	0.05	0.089	0.057
Household wealth	0.084***	0.159***	0.128***	0.225***	0.097***	0.180***	0.097***	0.181***
Breastfeeding	-0.128*	-0.072*	-0.284**	-0.178**	-0.193***	-0.106***	-0.193***	-0.129***
Maternal education	0.087*	0.072*	0.070	0.054	0.081*	0.066*	0.081*	0.065*
Breastfeeding								
Maternal employment (high)	-0.072*	-0.072*	-0.065	-0.065	-0.070**	-0.072**	-0.070**	-0.067**
Household wealth	-0.007	-0.024	-0.093***	-0.262***	**-0.009**	**-0.029**	**-0.082*** **	**-0.227*** **
Maternal education	-0.010	-0.015	0.044	0.054	-0.000	-0.000	-0.000	-0.000

Path	Unconstrained solution				Constrained solution			
HAZ								
Maternal employment (high)	0.116	0.036	0.054	0.017	0.112	0.035	0.112	0.033
Household wealth	0.095**	0.099**	-0.004	-0.004	0.083**	0.086**	0.083**	0.072**
Dietary diversity	0.119*	0.066*	0.031	0.015	0.102*	0.057*	0.102*	0.048*
Breastfeeding	-0.370**	-0.115**	-0.549**	-0.168**	-0.375***	-0.115***	-0.375***	-0.118***
Maternal education	-0.135	-0.062	0.196	0.075	-0.079	-0.036	-0.079	-0.030
χ^2 overall (df)	81.69(40)				123.43(64)			
RMSEA	0.039				0.037			
CFI	0.962				0.946			

*p-value<0.05, **p-value<0.01, ***p-value<0.001. **Bold:** Unconstrained parameter in the constrained model.

Note: For the constrained solution, the unstandardized coefficients (B) are identical by urban/rural residence, however the standardized (β) coefficients do vary by urban/rural residence unless the variances between the two groups are completely equal.

Table 5.9 Wald test for assessing statistical differences in paths between urban and rural areas

Path	Chi2	*P-value*
Maternal employment (high)		
Maternal education	0.74	0.389
Household wealth		
Maternal employment (high)	3.52	0.061
Maternal education	0.04	0.845
Dietary diversity		
Maternal employment (high)	1.01	0.315
Household wealth	1.39	0.239
Breastfeeding	2.19	0.139
Maternal education	0.05	0.831
Breastfeeding		
Maternal employment (high)	0.02	0.903
Household wealth	16.10	<0.001
Maternal education	1.35	0.246
HAZ		
Maternal employment (high)	0.09	0.766
Household wealth	1.67	0.197
Dietary diversity	0.51	0.474
Breastfeeding	0.71	0.399
Maternal education	4.39	0.056

5.3 Summary of findings

This section summarises the results of the second analysis; the findings are discussed in Chapter seven of this thesis (Chapter 7.3.3, p.215).

- With reference to the first research question proposed by this analysis chapter, better socioeconomic status, measured by level of maternal education, household wealth and high level of female employment, demonstrated positive associations with dietary diversity, but inverse associations with continued breastfeeding.
- Continued breastfeeding had a significant and negative association with dietary diversity, implying that if children were still being breastfed, they were less likely to receive a diverse diet. This is perhaps a reflection of the way in which dietary diversity is measured as breast milk is not included as one of the food groups, and therefore the dietary diversity of non-breastfed children may be inflated.
- Dietary diversity and continued breastfeeding were mediating factors in three of the pathways between socioeconomic status and HAZ:
    - High level of maternal employment had a small but significant association with HAZ that was mediated by breastfeeding status.
    - Dietary diversity and breastfeeding status were both mediating variables in the pathways between household wealth and HAZ.
- Urban/rural residence had a significant moderating effect the following associations (using an unconstrained solution for structural path analysis):
    - Within rural areas, a higher level of maternal education was associated with improvements in dietary diversity, but this was insignificant in urban areas.
    - Increasing household wealth demonstrated an inverse association with continued breastfeeding among urban households.
    - The unconstrained solution highlighted the importance of dietary diversity and household wealth for children residing in rural areas, with significant and positive pathways between both of these variables and the outcome, HAZ.

Chapter 6 Associations between early life factors and growth trajectories throughout childhood and adolescence: longitudinal evidence from Indonesia

6.1 Introduction

The results of the analysis presented in Chapter 5, which examined the hypothetical pathways to stunting using cross-sectional DHS data, suggested that dietary diversity and continued breastfeeding were significantly and positively associated with height-for-age Z-scores in children aged 6 to <24 months in Cambodia. That analysis also highlighted that there were underlying socioeconomic factors that were directly and indirectly associated with height-for-age Z-scores, where dietary diversity and continued breastfeeding sometimes played a mediating role in these associations. However, because that analysis used current-status data from a cross-sectional survey, it was not possible to assess the associations between the selected child feeding practices and longer-term growth or nutritional outcomes. Accordingly, the analysis presented here attempted to examine the role of early life environment (including feeding practices where data was available) on longer-term growth throughout childhood and adolescence, in order to determine whether the associations seen in the analysis presented in Chapter 5 could still be observed over a longer period.

The analysis presented in this chapter used longitudinal data from the Indonesian Family Life Survey (IFLS) and examined growth trajectories of a total 660 children aged between 6 and 36 months in IFLS-1 (1993) and followed-up in three subsequent waves of the IFLS: 1997, 2000 and 2007. As has been discussed in Chapter 2 of this thesis, Indonesia is currently challenged with a double burden of malnutrition with latest data from 2012 finding that 11.3% of children under-5 years of age were overweight or obese (UNICEF, 2018) whilst chronic stunting in a large proportion of children persists. Therefore, children's BMI was the child nutritional indicator employed in this analysis, in order to identify those children exhibiting pathways conducive to longer-term overweight and obesity. Two different analytical methods were applied to address the two main research questions (see section 6.2.1), posed by this study. Firstly, group-based trajectory models (GBTM) were used to identify distinctive BMI growth trajectories amongst the total eligible sample of Indonesian children (*n*=873); children were assigned to approximately homogenous groups based on the shape of their trajectories of BMI over time. Secondly, the early life factors associated with trajectory group membership were assessed using binary logistic regression analysis. This current analysis is one of few longitudinal studies assessing BMI trajectories in young children through to adolescence in low- and middle-income countries, and to the best of current knowledge, the first to be conducted using Indonesian data.

BMI-for-age is an anthropometric measure of child's weight relative to their height, used to assess incidence of underweight or overweight and obesity. Although the calculation of BMI as such is identical in both adults and children, BMI-for-age is both gender- and age-specific, relative to WHO child growth references (WHO, 2006), and is the recommended measure for children due to the substantial fluctuations in BMI throughout this period (Hammer et al., 1991; Pietrobelli et al., 1998). The study of childhood BMI has gained increasing recognition because of the associations between elevated BMI during childhood and/or adolescence and the increased probability of overweight and obesity in adulthood (Kvaavik et al., 2003; Guo et al., 2002; Buscot et al., 2018; Whitaker et al., 1997). Furthermore, high childhood BMI and evidence of overweight tracking through adolescence into early adulthood is also known to be significantly associated with several later onset co-morbidities, such as cardiovascular disease and Type-2 diabetes mellitus (Freedman et al., 2007; Stuart and Panico 2016; Dulloo et al., 2006). Buscat et al., (2018) emphasise the importance of early interventions, before age six years, in cases where children exhibit elevated BMI trajectories as pathways to overweight and obesity are difficult to reverse once they have been established (Giles et al., 2015; Monteiro and Victora, 2005). Therefore, it is important to assess the role of modifiable factors in the early life that may prevent development of overweight or obesity, such as breastfeeding which has been increasingly shown to offer protection against overweight and obesity in childhood (Arenz et al., 2004; Harder et al., 2005; Horta and Victora, 2013).

Group-based trajectory modelling (GBTM) is particularly suited to the study of longitudinal repeated BMI measures, as it simulates the continuity of real-life growth and allows for the identification of distinct trajectories at population level (Nagin, 2014). Developed by Daniel Nagin in 1999, GBTM works under the assumption that there may be meaningful sub-groups within a population and observations can be classified into approximately homogenous groups on the basis of them sharing similar developmental trajectories (Nagin, 2014).

Longitudinal data from the Indonesian Family Life Survey (IFLS) offers a unique and valuable opportunity to examine BMI trajectories in young children from a rapidly changing LMIC context where there are likely to be substantial socioeconomic differentials. Furthermore, Indonesia is a particularly interesting case study due to the emergence of a double burden of malnutrition. Using the same IFLS data set with repeated cross-sectional analysis, Rachmi and colleagues (2016) observed that between the first wave of the survey in 1993 and the fourth in 2007, prevalence of overweight and obesity increased from 10.3% to 16.5% in children aged 2.0 to 4.9 years. Although the prevalence of stunting decreased over the same period from 50.8% to 36.7%, it remains a priority public health concern. This double burden of malnutrition has even been observed at the individual level in Indonesia, with reports from a national survey that 6.8% of children under five exhibited both stunting and overweight or obesity in 2013. On the whole, Indonesian National Synthetic Growth charts suggest that Indonesian children have a shorter stature and are slightly heavier compared WHO growth standards, with the exception of early infancy and late adolescence (Pulungan et al., 2018). Previous research suggests that parental overweight or obesity is a strong predictor of child overweight or obesity in Indonesia (Rachmi et al., 2016; Syahrul et al., 2016), and that prevalence is between four to five times higher in non-poor urban children than in rural or poor urban children (Julia et al., 2004).

6.1.1 Research Questions

This chapter addresses the following research questions:

1) Can a distinctive BMI growth trajectory be identified in these Indonesian children (aged between 0 to <36 months in the first wave of the Indonesian family life survey and followed through to 14 to 17 years in wave four) that would indicate the development of overweight and obesity??
2) Does the early life environment – including early infant feeding practices - explain variability in child growth outcomes?

6.2 Results

This analysis used longitudinal data from the first four waves of the Indonesian Family Life Survey (IFLS) to model a total of 873 children's BMI growth trajectories from early childhood (6 to <36 months) to early adolescence (14 to <17 years). Group-based trajectory modelling (GBTM) was employed to firstly identify distinctive BMI trajectory groups among this population of Indonesian children, with BMI-for-age modelled as a continuous variable. GBTM identified two distinct BMI trajectory groups in the sample: the first in which children followed approximately normal growth and the second in which children demonstrated an elevated BMI pathway, leading to later prevalence of overweight or obesity. These two trajectory groups were transformed into one dichotomous outcome variable and Chi-square tests of association tested for potential relationships between trajectory group membership and relevant explanatory variables relating to early life and distal (underlying factors). Variables significant in bivariate analysis (p<0.05), were included in binary logistic regression models which modelled the likelihood of children belonging to the elevated BMI trajectory, according to different proximate and distal factors. A more in-depth discussion of the methodological approach is provided in Chapter 3.3.

Firstly, characteristics of the sample are described and then the selected GBTM model is presented, with some descriptive analysis which supports the explanation of the model fit. Bivariate analysis and results of multivariable logistic regression models then follow.

6.2.1 Description of sample

Table 6.1 presents the descriptive analysis of the sample *(n*=873). Of the 873 children aged between six months and three years in 1993, 47.9% were female and 52.1% male. The average age of these children in IFLS-4 (2007) was 15.4 years. Although 39.2% of children had no birth weight data, of those who did have this data 9.5% were of low birthweight (<2.5 kg), and 3.6% of large birth weight (≥ 4.0 kg). Prevalence of stunting (<-2 SD, height-for-age z-score) was apparent in less than half of the sample in 1993 (42.7%), declining in 1997 to 24.9%, to increase and fall again in 2000 and 2007. There was a slight decrease in prevalence of underweight, as defined by weight-for-age z-score (<-2 SD), between 1993 and 1997, from 27.7% to 20.3%. However, underweight as represented by BMI-for-age z-scores decreased from 10.1% to 8.2% over the same period. The proportion of children considered overweight or obese varied from 13.4% in 1993 (117 children) to 9.0% in 2007 (70 children). In terms of early life factors such as infant feeding practices, the majority of children were ever breastfed (98.2%), however only 25.7% of mothers reportedly breastfed exclusively for 3 months or more. Duration of any breastfeeding was significantly longer, with 82.1% of mothers breastfeeding for six months or longer, but over two-thirds of children (80.1%) had received complementary foods before the recommended age of six months.

Approximately one quarter of mothers were aged below 25 year at the time of IFLS-1 (25.2%), and just 19.0% had completed a secondary or higher level of education. At the time of IFLS-1, 19.7% of women reported working for wages during the past seven days, however those who worked without wages were not captured by the survey or at least distinguished from those who did not work at all. The majority of households were Muslim (87.7%), and just under half of the sample resided in urban areas (42.5%).

Table 6.1 Characteristics of study sample of Indonesian children (*n*=873), aged between 6 months and <3 years at IFLS-1 (1993), followed up for at least 1 subsequent wave

	Indonesia (*n*=873)							
	IFLS-1 (1993) (*n*=873)		**IFLS-2 (1997) (*n*=775)**		**IFLS-3 (2000) (*n*=838)**		**IFLS-4 (2007) (*n*=779)**	
Characteristics	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Inherent (biological) factors								
Child age (years) [mean]	1.2		5.1		8.0		15.4	
Sex								
Male	455	52.1						
Female	418	47.9						
Birth weight								
<2.5 kg	83	9.5						
2.5 kg <4.0 kg	417	47.8						
≥ 4.0kg	31	3.6						
(missing)	342	39.2						
Height-for-age								
Normal height	500	57.3	582	75.1	487	58.1	593	76.1
Stunted	373	42.7	193	24.9	351	41.9	186	23.9
Weight-for-age								
Normal weight	628	72.4	619	79.7				
Underweight	240	27.7	158	20.3				
BMI-for-age								
Underweight	88	10.1	63	8.2	85	10.3	66	8.5
Normal	668	76.5	670	87.4	695	83.9	639	82.5
Overweight/obese	117	13.4	34	4.4	48	5.8	70	9.0
Maternal BMI								
Normal	610	69.9						
Underweight	134	15.4						
Overweight/obese	114	13.1						
(missing)	15	1.7						

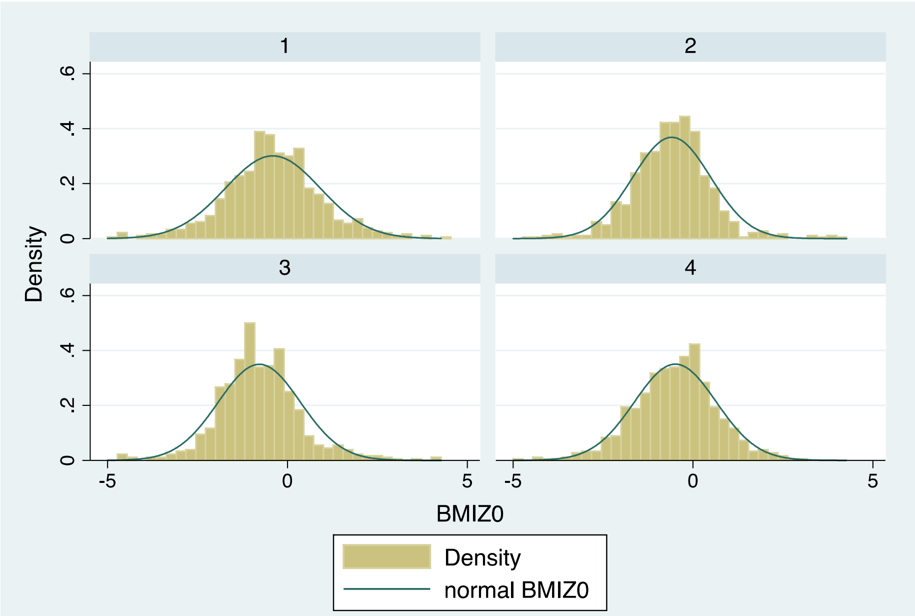
	Indonesia (*n*=873)							
	IFLS-1 (1993) (*n*=873)		IFLS-2 (1997) (*n*=775)		IFLS-3 (2000) (*n*=838)		IFLS-4 (2007) (*n*=779)	
Characteristics	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Maternal stature								
Normal stature	725	83.1						
Short stature (<145 cm)	133	15.2						
(missing)	15	1.7						
Proximate factors								
Duration of exclusive breastfeeding								
< 3 months	632	72.4						
≥ 3 months	224	25.7						
Never breastfed	16	1.8						
(missing)	1	0.1						
Introduction of complementary foods								
< 6 months (early introduction)	699	80.1						
6-8 months	103	11.8						
≥ 8 months (late introduction)	63	7.2						
(missing)	8	0.9						
Duration of continued breastfeeding								
< 6 months	32	3.7						
≥ 6 months	717	82.1						
Never breastfed	16	1.8						
(missing)	108	12.4						
Colostrum given to baby								
No	305	34.9						
Yes	550	63.0						
(missing)	18	2.1						
Intermediate Factors								
Check-up during pregnancy								
No	92	10.5						
Yes	769	88.1						
(missing)	12	1.4						
Mother's age at IFLS-1 (1993)								
35+ years	181	20.7						
25-34 years	472	54.1						
15-24 years	220	25.2						
(missing)	0	0.0						
Distal (underlying) factors								
Mothers highest educational level								
No education/primary	579	66.3						
Middle school	127	14.6						
Secondary & Higher	166	19.0						

Characteristics	Indonesia (*n*=873) IFLS-1 (1993) (*n*=873) N	%	IFLS-2 (1997) (*n*=775) N	%	IFLS-3 (2000) (*n*=838) N	%	IFLS-4 (2007) (*n*=779) N	%
(missing)	1	0.1						
Maternal employment at IFLS-1								
Did not work for wages in past 7 days	684	78.4						
Worked for wages in past 7 days	172	19.7						
(missing)	17	2.0						
Religion								
Muslim	766	87.7						
Hindu, Buddhist, Protestant, Other	107	12.3						
(missing)	0	0.0						
Household wealth (by urban rural)								
Poorest	290	33.2						
Middle	289	33.1						
Richest	289	33.1						
(missing)	5	0.6						
Place of residence								
Rural	502	57.5						
Urban	371	42.5						
(missing)	0	0.0						

6.2.2 oup-based Trajectory Models – Model Selection

Further exploratory analysis was conducted prior to estimating GBTM in order to assess the suitability of continuous BMI estimate as the outcome of interest compared to international reference standards, as well as empirical evidence from Indonesia itself. Since GBTM requires that the distribution of the model be specified, it was essential to assess whether the distribution of BMI at each wave was approximately normal. Evidence from Figure 6.1suggested that at each wave of the IFLS, the assumption of normal distribution holds for raw BMI estimate, indicating that a censored normal distribution should be used in the model specification.

Figure 6.1 Distribution plots for continuous BMI at each IFLS wave



Note: Plot 1: IFLS-1 (1993), Plot 2: IFLS-2 (1997), Plot 3: IFLS-3 (2000), Plot 4: IFLS-4 (2007)

Figure 6.2plots the mean BMI-for-age with 95% confidence intervals in parentheses at each wave for the selected sample of children (n=873), confirming that the shape of plotted mean BMI at each age in this sample is approximately similar to percentile charts modelled by the WHO Multicentre Growth Reference Study Group (2006), albeit that on average mean BMI is slightly lower for this sample of Indonesian children. Further comparison with Indonesian national synthetic growth charts substantiates our findings with slightly lower mean BMI estimates by age, which is comparable to the results from our study (Pulungan et al., 2018). The overall shape of mean BMI-for-age over the study period suggests a biologically plausible pattern, in line with international WHO growth curves, where BMI tends to experience a nadir after one year of age, falling to its lowest point between the ages of 4-6 which can be depicted here at IFLS-2. It is at this point that BMI usually experiences a steady, gradual increase which can be observed here with rising mean BMI at IFLS-3 and IFLS-4, perhaps further evidence of the so-called 'adiposity rebound' (Rolland-Cachera et al., 1984). Additional stratification by child sex (Figure 6.3) confirms that mean BMI growth patterns are approximately similar for both girls and boys in this sample.

Figure 6.2 Mean BMI-for-age by IFLS wave, *n*=873 (min. and max. represented by error bars)

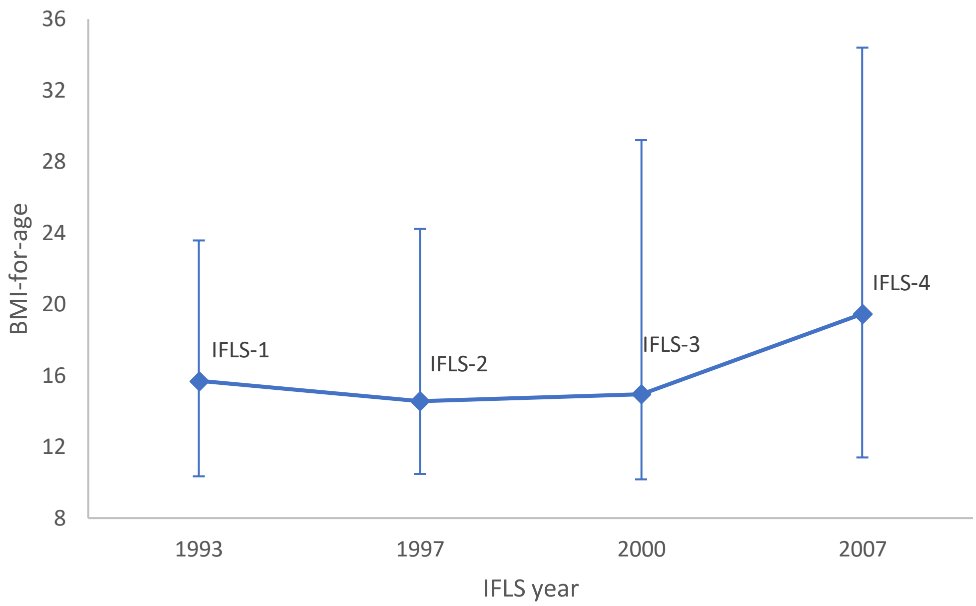
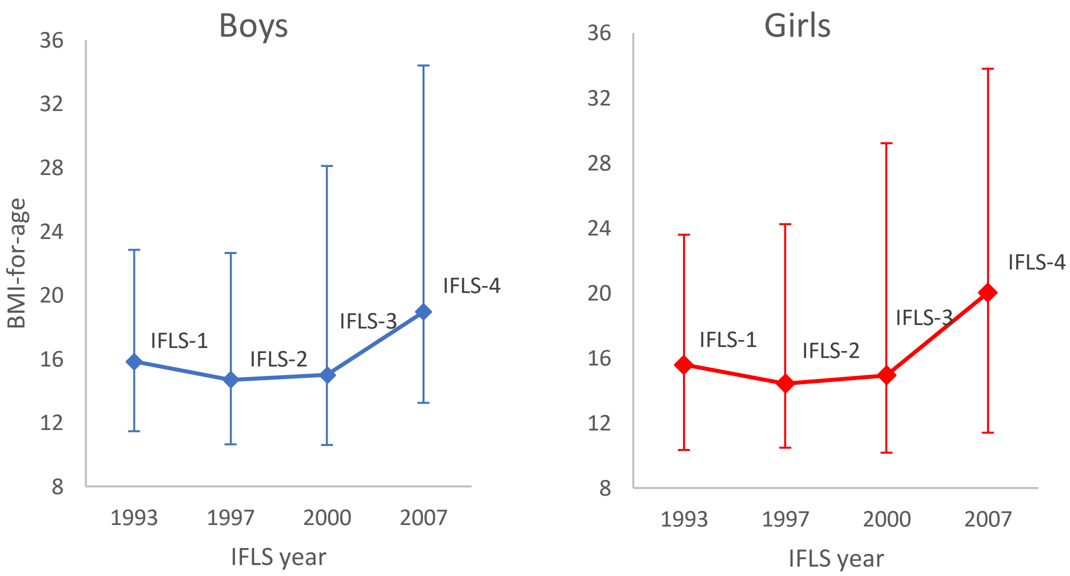


Figure 6.3 Mean BMI-for-age by IFLS wave and sex, *n*=873 (min. and max. represented by error bars)



6.2.3 GBTM Model Selection

Figure 6.2 shows that BMI development in children is not linear, but characterised by inflections at each time point. As a result, it was decided that the cubic polynomial function be assigned to the shape of each trajectory to account for non-linear change in BMI. A step-wise approach was taken to fitting the GBTM and the number of trajectory groups were added incrementally to assess the change in BIC estimate (Table 6.2).

Table 6.2 Model selection statistics

Number of groups	Polynomial order	BIC	Average posterior group membership probability[a]
1	3	-7065.87	>0.7
2	3, 3	-6767.61	>0.7
3	3, 3, 3	-6670.22	>0.7
4	3, 3, 3, 3	-6638.95	>0.7

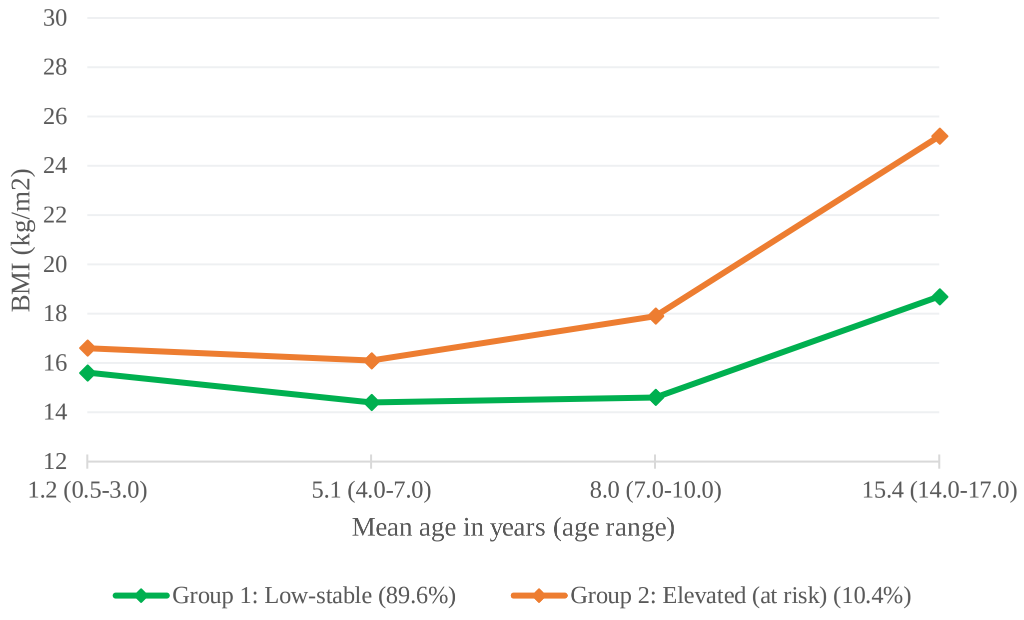
Note: [a] According to Nagin and Odgers (2010), average posterior group membership probabilities should exceed 0.7 for optimal model selection.

The four-group and three-group models indicated a higher BIC[32] estimate compared to models with less groups, however, due to the small sample size it was decided that the four-group and three-group model would not be appropriate since probability of group membership would be too small for one or more of the groups. The two group trajectory model (3 3) was selected and the results are described in the following section.

[32] The Bayesian information criterion (BIC) is an estimate used for model selection and measures goodness-of-fit. Higher values of BIC (least negative), indicate a model with a better fit.

Two-group trajectory model

Figure 6.4 Body Mass Index (BMI) trajectory groups (BMI calculated as kg/m²). 2-group model based on longitudinal data from Indonesian Family Life Survey, *n*=873.



GBTM identified two distinct BMI trajectories in this sample of Indonesian children. The majority of children belonged to the first trajectory which was labelled a 'low-stable' and the second trajectory identified a smaller group of children who followed 'elevated (at risk)' BMI growth. The characteristics of these two trajectories and the implications for such growth are described in more detail in the sections which follow.

Group 1: Low-stable

This model identified a group of children who followed an approximately 'low-stable' trajectory (89.6%, *n*=782) similar to growth demonstrated by the median BMI growth trajectory of WHO Child Growth References (2006). Although the mean BMI estimates (Table 6.3, p.190) for this trajectory group insinuate that these children follow approximately normal growth, the range of BMI values at each wave suggested that some children were also severely underweight, with some falling below the 3rd percentile on WHO growth reference curves (see Appendix G, p.253). For example, for children following the 'low-stable' trajectory, BMI values ranged from a minimum of 11.4 to a maximum of 24.3 at IFLS-4 when the mean age of children was 15.4 and mean BMI was 18.7 (Table 6.3, p.190). With reference to the WHO BMI growth references for children aged 15.4 years, median BMI is 20.4 for girls and 20.0 for boys which suggests that although overall children in this trajectory group fall within the normal BMI growth range[33], their average BMI falls slightly below the international reference (WHO, 2007; see Appendix G, p.253). Therefore, this trajectory group was labelled ‘low-stable’ because whilst it overall represented approximately normal BMI growth, the mean BMI estimates fall slightly short of the median WHO growth references and there are some children with BMI values which fall below the 3rd percentile which is considered underweight.

Group 2: Elevated (at risk)

Conversely, the GBTM identified a smaller group of children who followed an elevated BMI trajectory (10.4%, *n*=91), some of whom were already experiencing overweight and obesity by IFLS-3 or IFLS-4. Although some of the children following this elevated BMI trajectory had not surpassed the threshold for overweight and obesity, they could be considered ‘at risk’ of developing overweight and obesity before these cut-offs were reached[34]. The WHO also emphasises that the co-morbidities associated with overweight and obesity are continuous and may have a negative impact on a child’s quality of life, even before these thresholds are met (2016). With reference to the mean BMI estimates at each wave for this elevated BMI trajectory (Table 6.3) the mean BMI of children in IFLS-1 and IFLS-2 fell within the normal growth range, but slightly below the 85th percentile when compared to WHO BMI growth references (see Appendix G, p.253). However, by IFLS-3 and IFLS-4, the mean BMI estimates of children following this elevated trajectory exceeded the 85th percentile with some children considered to be in the 99th percentile which is severely obese. This was also evident on the plotted trajectories (Figure 6.4), where there seems to be an apparent divergence in BMI trajectories in IFLS-3 and an even greater divergence in IFLS-4.

Table 6.3 Mean BMI estimates and range for each trajectory group by IFLS wave (age). 2-group model.

IFLS wave	Mean age in years (age range)	Group 1: Low-stable (*n*=782)		Group 2: Elevated (at risk) (*n*=91)	
		Mean BMI	**(range)**	**Mean BMI**	**(range)**
IFLS-1 (1993)	1.2 (0.5-3.0)	15.6	(10.3, 23.6)	16.6	(11.8, 20.9)
IFLS-2 (1997)	5.1 (4.0-7.0)	14.4	(10.5, 22.6)	16.1	(13.6, 24.2)
IFLS-3 (2000)	8.0 (7.0-10.0)	14.6	(10.2, 27.3)	17.9	(12.9, 29.2)
IFLS-4 (2007)	15.4 (14.0-17.0)	18.7	(11.4, 24.3)	25.2	(20.3, 34.4)

[33] Normal weight range is considered to be between the 5th and 85th percentile (WHO, 2007).
[34] Above 85th percentile is considered overweight (WHO, 2007).

This two-group trajectory outcome was employed throughout the remainder of this study as the main dependent, dichotomous variable where an outcome of belonging to the 'elevated (at risk)' trajectory was coded as 1 and the low-stable coded as 0.

6.2.4 Bivariate analysis

Chi-square tests of association were conducted to examine bivariate associations between relevant independent variables relating to the early life environment and the probability of following the 'elevated (at risk)' trajectory pathway (Table 6.4). Observations with missing data were excluded from analyses where the proportion of missing data was less than 5% for each independent variable. However, for independent variables with more than 5% of missing data, a separate 'missing' category was included, in order to retain sample size and reduce bias. Exact numbers of missing observations by independent variable were presented previously in Table 6.1, (p.183).

In terms of biological factors associated with trajectory group membership, bivariate analysis suggested that female children were significantly more likely to belong to the 'elevated (at risk)' BMI trajectory (p= 0.011), as were children whose mothers were overweight or obese (p<0.001). A larger proportion of children with high birth weight (≥ 4.0 kg) were classified in the elevated BMI trajectory (16.1%), compared to children who were born underweight (9.6%), although this variable was interpreted with caution due to the high proportion of missing data.

There seemed to be no significant differences in BMI trajectory group by proximate factors such as those relating to early feeding practices.

At the level of the distal (underlying) factors, significant differences in trajectory group membership were shown for each independent variable. Children of mothers with secondary or higher education (p=0.013) and whose mothers reported working for wages in the past seven days at the time of IFLS-1 (p=0.011) had a higher proportion of children following the 'elevated (at risk)' trajectory. A larger proportion of children from non-Muslim households (15.9%) belonged to the elevated (at risk) BMI trajectory and similarly, children residing in urban areas (14.3%). In terms of household wealth, the highest proportion of children classified in the elevated BMI trajectory were from the richest households (p=0.001).

Table 6.4 Proportion of children belonging to each trajectory group, as defined by GBTM, with Chi-square tests of association (*n*=873)

Characteristics	Trajectory Group Low-Stable (*n*=782) %	n	Elevated (at risk) (*n*=91) %	n	*P* Value
Inherent (biological) factors					
Sex					
Male	92.1	419	7.9	36	0..011
Female	86.8	363	13.2	55	
Birth weight					
<2.5 kg	90.4	75	9.6	8	0.001
2.5 kg <4.0 kg	85.9	358	14.2	59	
≥ 4.0kg	83.9	26	16.1	5	
(missing)	94.4	323	5.6	19	
Maternal BMI at IFLS-1 (1993)					
Normal	89.7	547	10.3	63	<0.001
Underweight	96.3	129	3.7	5	
Overweight/obese	80.7	92	19.3	22	
Proximate factors					
Duration of exclusive breastfeeding					
< 3 months	90.7	573	9.3	59	0.199
≥ 3 months	86.6	194	13.4	30	
Never breastfed	93.8	15	6.3	1	
Introduction of complementary foods					
< 6 months (early introduction)	90.1	630	9.9	69	0.504
6-8 months	86.4	89	13.6	14	
≥ 8 months (late introduction)	88.9	56	11.1	7	
Duration of continued breastfeeding					
< 6 months	90.6	29	9.4	3	0.903
≥ 6 months	89.3	640	10.7	77	
Never breastfed	93.8	15	6.3	1	
(missing)	90.7	98	9.3	10	
Intermediate Factors					
Mother's age at IFLS-1 (1993)					
35+ years	92.8	168	7.2	13	0.122
25-34 years	87.7	414	12.3	58	
15-24 years	90.9	200	9.1	20	
Distal (underlying) factors					
Mothers highest educational level					
No education/primary	90.3	523	9.7	56	0.013
Middle school	93.7	119	6.3	8	
Secondary & Higher	83.7	139	16.3	27	
Maternal employment at IFLS-1					
Did not work for wages in past 7 days	90.9	622	9.1	62	0.011

Characteristics	Trajectory Group				P Value
	Low-Stable (*n*=782)		Elevated (at risk) (*n*=91)		
	%	*n*	%	*n*	
Worked for wages in past 7 days	84.3	145	15.7	27	
Religion					
Muslim	90.3	692	9.7	74	0.048
Hindu, Buddhist, Protestant, Other	84.1	90	15.9	17	
Household wealth (by urban rural)					
Poorest	91.7	266	8.3	24	0.001
Middle	93.1	269	6.9	20	
Richest	84.1	243	15.9	46	
Place of residence					
Rural	92.4	464	7.6	38	0.001
Urban	85.70	318.00	14.30	53.00	

[a] **Low-stable** trajectory group characterised by children following a BMI trajectory that falls within the normal range (between 5th and 85th percentile) according to WHO growth references (2007). **Elevated (at risk)** trajectory group characterised by children whose BMI is approximately at or above the cut-off for overweight (above 85th percentile).

6.2.5 Binary Logistic Regression

Table 6.5 (p.195) presents the results from univariable and three multivariable regression analyses. The third multivariable model with an interaction term between household wealth and maternal employment was selected as the final model. Although the IFLS does not include a variable for household wealth, this was computed separately for urban and rural areas using principle components analysis (see Chapter 3.4.5 for detailed explanation of the calculation of household wealth).

Inherent (biological) factors associated with trajectory group membership

Results from multivariable model 3 (Table 6.5, p.195) suggested that female children were significantly more likely to follow the 'elevated (at risk)' BMI trajectory (aOR 1.70, 95%CI 1.11-2.90) and children whose mothers were overweight or obese were also more than twice as likely to follow the elevated BMI trajectory (aOR 2.13, 95%CI 1.18-3.82).

Proximate (early life feeding practices) associated with trajectory group membership

Results from bivariate analyses and univariable models suggested that there were no significant associations between the outcome and timing of introduction of complementary foods or duration of continued breastfeeding. As a result, these variables were not included in final multivariable analyses. However, duration of exclusive breastfeeding was retained in the model based on mixed results from previous research which has debated this association with children's

BMI (Armstrong and Reilly, 2002; Kramer et al., 2007; Dewey, 2003). Although this variable remained insignificant in the final multivariable model, a longer duration of exclusive breastfeeding (≥ 3 months) seemed to suggest an increased likelihood of belonging to the 'elevated (at risk)' BMI trajectory.

Intermediate factors associated with trajectory group membership

Compared to older mothers (35+ years), children of younger mothers aged between 15 to 24 years and 25 to 34 years were more likely to follow the elevated BMI trajectory, although this result was insignificant.

Distal (underlying) factors associated with trajectory group membership

In terms of level of maternal education, children whose mothers had completed middle school were 59% less likely to be assigned in the 'elevated (at risk)' BMI trajectory (aOR 0.41, 95%CI 0.17-0.97), however no significant result was observed for children whose mothers had achieved secondary or higher level of education. Children of mothers who reported paid employment in the previous 7 days at the time of IFLS-1 were more than five times more likely than mothers who were not working for wages to follow the elevated BMI pathway (aOR 5.13, 95%CI 1.95-13.47). At the household level, being from a non-Muslim household was significantly associated with elevated BMI trajectory (aOR 2.40, 95%CI 1.27-4.51). However, although household wealth tested significant in univariable analysis, with children from the richest households most likely to belong to the adverse trajectory group, no significant association was observed in the final multivariable model, although the odds ratios suggested an association in the same direction.

Finally, the interaction term between household wealth and maternal paid employment suggested that children of mothers in the richest households who reported participating in paid employment were 77% less likely to belong to the elevated BMI trajectory when compared to children of mothers from the poorest households who weren't working (aOR 0.23, 95%CI 0.07-0.77). Further exploration of the predicted probabilities of this interaction term (

Table 6.6, p.198; Figure 6.5, p.198) suggested that in fact, children to mothers from the poorest households who reported participating in paid employment had the highest probability of belonging to the 'elevated (at risk)' BMI trajectory group. This result was also clearly depicted in Figure 6.6 where there is distinct divergence in the predicted probabilities of the poorest children, which can be explained by maternal employment status.

Table 6.5 Unadjusted and adjusted odds ratios for factors associated with 'elevated (at risk)' BMI trajectory (*n*=846)

Characteristics	Univariable			Multivariable Model 1			Multivariable Model 2 (with interaction 1)			Multivariable Model 3 (with interaction 2)		
	UOR	95% CI	*P*	AOR	95% CI	*P*	AOR	95% CI	*P*	AOR	95% CI	*P*
Inherent (biological) factors												
Sex												
Male	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Female	1.76	1.13, 2.75	0.012	1.95	1.20, 3.17	0.007	1.89	1.17, 3.05	0.009	1.79	1.11, 2.90	0.018
Birth weight												
<2.5 kg	1.00	Ref.	-									
2.5 kg <4.0 kg	1.55	0.71, 3.37	0.274									
≥ 4.0kg	1.80	0.54, 6.00	0.337									
(missing)	0.55	0.23, 1.31	0.177									
Maternal BMI at IFLS-1 (1993)												
Normal	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Underweight	0.34	0.13, 0.85	0.022	0.28	0.10, 0.80	0.018	0.28	0.10, 0.80	0.017	0.28	0.10, 0.82	0.020
Overweight/obese	2.08	1.22, 3.54	0.007	2.04	1.14, 3.65	0.016	2.00	1.12, 3.59	0.020	2.13	1.18, 3.82	0.012
Proximate factors												
Duration of exclusive breastfeeding												
< 3 months	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
≥ 3 months	1.50	0.94, 2.40	0.089	1.48	0.89, 2.45	0.128	1.49	0.90, 2.46	0.123	1.54	0.92, 2.56	0.098
Never breastfed	0.65	0.08, 4.99	0.676	0.69	0.08, 5.68	0.733	0.67	0.08, 5.51	0.713	0.67	0.08, 5.51	0.713
Introduction of complementary foods												
< 6 months (early introduction)	1.00	Ref.	-									
6-8 months	1.44	0.78, 2.66	0.249									
≥ 8 months (late introduction)	1.14	0.50, 2.60	0.753									

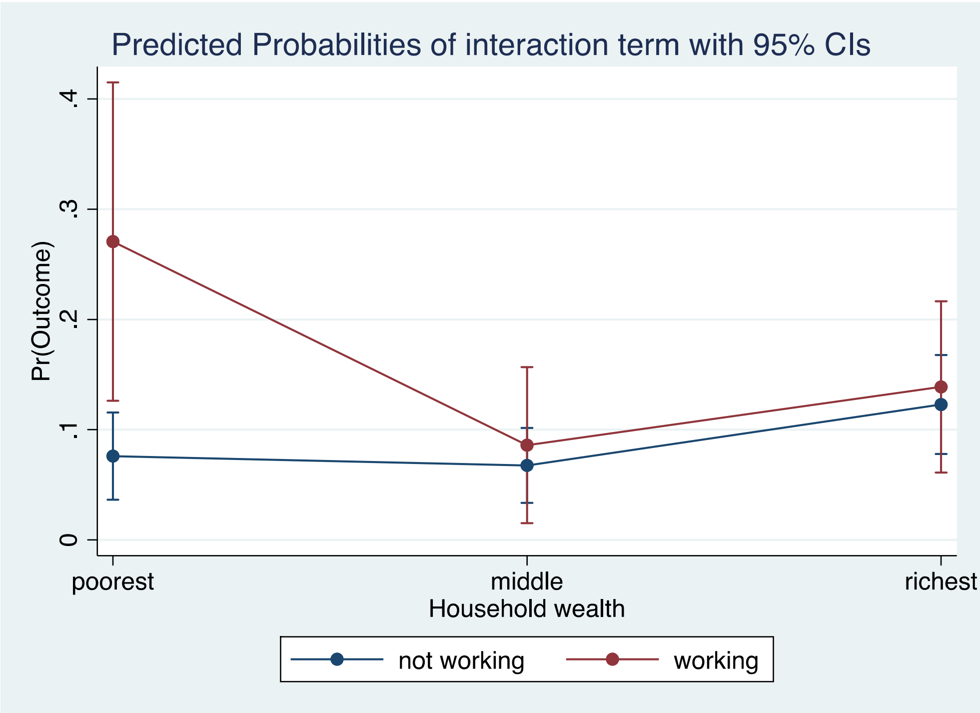
Characteristics	Univariable			Multivariable Model 1			Multivariable Model 2 (with interaction 1)			Multivariable Model 3 (with interaction 2)		
	UOR	95% CI	*P*	AOR	95% CI	*P*	AOR	95% CI	*P*	AOR	95% CI	*P*
Duration of continued breastfeeding												
< 6 months	1.00	Ref.	-									
≥ 6 months	1.16	0.35, 3.91	0.807									
Never breastfed	0.64	0.06, 6.74	0.714									
(missing)	0.99	0.25, 3.82	0.984									
Intermediate Factors												
Mother's age at IFLS-1 (1993)												
35+ years	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
25-34 years	1.81	0.97, 3.39	0.064	1.83	0.95, 3.55	0.073	1.79	0.92, 3.48	0.084	1.78	0.92, 3.47	0.088
15-24 years	1.29	0.62, 2.68	0.490	1.68	0.76, 3.70	0.198	1.66	0.75, 3.66	0.209	1.62	0.73, 3.58	0.236
Distal (underlying) factors												
Mothers highest educational level												
No education/primary	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Middle school	0.63	0.29, 1.35	0.234	0.41	0.17, 0.98	0.044	0.40	0.17, 0.95	0.039	0.41	0.17, 0.97	0.043
Secondary & Higher	1.81	1.10, 2.98	0.019	0.86	0.46, 1.61	0.628	0.82	0.43, 1.56	0.554	0.91	0.48, 1.71	0.772
Maternal employment at IFLS-1												
Did not work for wages in past 7 days	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Worked for wages in past 7 days	1.87	1.15, 3.04	0.012	1.80	1.05, 3.09	0.034	1.84	1.07, 3.17	0.028	5.13	1.95, 13.47	0.001
Religion												
Muslim	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Hindu, Buddhist, Protestant, Other	1.77	1.00, 3.13	0.051	2.37	1.27, 4.43	0.007	2.34	1.25, 4.37	0.008	2.40	1.27, 4.51	0.007
Household wealth (by urban rural)												

Characteristics	Univariable			Multivariable Model 1			Multivariable Model 2 (with interaction 1)			Multivariable Model 3 (with interaction 2)		
	UOR	95% CI	*P*	AOR	95% CI	*P*	AOR	95% CI	*P*	AOR	95% CI	*P*
Poorest	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Middle	0.82	0.44, 1.53	0.539	0.61	0.31, 1.21	0.155	0.62	0.27, 1.43	0.264	0.88	0.39, 1.96	0.747
Richest	2.10	1.24, 3.54	0.006	1.19	0.58, 2.42	0.638	0.89	0.33, 2.42	0.825	1.76	0.79, 3.93	0.169
Place of residence												
Rural	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Urban	2.04	1.31, 3.16	0.002	2.06	1.16, 3.66	0.014	1.46	0.39, 5.40	0.574	1.96	1.10, 3.50	0.023
Interaction term 1 (household wealth*urban/rural)												
Poorest*rural	1.00	Ref.	-				1.00	Ref.	-			
Poorest*urban	1.12	0.32, 3.99	0.857				-	-	-			
Middle*rural	0.63	0.28, 1.41	0.258				-	-	-			
Middle*urban	1.14	0.53, 2.46	0.729				1.24	0.25, 6.30	0.792			
Richest*rural	1.19	0.49, 2.93	0.702				-	-	-			
Richest*urban	2.48	1.41, 4.36	0.002				2.92	0.38, 9.73	1.433			
Interaction term 2 (household wealth*maternal employment)												
Poorest*not working	1.00	Ref.	-							1.00	Ref.	-
Poorest*working	4.68	1.88, 11.62	0.001							-	-	-
Middle*not working	1.06	0.50, 2.25	0.879							-	-	-
Middle*working	1.47	0.51, 4.23	0.473							0.26	0.06, 1.11	0.068
Richest*not working	2.88	1.52, 5.46	0.001							-	-	-
Richest*working	3.07	1.37, 6.90	0.007							0.23	0.07, 0.77	0.018

Table 6.6 Predicted probabilities of the interaction term between household wealth and maternal employment

Interaction term (Household wealth*maternal employment)	PP	95% CI	*P*
Poorest * not working	0.076	0.04, 0.12	<0.001
Poorest * working	0.271	0.13, 0.42	<0.001
Middle * not working	0.068	0.03, 0.10	<0.001
Middle * working	0.086	0.02, 0.16	0.017
Richest * not working	0.123	0.08, 0.17	<0.001
Richest * working	0.139	0.06, 0.22	<0.001

Figure 6.5 Graphical representation of predicted probabilities of interaction term between household wealth and maternal employment with 95%CIs



6.3 Summary of findings

This section summarises the results of the third analysis; the findings are discussed in Chapter seven of this thesis (Chapter 7.3.6, p. 218).

With reference to the first research question proposed by this study, the analysis highlights the value of applying GBTM to longitudinal data in order to identify distinct sub-populations within the data that follow relatively homogenous BMI trajectories. At the time of writing this is the first study of this kind to be conducted using Indonesian data or data from any other LMIC.

- The identification of trajectory groups is very suitable for population-level research as it highlights groups of individuals that diverge from the healthy normative BMI growth model, and health interventions can be designed accordingly to target children who may be at risk of becoming overweight/obese later.

- This study highlights the importance of maternal overweight and obesity and the association with elevated child BMI trajectory.

• According to the second research question posed by this study, the proximate level factors which considered features of the early environment such as early feeding practices showed no significant associations with BMI trajectories in bivariate analyses or adjusted multivariable models, suggesting that over longer periods of time the effect of these variables may be overtaken by other distal (underlying) factors.

- The significant interaction between household wealth and maternal employment in the final multivariable model suggests that the poorest children whose mothers were participating in paid employment were the most likely to follow the adverse BMI trajectory. This could be representative of reduced time allocation to unpaid care of children and a consequent increase in processed, energy-dense, nutrient-poor foods.

Chapter 7 Discussion and conclusion

7.1 Introduction

Although there is a wealth of research regarding the associations between breastfeeding (exclusivity or duration of) and child growth or nutritional outcomes (Victora et al., 2016; Horta and Victora, 2013; Kramer and Kakuma, 2012), less is known about the practices that ensue during the weaning transition when complementary foods are introduced. Even less is known about the complementary feeding period in LMIC contexts and the associations that certain aspects of complementary feeding may have with child growth or nutritional status. Southeast Asia presents a relatively understudied region, in terms of the weaning transition and complementary feeding practices, and makes an interesting case for study as many countries in the region are undergoing a distinctive nutrition transition, which could have multiple implications for IYCF practices and child nutritional status. Therefore, this research first aimed to broaden understanding of infant and young child feeding practices, with a particular focus on the transition from exclusive breastfeeding to complementary feeding, in three economically and culturally diverse countries in Southeast Asia: Cambodia, Myanmar and Indonesia. The subsequent two analyses sought to shed light on the associations between early life feeding practices and child nutritional status and longer-term physical growth, in the hope that it may highlight the potential role of early life feeding practices as an essential child health intervention in LMIC contexts. The role of socioeconomic status, in defining IYCF practices and child nutrition, was a central theme also explored throughout this thesis in response to the rapid economic growth and socio-cultural shifts that have occurred in Southeast Asia in recent decades.

This concluding chapter first seeks to provide an overview of the research design, outlining the data and methodologies that were employed in order to investigate the research questions posed at the beginning of the thesis. Table 7.1 (p.203) presents a summative table of the main findings in relation to the original research objectives and research questions, followed by a critical discussion of the main findings in relation to previous research (section 7.3). Section 7.4 then considers these main findings in the context of their implications for policy and recommendations. The strengths and limitations of the study are outlined in section 7.5 and the proposals for further research are suggested in section 7.6, with concluding remarks in section 7.7.

7.2 Overview of the research design

The research for this thesis addressed three main research objectives, and aimed to contribute to understanding of the potential role of early life feeding practices in optimising child nutrition and longer-term growth in LMIC contexts, in particular accounting for the wide socioeconomic differentials that exist in Southeast Asia. Table 7.1 presents these three principal objectives, the research questions associated with each objective, and the main findings from this PhD project.

Quantitative methodology was employed throughout the thesis, with use of secondary data that was publicly available upon registration from the respective organisations that supplied the data. Throughout the thesis, selection of explanatory variables and associations between them were based on the conceptual framework presented in section 2.2, which was adapted for this thesis from the WHO framework for child stunting (Stewart et al., 2013) and the framework employed in the study by Wamani et al., (2006). The conceptual framework depicted the role of infant and young child feeding practices as proximate determinants of healthy child growth and development, amongst other broader contextual variables, operating at different hierarchical levels such as the distal (underlying), intermediate and inherent (biological) factors.

Table 7.1 Synthesis of the research, by objective and research questions

Research Objectives	Research Questions	Gaps in knowledge	Data & Analytical methods	Key research findings
Analysis 1: To examine demographic and socioeconomic factors associated with two important IYCF practice: exclusive breastfeeding in 0 to <6 month olds and minimum dietary diversity in 6 to <24 month olds in three economically and culturally diverse countries of Southeast Asia (Cambodia, Myanmar and Indonesia).	1) Are there clear socioeconomic differentials in achievement of the WHO recommendation of exclusive breastfeeding status and do these associations vary by country?	No recent analysis or cross-country comparison of factors associated with exclusive breastfeeding in the Southeast Asian context. Few studies focusing on the dietary diversity aspect of complementary feeding practices, especially in the Southeast Asian context.	• Demographic and Health Survey (DHS) data from Cambodia (2014), Myanmar (2015-16) and Indonesia (2012). • Exclusive breastfeeding (0 to <6 months): *N*=668 (Cambodia); 460 (Myanmar); 1,665 (Indonesia) • Minimum dietary diversity (6 to <24 months): *N*=2,096 (Cambodia); 1,336 (Myanmar); 5,160 (Indonesia) • Binary logistic regression models (country-level and pooled analysis) Addressed in Chapter 4	• Living in an urban area, and high level of participation in maternal employment were inversely associated with prevalence of EBF in Cambodia and Indonesia. • Pre-lacteal feeding was negatively associated with EBF status in Cambodia and Indonesia. • Delivery by caesarean section is a significant risk factor for not EBF in Cambodia and Indonesia. • Contrary to results from other LMICs, higher level of education was actually associated with increased incidence of EBF in Indonesia.
	2) Are there clear socioeconomic differentials in achievement of the WHO recommendation for minimum dietary diversity and do these associations vary by country?			• Children from urban areas, and those from the richest households were most likely to have received the MDD in all three countries. • High level of participation in maternal employment associated with increased likelihood of achieving MDD in all three countries, although this association reached significance only in Indonesia. • Children of mothers with secondary or higher level of education in Indonesia more likely to meet MDD compared to those with no education or primary level.

	3) What conclusions can be drawn about the effect of overall improvements in socioeconomic conditions on exclusive breastfeeding and dietary diversity in Southeast Asia?			• Rapid economic growth in Southeast Asia has perhaps exacerbated socioeconomic inequalities in IYCF. • Although Improvements in socioeconomic status may have a positive effect on dietary diversity, reflected by the positive association between household wealth and meeting MDD, it seems to have a deleterious effect on EBF, with formula feeding becoming the preferable practice amongst wealthier, urban and working mothers. • Maternal employment is a significant barrier to EBF and MDD, and with increasing maternal employment in the sub-region, this is an important factor to consider • The negative association between caesarean section and EBF suggests that the medicalisation of child birth which is on the rise in Southeast Asia, is a significant barrier, especially among urban wealthy women.
Analysis 2: To explore pathways to predicting height-for-age (HAZ) Z-scores among children aged 6 to <24 months in Cambodia and determine the role of dietary diversity, continued breastfeeding and underlying socioeconomic factors.	1) Is maternal education, household wealth and maternal employment associated with dietary diversity and continued breastfeeding?	Few studies have examined pathways to stunting and the complex nature of factors associated with this outcome, and there is no such study that has been carried out in the Cambodian context. Infant and young child feeding practices are usually included in multivariable analysis as direct effects,	• Demographic and Health Survey data from Cambodia (2014) • *N*= 1,365 children aged 6 to <24 months • Structural path analysis Presented in Chapter 5	• Higher socioeconomic status measured by level of maternal education, household wealth and high level of maternal employment, was positively associated with dietary diversity, but inversely associated with continued breastfeeding.

	2) To what extent (if at all) do dietary diversity and continued breastfeeding mediate the association between socioeconomic factors and children's height-for-age Z-scores?	and rarely has their role as mediating variables been examined. The majority of research that has examined the association between urban/rural residence and stunting in Cambodia has been conducted using a pooled analysis approach, which does not allow for the moderating effect of urban/rural residence and the impact it has on of other explanatory variables.		• Dietary diversity and breastfeeding status were mediating factors in three of the pathways between socioeconomic status and HAZ: • High level of maternal employment had a small but significant association with HAZ that was mediated by breastfeeding status. • Household wealth also had a small but statistically significant association with HAZ that was mediated by both dietary diversity and breastfeeding status.
	3) Are these aforementioned associations moderated by urban/rural residence?			• Urban/rural residence had a significant moderating effect on the association between maternal education and dietary diversity with increases in maternal education more likely to be associated with an improvement in dietary diversity in rural areas. • In rural areas, a high level of maternal employment had a significant, negative association with continued breastfeeding, compared to an insignificant effect in urban areas. • Increasing household wealth had an inverse association with continued breastfeeding in urban areas only. • Both household wealth and dietary diversity had a significant, direct association with HAZ in rural areas only in an unconstrained moderation model.

Analysis 3: To identify distinct BMI growth trajectories in a cohort of Indonesian children using longitudinal data and assess whether the early life environment (including feeding practices) explains variability in growth throughout childhood and adolescence.	1) Are there distinctive growth trajectories amongst Indonesian children aged 0-36 months in 1993, followed until age 14-17 years?	There are very few studies that have examined childhood BMI trajectories in an LMIC context and whether they differ from trajectories of children in high-income countries. Inconclusive evidence on whether early feeding practices have a longer-term impact on health and nutrition.	• Longitudinal data from four waves of the Indonesian Family Life Survey (IFLS) • *N*=873 children aged 0-36 months at IFLS-1 (1993), followed through to IFLS-4 (2007) when children were aged 14-17 years • Group-based trajectory models (GBTM) and binary logistic regression Presented in Chapter 6	• GBTM identified two distinct BMI trajectories in this sample of Indonesian children, highlighting a group of children that diverge from healthy, normative BMI growth. • The first trajectory in which 89.6% of children belonged to represented approximately normal BMI growth. The second trajectory in which 10.4% of children belonged, represented elevated BMI growth with some children already experiencing overweight/obesity by IFLS-3 and IFLS-4. • Divergence in the two BMI growth trajectories begins from the second wave of the IFLS and becomes more exaggerated with each subsequent wave. • By wave four of the IFLS, the majority of children following the elevated BMI trajectory were already experiencing overweight or obesity.
	2) Does the early life environment – including early infant feeding practices – explain variability in child growth outcomes?			• Similar to findings from previous research conducted in high-income countries, this study highlights the importance of maternal BMI and its association with long-term child growth. • There were no significant associations between proximate level factors such as early feeding practices and BMI trajectory membership. • Interaction term between household wealth and maternal paid employment in adjusted analysis, suggested that children from the richest households whose mothers were participating in paid employment were less likely to follow the elevated BMI trajectory, compared to those from the poorest households whose mothers were also working.

7.3 Discussion of main findings

7.3.1 Demographic and socioeconomic differentials in exclusive breastfeeding in Cambodia, Myanmar and Indonesia

With reference to the conceptual framework (Figure 2.1, p.55), factors associated with exclusive breastfeeding are discussed by hierarchical grouping as depicted in the framework. Overall, results from pooled analysis from all three countries suggested significant differences between countries with children aged 0 to <6 months in both Cambodia and Myanmar more than twice as likely to be exclusively breastfed, compared to Indonesian children. Girls and children whose mothers had a higher or secondary education were more likely to be exclusively breastfed, as well as those born in a public health facility, than those born at home. On the other hand, pooled results also indicated that children who were born by caesarean section, those who received pre-lacteal feeds, resided in urban areas and whose mothers had a high level of participation in the labour force, were all less likely to be exclusively breastfed. The following section focuses on the findings from country level analysis.

Allowing for socioeconomic and demographic variables in pooled analysis, exclusive breastfeeding rates independently, significantly differed by country, which would indicate that there were additional, unaccounted factors or underlying characteristics in each country that were not included in the model. Such independent country differences could reflect country-specific practices/policies or unique influential factors. For example, significant differentials in exclusive breastfeeding may arise from variation in the enforcement of national codes which regulate the marketing of breast milk substitutes (Piwoz and Huffman, 2015). In Indonesia, the aggressive marketing of breast milk substitutes, coupled with a lack of official 'Baby-Friendly' health facilities have been cited by other researchers as reasons for the low rates of exclusive breastfeeding (Siregar et al., 2018; Shetty, 2014), perhaps giving partial explanation as to why the odds of being exclusively breastfed were significantly higher in Cambodia and Myanmar in the current pooled analysis. Data that reflects these country-specific policies or programmes were not available for inclusion in the model but are important to draw upon in the discussion of these results.

Inherent (biological) factors

Results from adjusted analysis showed that Myanmar was the only country in which there were apparent sex differentials in exclusive breastfeeding, with girls more than twice as likely to be exclusively breastfed than boys. There are very few studies focusing on exclusive breastfeeding in Myanmar, and there has been no such study that has explored sex differentials in exclusive breastfeeding in this county. However, evidence form a qualitative study conducted in North-eastern Thailand found that there was a general perception amongst the participating mothers that male infants had greater nutritional needs compared to female babies, and that their breast milk was insufficient to satisfy boys' needs, resulting in additional formula feeds (Thepha et al., 2018). It is therefore possible that this misconception also acts as a barrier to exclusive breastfeeding for male infants in Myanmar.

Proximate factors

Despite missing data on pre-lacteal feeding in all three countries, the likelihood of being exclusively breastfed in the 24 hours before the visit for children in Cambodia and Indonesia was significantly reduced if pre-lacteal feeds had been given in the three days following birth. This result was also in line with a report by Som (2018) which stated that the proportion of children who received pre-lacteal feeds increased by 8.6% between 2000 and 2014 in Cambodia, and this was particularly so in urban areas where more than half of new-borns received some form of pre-lacteal feeds. Evidence from Nias Island in Indonesia where pre-lacteal feeding has also been cited as a common occurrence, suggested that this practice could be associated with cultural perceptions that colostrum is harmful to the baby and should therefore be discarded (Inayati et al., 2012). Sugar water and formula milk were reported by these authors as a popular pre-lacteal feed in Nias Island. This increased use of pre-lacteal feeds in Cambodia especially raises concern as this practice has been consistently found to be a barrier to exclusive breastfeeding in multiple LMIC contexts (Nguyen et al., 2013; Kanagasabapathy and Sadhasivam, 2015), due to delayed initiation; it may also introduce exposure to pathogenic contaminants, thus increasing the risk of incidence of infectious disease such as diarrhoea and respiratory tract infections (Khanal et al., 2013; Bekele, Mengistie and Mesfine, 2014).

Intermediate factors

The results of univariable analysis suggested that children born in a private health facility in Cambodia were 68% less likely to be breastfed. However, after controlling for other explanatory variables in multivariable analysis such as type of delivery, this association was no longer statistically significant, a finding perhaps in part explained by the significant effect of birth by caesarean section (associated with reduced likelihood of exclusive breastfeeding by 50%) in the multivariable model. In their study on the increasing use of breast milk substitutes in Cambodia, Prak and colleagues (2014) reported that the use of breast milk substitutes was five times greater among women who gave birth in a private clinic than in women who gave birth in a public clinic.

When this is considered in tandem with the increasing trend of elective caesarean sections amongst more affluent, urban women in Cambodia (UNICEF, 2016) which mostly occur within private institutions, it could be hypothesised improvements in socioeconomic status have resulted in declines in exclusive breastfeeding through the medicalisation of child birth. This negative association between delivery by caesarean section and exclusive breastfeeding was also noted in Indonesia.

In light of rapid economic growth in the Southeast Asia region and increases in deliveries by caesarean section, the possible implications for exclusive breastfeeding could be serious, with many studies highlighting the negative impact of caesarean sections on earlier cessation of breastfeeding (Hobbs et al., 2016; Chen et al., 2018). Although delivery by caesarean section and birth place were not clearly associated with exclusive breastfeeding in Myanmar, children whose mothers had the least amount of antenatal care visits (0-1 visits) were more than half as likely to be exclusively breastfed than children who whose mothers reported more than five antenatal visits during pregnancy. This may highlight a broader issue with antenatal care in Myanmar, as there is a substantial shortage of healthcare workers who are able to provide maternal care both during pregnancy and during the postnatal period – just 14 health care providers (doctors, nurses or midwives) per 10,000 people. As a result, a large proportion of maternal care in Myanmar is undertaken by auxiliary midwives (AMWs), who are voluntary community workers that provide support and counselling to pregnant women in hard-to-reach areas on antenatal care. In a study which explored the knowledge of AMWs in Magwe region in Myanmar, Than and colleagues (2017) reported a low level of knowledge about the critical danger signs and immediate new-born care, perhaps highlighting along with the results presented in this thesis, that knowledge of breastfeeding support be a priority in the training of AMWs. The influential role of health care professionals in Myanmar has already been highlighted by Hmone et al. (2017) who found in an adjusted analysis that breastfeeding intention was two times higher in women who reported that the information they received was from a health care professional, compared to those who did not, which is important to highlight as breastfeeding intention is ultimately highly associated with actual breastfeeding practices.

Distal (underlying) factors

Having a secondary or higher level of education was significantly and positively associated with exclusive breastfeeding only in Indonesia. This finding was incongruent with a later study which used a 2013 national survey from Indonesia (Paramashanti, Hadi and Gunawan, 2016), where maternal education was not significantly related to exclusive breastfeeding practice, but in line with findings from other high-income settings where longer durations of exclusive breastfeeding are generally more likely among more educated women (Victora et al., 2016).

High level of maternal labour force participation presented a critical barrier to achieving exclusive breastfeeding in Cambodia and Myanmar, although this result was only statistically significant in Indonesia in multivariable analyses which also adjusted for maternal education. Evidence for this association in other LMIC contexts has been inconclusive, with a pooled analysis of 50 LMIC countries showing no significant associations between employment (informal or formal) (Oddo and Ickes, 2018) and exclusive breastfeeding, whereas country-level studies from Kenya, Vietnam and Bangladesh each reported a negative association between maternal employment and exclusive breastfeeding duration (Lakati, Binns and Stevenson, 2003; Dearden et al., 2002; Rasheed et al., 2009). However, maternal employment was shown to be the most frequently reported obstacle to exclusive breastfeeding in a more recent systematic review including 25 studies, from 19 LMIC countries (Balogun et al., 2015). The authors of that study also noted that for mothers working in formal employment in LMIC contexts, the negative association between employment and exclusive breastfeeding may be even more pronounced due to less flexible working arrangements, inadequate maternity leave and longer working hours which was also echoed by Rollins et al., (2016). On the other hand, it has been suggested that informal employment, which is common in LMIC contexts (e.g. street vending, domestic worker), may actually provide more favourable conditions for exclusive breastfeeding because working arrangements can be more accommodating and there may be the possibility for infants to accompany their mother to work (Oddo and Ickes, 2018). The results from the analysis in this thesis, in combination with other research from LMIC contexts, highlight the importance of not only considering employment status, but also examining differences between formal and informal employment which have varying implications for infant and young child feeding practices in LMIC countries.

Indonesia was the only country in which household wealth was significantly associated with exclusive breastfeeding, with children from richer households approximately 40% less likely to be breastfed than children from the poorest households. This result was also seen in a multi-country study on Southeast Asia, where better socioeconomic status was associated with an increased likelihood of non-exclusive breastfeeding (Senarath et al., 2010). The consistent finding that mothers from wealthier households in LMICs are less likely to exclusively breastfed (Rollins et al., 2016) has been referred to as the breastfeeding paradox, as the opposite effect is true in high-income settings where more educated, and poorer women are less likely to breastfeed. This could in part be a result of the increasing use and promotion of breast milk substitutes in LMIC contexts, which are often portrayed as modern and somewhat more scientifically advanced than breast milk (Piwoz and Huffman, 2015), but perhaps only affordable for wealthier mothers.

Residing in an urban area was significantly and negatively associated with exclusive breastfeeding in Cambodia, consistent with findings from Prak and colleagues (2014) who also analysed older Cambodian DHS data, finding that differences in exclusive breastfeeding rates between rural/urban areas were also present in 2000, 2005 and 2010. Further analysis using cross-sectional data from the capital city Phnom Penh (Pries et al., 2016) also revealed high rates of formula milk usage amongst urban women, especially amongst those who were employed. This suggests urban residence is also perhaps reflective of other indicators of better socioeconomic status, as urban women are more likely to be employed and have a higher income, however interactions between these variables were tested in adjusted analysis and found to be insignificant.

7.3.2 Demographic and socioeconomic differentials in minimum dietary diversity in Cambodia, Myanmar and Indonesia

The results from pooled analysis where Cambodia was the reference country, showed that children aged 6 to <24 months in Myanmar were 68% less likely to meet the minimum dietary diversity and Indonesian children 22% more likely. Overall, pooled adjusted analysis showed a noticeable positive association between socioeconomic status and dietary diversity, with children from the richest households, those residing in urban areas, and those whose mothers had a high level of labour force participation and a higher education more likely to have received the minimum dietary diversity. The likelihood of children receiving the minimum dietary diversity was significantly reduced if they were still being breastfed at the time of survey, which on the one hand, could indicate bias in the way in which the minimum dietary diversity indicator is measured as breast milk is not considered as one of the food groups, as a result dietary diversity of breastfed children is perhaps underestimated. On the other hand, the association between continued breastfeeding and reduced likelihood of consuming a diverse diet, is perhaps indicative of poverty, as a study in Thailand found that prolonged breastfeeding may be the only viable option, when complementary foods are lacking in households which are food insecure (Cetthakrikul et al., 2018). In terms of the demographic characteristics of the mother, children of younger mothers (15-24 years) were less likely to meet the minimum dietary diversity than children of older mothers (35-49 years).

As was the case in the pooled analysis of factors associated with exclusive breastfeeding, results from multivariable analyses showed significant differences between countries in likelihood of meeting minimum dietary diversity, with children in Indonesia significantly more likely to receive the minimum dietary diversity and children in Myanmar significantly less likely to receive the minimum dietary diversity as compared to Cambodia. This suggests country-level differences in factors associated with dietary diversity that have not been represented in the modelling. A possible reason for differences by country could be the time of year in which a survey was conducted, as seasonal variations are known to predict food insecurity in places where the population rely on agriculture to subsist (Madan et al., 2018). Further, the World Food Programme highlights that extended periods of military rule, economic sanctions and ongoing internal conflict have contributed to underdeveloped agricultural systems in Myanmar (WFP, 2018), which ultimately influences the lack of availability of a diverse range of foods. Although aggregate level data is available, there is no micro-level data on political and economic affairs that would be suitable to include in this pooled analysis to determine possible associations with minimum dietary diversity.

Inherent (biological) factors

Although no sex differences were noted in Cambodia and Indonesia, girls were significantly less likely to meet the requirements for minimum dietary diversity in Myanmar. Although there are few studies to confirm this finding in Myanmar, it has been suggested that there is a tendency for son preference in Myanmar and boys (especially from Muslim communities) are more likely to be breastfed longer or attend school (World Food Programme, 2016). This can perhaps be linked to the finding from Chapter 4.2 which found that girls were more likely to be exclusively breastfed in Myanmar, suggesting that boys are introduced to complementary foods earlier than girls and therefore more likely to meet dietary diversity between 6 and <24 months in adjusted analyses that adjusted for other relevant demographic and socioeconomic characteristics.

Proximate factors

In all three countries, children who were still being breastfed at the time of survey were significantly less likely to meet minimum dietary diversity in multivariable models which also adjusted for the age of the child. Similar findings were observed from a study in Pakistan, where children who were still being breastfed were significantly less likely to receive a diverse diet in multivariable linear regression using dietary diversity score (DDS) as an outcome variable (Iqbal et al., 2017). It is possible that this finding is driven by socioeconomic status as women from poorer households are likely to continue breastfeeding for longer durations, yet may not have the financial means to purchase a variety of foods or suitable breast milk alternative.

Intermediate factors

Short preceding birth intervals (<24 months) were associated with a reduced likelihood of meeting requirements for minimum dietary diversity in both Cambodia and Myanmar, in line with findings from Nepal (Khanal, Sauer and Zhao, 2013) and Ethiopia (Epheson et al., 2018). This can perhaps be explained by the pressure of trying to meet the competing nutritional requirements of two very young children, as well as posing additional time constraints for caring and preparing food for the child.

The results of multivariable analysis also showed that children of younger mothers (15-24 years) were the least likely to meet minimum dietary diversity in all three countries, suggesting that nutrition education amongst younger mothers is lacking. A qualitative study conducted in Bangladesh to assess IYCF knowledge of adolescent mothers and nulliparous women highlighted the gaps in IYCF knowledge, in particular knowledge pertaining to dietary diversity and types of nutrient-rich foods (Hackett et al., 2015). Young motherhood, especially adolescence has also been highlighted by the WHO (2006) as a significant risk factor for child malnutrition due to less years of education, decreased earning potential and employment opportunities which translates into scarcer financial resources for purchasing a variety of foods. These findings are particularly important to take note of in Southeast Asia, due to the high yet unwavering adolescent birth rates in the region with an average of 47 births per 1000 females aged 15 to 19 years which is significantly higher than the average in South Asia of 35 births (UNFPA, 2018).

Distal (underlying) factors

In terms of the distal (underlying) factors associated with minimum dietary diversity, urban residence offered a clear advantage over rural residence, although intra-urban socioeconomic differentials were evident when an interaction term between household wealth and urban/rural residence was considered. This urban/rural disparity in dietary diversity is underscored by rapid urbanization within Southeast Asia where 48.9% of the population live in urban areas and the urban population is growing by 2.2% per annum (UNESCAP, 2018). This apparent urban advantage is likely representative of the better employment opportunities, greater household incomes, and availability and affordability of a wide range of food types (Bloem et al., 2013), compared to rural areas where there is often an increased reliance on subsistence agriculture and staple food crops such as rice.

Using a stratified wealth index for urban and rural areas, children from the poorest households in Cambodia, Myanmar and Indonesia were consistently least likely to consume a diverse diet compared to children from the richest households, a finding which was also confirmed in other

LMICs in South Asia (Na et al., 2018; Patel et al., 2012; Kabir et al., 2012; Senarath et al., 2012). This finding is also inextricably linked with urban/rural residence in the Southeast Asian context as the majority of poor people reside in rural areas where household food insecurity is more likely due to the dependence on unpredictable agricultural sources. Natural disasters such as droughts, flooding and landslides which are common throughout Southeast Asia also exacerbate the situation for families relying on the land for sustenance (World Food Programme, 2019).

Results from multivariable analysis also revealed that maternal education (Secondary or higher) was positively associated with minimum dietary diversity in both Myanmar and Indonesia, findings also confirmed in multiple studies from Asia (Ng, Dibley and Agho, 2012; Na et al., 2018; Patel et al., 2012; Kabir et al., 2012; Senarath et al., 2012). Although level of completed maternal education is usually representative of socioeconomic status in LMIC contexts, it has been contended by Ruel and colleagues (1999) that the effect of maternal education on child nutrition is independent of socioeconomic status because mothers may possess a good knowledge of appropriate complementary feeding practices, but still lack the financial resources to implement them. This dichotomy was referred to as a *knowledge-practice discrepancy* in a study conducted in Uganda in which the majority of mothers had adequate knowledge of IYCF practices, but lacked the financial means to put knowledge into practice (Wamani et al., 2005).

Maternal labour force participation was defined in this thesis using a composite indicator which was created especially for this research using principal component analysis, in order to account for the multiple dimensions of employment. Although a high level of maternal labour force participation was negatively associated with exclusive breastfeeding of children 0 to <6 months, a contradictory effect on minimum dietary diversity among children 6 to <24 months was observed, although this result was only statistically significant in Indonesia. This meant that Indonesian children whose mothers were actively engaged in the labour force in high-skilled or professional employment, who worked the whole year round and received monetary wages were more likely to consume a diverse diet. This result emphasised the value of considering the different aspects of female employment in a context where 85.2% of the female working population participated in informal employment in 2017 (UNESCAP, 2018), which is usually characterised by low-skilled, labour intensive jobs, non-monetary wages and seasonal work. This finding was in line with results from a pooled analysis of 50 LMICs using DHS data conducted by Oddo and Ickes (2018), whereby in comparison to children whose mothers were unemployed, children of mothers involved in formal or informal employment were significantly more likely to meet the minimum dietary diversity, with higher odds experienced by children of formally employed mothers. The positive association between children's dietary diversity and maternal employment has also been corroborated by previous research which observed positive correlations between income earned from maternal labour force participation and expenditure on higher quality, nutritious foods (Tucker and Sanjur, 1988; Mascie-Taylor et al., 2010). Female labour force participation presents a trade-off scenario between household income and time allocation; while an improving socioeconomic situation allows for a greater food expenditure, time allocation is reduced for caregiving and in the context of IYCF, preparing nutritious meals and continued breastfeeding.

7.3.3 The role of dietary diversity, continued breastfeeding and socioeconomic status in pathways to height-for-age

With reference to the second objective of this thesis, the hypothetical structural path model presented in this study proposed a plausible, theoretical illustration of the pathways associated with children's height-for-age in the Cambodian context. Overall, results confirmed that improvements in socioeconomic status such as maternal education, household wealth and participation in employment, were associated with an increase in children's dietary diversity, but a decrease in continued breastfeeding, and overall household wealth had the largest effect.

Previous studies have suggested that the timing of growth faltering is consistent across geographical contexts, which show that on the whole, HAZ scores deteriorate with increasing age of the child until approximately 24 months when the lowest HAZ score is often observed (Shrimpton et al., 2001; Victora et al., 2010). The worsening of mean HAZ scores by increasing child age in this study of Cambodian children substantiated a timing and pattern of growth faltering similar to that of other studies.

In relation to the first research question proposed for the second analysis in this thesis, the small yet significant, independent, effect of maternal education on dietary diversity in this study was consistent with the findings of other studies conducted in low- and middle-income countries (Na et al., 2017; Patel et al., 2012; Kabir et al., 2012; Senarath et al., 2012), in addition to studies which confirmed a strong association between increasing household wealth and improvements in dietary diversity (Smith, Ruel and Ndiaye, 2004; Iannotti et al., 2012). A significant pathway between breastfeeding and dietary diversity revealed an additional, interesting observation, that continued breastfeeding was associated with a less diverse diet, even after adjusting for age. This is perhaps indicative of the situation in poorer households where prolonged breastfeeding may be practiced to make up for the lack of complementary foods, a finding which was proposed following a study of feeding practices in Thailand (Cetthakrikul et al., 2018).

In light of the nutrition transition which has been occurring in many low- and middle-income countries, Popkin and Bisgrove (1988) reported that duration of breastfeeding was declining in urban areas as a result of the increased maternal education and employment opportunities that arise from urbanisation. In line with this theory, the results from Chapter 5 also suggested that increasing household wealth and high level of participation in employment were negatively associated with breastfeeding status in Cambodia. Furthermore, the negative association between increasing household wealth and continued breastfeeding is perhaps underscored by the increasing trend in use of breast milk substitutes among children aged over six months in Cambodia (Prak et al., 2014).

7.3.4 Continued breastfeeding and dietary diversity as mediating factors in pathways to height-for-age

The second main finding of Chapter 5 revealed in relation to the second research question proposed under objective two, that dietary diversity and continued breastfeeding status were mediating factors in the association between socioeconomic status and HAZ, however this was only true for pathways from maternal employment and household wealth. The results of this study suggested a positive and direct association between Cambodian children's dietary diversity and height-for-age z-scores, which has also been supported by other studies conducted in Cambodia (Grefeuille et al., 2016; Darapheak et al., 2013). Moreover, dietary diversity was a significant mediator of the association between household wealth and HAZ suggesting that the positive effect of increasing household wealth can partially be explained by improved dietary diversity. This highlights the necessity to target interventions within the poorest households to improve dietary diversity, and hence prevent child stunting. A further 71% of the total effect of household wealth on HAZ was found to be direct, suggesting the importance of other mediating factors not included in this model but known to be associated with child stunting, such as access to health care, WASH facilities and immunization status.

On the other hand, breastfeeding was associated with a negative, direct effect on children's HAZ in Cambodia in a path model that also adjusted for age of the child. A similar finding was also noted by Arimond and Ruel (2004), in a study using Cambodian DHS data from 2000, and in a review of 13 studies by Grummer-Strawn (1993) where this inverse association was identified in eight of the studies. This negative effect of breastfeeding on children's height-for-age status has been discussed by many researchers. One proposed explanation is reverse causality, whereby the decision to wean is related to size and stature of the child, hence malnourished children may be more likely to be breastfed for longer durations. This hypothesis was confirmed by Simondon et al.'s study of Senegalese children (2001), in which prolonged breastfeeding was found to be associated with size of the child. However, as Martin (2001) points out, due to the cross-sectional nature of the structural path analysis in Chapter 5, it is not possible to account for the direction in the relationship between prolonged breastfeeding and HAZ. In terms of the indirect effects, structural path analysis revealed that breastfeeding was a small but significant mediator in the association between maternal employment and HAZ, as well as household wealth and HAZ.

7.3.5 Moderating effect of urban/rural residence

Finally, this study highlighted the moderating effect of urban-rural residence, in particular, the differences in individual factors that are associated with specific pathways to HAZ, but also that the strength of these associations varies by urban-rural residence. This analysis shed new light on the differences in pathways to stunting by urban-rural residence in Cambodia, and so far is one of the first studies which has separately analysed the effect of urban-rural residence in this country context. Results from simultaneous path analysis by urban-rural residence demonstrated the moderating effect of this variable, stressing the importance of designing stunting interventions which account for the differences in the determinants of stunting between urban and rural areas. This is especially important for low- and middle-income contexts such as Cambodia, where there are distinct urban-rural differentials in the incidence of stunting and where rapid urbanisation is causing a shift in the geographical patterning of stunting. Results from an unconstrained model where all parameters were permitted to vary by urban-rural residence, suggested that maternal education was a significant and positive predictor of dietary diversity in rural areas, a finding which was not confirmed amongst children in urban areas. Although this difference between rural and urban areas was not statistically significant, it perhaps provides evidence in support of community-based interventions that target nutrition education programmes amongst rural mothers. For example, a successful FAO-supported agricultural intervention known as MALIS (Improving market linkages for smallholder farmers) was combined with a nutritional education programme focused on IYCF practices in the Northern provinces of Cambodia: Preah Vihear and Oddar Meanchey provinces (Reinbott et al., 2016).

Although increasing household wealth was a significant and negative predictor of breastfeeding status in the full structural path model, further analysis which controlled for the moderating effect of urban-rural residence revealed a statistically significant difference in the effect of household wealth on breastfeeding status between urban and rural areas. Household wealth was significantly and negatively associated with breastfeeding status in urban areas in both an unconstrained and constrained solution which controlled for this moderating effect, suggesting extreme intra-urban inequality in breastfeeding practices between the urban-poor and the urban-rich. This emphasises the fact that within urban areas interventions to improve breastfeeding practices should be mindful of the socioeconomic disparities in practices that occur even within urban spaces.

7.3.6 The role of the early life environment in explaining variability in longer-term growth trajectories

The results of Chapter 6 presented convincing evidence for the shape of children's BMI trajectories in Indonesia, an LMIC context that is undergoing a distinctive nutrition transition, driven by widening socioeconomic inequality, the result of which has been the emergence of a double burden of malnutrition. This is one of the first studies to model children's BMI trajectories in an LMIC context, using longitudinal data and group-based trajectory modelling for population level analysis.

Identification of distinctive BMI growth trajectories

Using longitudinal data from four waves of the Indonesian Family Life Survey (IFLS), group-based trajectory modelling (GBTM) identified two marked BMI trajectories in a sample of children who were followed between the ages of 6 to <36 months at wave one and 14 to 17 years by wave four. The 'low-stable' trajectory in which nearly 90% of children belonged to, was characterised by approximately normal BMI growth which was representative of the median BMI growth trajectory of the WHO Child Growth References (2006). In a systematic review of studies that employed GBTM for childhood BMI trajectories, all of the total fourteen studies also identified a stable, average trajectory which the majority of children belonged to (Mattsson et al., 2019), although all but one of these studies was conducted in high-income countries. The second trajectory which was detected in the modelling process was characterised by a smaller group of children (10%) following an elevated BMI trajectory, with some of these children already experiencing overweight or obesity by the third or fourth wave of the IFLS. In accordance with plotted BMI trajectories of children from a British cohort study (Stuart and Panico, 2016), differences between the two trajectories were evident by the second wave of the IFLS when children were aged between four and seven years, as trajectories started to diverge from one another, becoming more pronounced with each subsequent wave. This trajectory group was labelled as 'elevated (at risk)' because although some children in this group had not exceeded the WHO threshold for childhood overweight or obesity (2006), they could be considered 'at risk' of subsequently developing overweight and obesity. Nevertheless, without having surpassed the cut-offs for overweight or obesity, the co-morbidities associated with a raised BMI are continuous and can still have serious health consequences for children and adolescents (WHO, 2016).

The results of GBTM also alluded to an apparent adiposity rebound around wave 2 when children were aged between four and seven years old, which was depicted by a slight nadir in BMI prior to a gradual increase throughout later childhood and adolescence, in both BMI trajectory groups. Although the age of adiposity rebound has been found to vary slightly between study settings, the approximate age range reportedly lies between three and eight years (Rolland-Cachera, 1984; Mattsson et al., 2019; Pour et al., 2016), suggesting that the BMI trajectories presented in this thesis are biologically plausible. When compared to Indonesian synthetic child growth charts, the results obtained using GBTM to model children's BMI in Chapter 6 indicated comparable results, although it was noted by Pulungan et al., (2018) that children in Indonesia tended to be significantly shorter compared to the WHO Child Growth References (2006), regardless of age.

7.3.7 Associations between the early life environment and BMI growth trajectories

In terms of features of the early life environment, data on IYCF practices in the IFLS was limited, however some key variables were created using available data to measure duration of exclusive breastfeeding, age at introduction to complementary foods and duration of continued breastfeeding. None of these proximate factors relating to early feeding practices were associated with trajectory group membership in unadjusted or adjusted analysis, despite some previous research reporting links between early life feeding practices and prevalence of overweight/obesity in later childhood or adolescence (Li et al., 2012; Pearce, Taylor and Langley-Evans, 2013; Horta and Victora, 2013). However, overall evidence for these associations is inconsistent, with some studies finding no independent effect of infant feeding practices on children's BMI trajectories (Salahuddin et al., 2017), suggesting that any initial associations between early life feeding practices and children's early BMI measurements are attenuated over the life course by other variables that come into play. For example, children's diet in later childhood and adolescence, physical activity and socioeconomic shifts within the household over time, also undoubtedly play a role in shaping BMI trajectories, yet this information may not always be readily available. Furthermore, the current evidence base for associations between early life feeding practices and overweight/obesity is founded mainly on research that measures the nutritional outcome at one point in time, therefore not accounting for change in BMI over time (*ibid.*). In their study on breastfeeding duration and weight gain trajectories in infancy, Carling and colleagues (2015) emphasised the challenges associated with extracting the independent effect of optimal breastfeeding practices on obesity development as feeding practices are usually inextricably linked with socioeconomic status, moreover, it was suggested that the cumulative effect of multiple risk factors may bear more weight than one factor taken independently.

However, in line with other BMI trajectory studies conducted in high-income countries (Li et al., 2012; Pryor, Tremblay and Boivin, 2011), the results from Chapter 6 underlined the importance of maternal BMI for longer-term child growth with children of overweight or obese mothers twice as likely to follow the elevated BMI trajectory than children whose mothers were of normal weight.

However, the majority of studies for which this finding has already been confirmed focus on maternal pre-pregnancy BMI and this information was not available in the IFLS, so maternal BMI at IFLS-1 was used as a proxy measure. This finding emphasises the dyadic nature of the relationship between mothers and their offspring during pregnancy and the postnatal period, as well as the importance of reducing maternal overweight and preventing rapid weight gain during pregnancy (Williams, Mackenzie and Gahagan, 2014).

In terms of other inherent (biological) factors associated with BMI trajectory membership, being a girl was significantly and positively associated with the ‘elevated (at risk)’ trajectory in this sample of Indonesian children. A literature review of the factors associated with overweight and obesity in Indonesia (Rachmi, Li and Baur, 2017) also reported higher prevalence rates of overweight and obesity in females during adolescence and early adulthood, however prevalence was higher amongst boys during childhood, a finding also confirmed by Li et al. (2012).

In an adjusted multivariable model, maternal employment was significantly associated with BMI trajectory membership, with children whose mothers reported being employed at the time of wave one of the survey, five times more likely to follow the ‘elevated (at risk)’ BMI trajectory. This finding is perhaps representative of the fact that although maternal employment has the potential to increase household expenditure on high-quality foods, it also introduces a trade-off between time and money, as employment limits time available for child care and preparing foods (Oddo and Ickes, 2018; Popkin, 1980; Bisgrove and Popkin, 1996). As a result, mothers who are time poor due to involvement in the labour force, may be more likely to purchase nutrient-poor, energy dense processed foods for their children, especially in a context where feeding the family is often the responsibility of women (Nurbani, 2015). In a qualitative study of food price volatility in Indonesia, women reported a greater reliance on pre-prepared foods due to time limitations imposed by employment and types of food that were readily available included instant noodles, chocolate, and sausages from street vendors (*ibid.*). Furthermore, over the three-year study period between 2012 and 2014, the researchers noted that processed snack consumption increased among children, stressing the extent of the nutrition transition and the implications for children in Indonesia.

An interaction term between maternal employment status and household wealth revealed additional information about the effect of employment according to socioeconomic status, although household wealth was not independently associated with BMI trajectory group. Further investigation of this interaction revealed that children of mothers from the poorest households who were employed, experienced the highest probability of belonging to the elevated BMI trajectory, characteristic of overweight and obesity, compared to children of working mothers from the richest households. This perhaps implies more about the nature and affordability of child care in Indonesia, where there has been significant commodification of domestic work. For example, in a study conducted among urban middle-class working and non-working women resident in a satellite city of Jakarta, household duties such as caring for children, cooking and household chores were commonly undertaken by paid domestic workers (Roshita, Schubert and Whittaker, 2011). It could be hypothesised that among poorer working mothers who do not have the financial means to afford domestic caregivers, time allocation to caretaking activities is significantly reduced, resulting in the purchase of convenience processed foods which are energy dense, yet nutrient poor.

Finally, there were clear urban/rural disparities in trajectory group membership as children residing in urban areas were nearly twice as likely as children from rural areas to follow the elevated BMI trajectory. Despite the lack of studies that have assessed longer-term change in childhood BMI over time within LMIC contexts, it is of note that 81 cross-sectional studies from LMICs reported on average, slightly higher prevalence of childhood overweight in urban areas (Black et al., 2013). Popkin (1999) noted that urban/rural disparities in diet are particularly marked in LMIC settings consistent with the nutrition transition, which are characterised by increased consumption of foods high in fat and sugar content, more animal source food products and more processed foods within urban areas (Popkin and Bisgrove, 1988). Aside from food consumption, urban areas also present an obesogenic environment for children due to the increased sedentary activity and time spent indoors, as a result of limited outdoor space and popularity of video games and television (Pirgon and Aslan, 2015). This urban disadvantage has important implications for longer-term child growth and the co-morbidities associated with an elevated BMI trajectory, especially in a country such as Indonesia where 55.3% of the population reside in urban areas (UNESCAP, 2018).

7.3.8 Summary of discussion and contributions to knowledge

This research has contributed to the knowledge and understanding of IYCF practices in emerging LMIC contexts and highlighted the potential role of optimising early infant feeding for favourable child growth outcomes. In light of rapid socioeconomic transformation in recent decades in Southeast Asia, this thesis also sheds light on the underlying socioeconomic factors associated with particular IYCF practices and draws links between these contextually relevant factors and child nutritional status, emphasising the complex interactions and interdependencies between them.

It was evident that there were marked socioeconomic differentials in selected infant and young child feeding practices and child nutritional status in Southeast Asia, consistent with the findings of studies conducted in other low- and middle-income countries (Rollins et al., 2016; Senarath et al., 2010). There was a clear urban-rural dichotomy in IYCF practices that was apparent throughout the thesis with urban areas showing lower levels of exclusive and continued breastfeeding, perhaps indicative of higher levels of maternal employment and household wealth, or changing social norms (Popkin, 1998; Cyril, Oldroyd and Renzaho, 2013). On the other hand, urban areas seemed to provide a clear advantage in terms of dietary diversity, although intra-urban inequalities still existed with children from urban-poor families also at risk. This urban-rural dichotomy extended to child nutritional status, with urban children less likely to experience undernutrition which was demonstrated in this thesis by modelling children's height-for-age Z-scores in Cambodia using structural path analysis. Conversely, the results from the final analysis focusing on a sample of Indonesian children, identified a group of children following an elevated BMI trajectory characteristic of overweight and obesity in Indonesia, suggesting that overnutrition was more endemic within urban areas, in line with the patterns of overweight and obesity represented by the nutrition transition theory in urban LMIC populations (Popkin, 1998). The role of rapid urbanization on IYCF practices and child nutritional status is particularly pertinent for the Southeast Asian region, where the urban population is estimated to climb from 299 million in 2015 to a predicted 526 million people by 2050 (United Nations, 2018).

The findings presented in this thesis have challenged the theories and research that draws parallels between improvements in socioeconomic status and reductions in child malnutrition and mortality (Preston 1975; Pritchett and Summers, 1996; Smith and Haddad, 2002). Whilst it is irrefutable that improvements in underlying socioeconomic conditions have led to reductions in child undernutrition, infectious morbidity and mortality, there is evidence to suggest that this effect is also paradoxical as rapid economic growth has also paved the way for declines in optimal breastfeeding practices in LMIC contexts and the rise of child overnutrition, as was evidenced in the final study using Indonesian data. In other words, there is evidence in support of a distinctive nutrition transition that has been propelled by rapid economic growth in the region, and a subsequent double burden of malnutrition. Together, Cambodia, Myanmar and Indonesia account for just over half of the total population of Southeast Asia, making the findings from this thesis perhaps generalizable to other countries within the region as well as to other LMICs with similar economic characteristics.

This research along with other studies conducted in Cambodia and Indonesia, also revealed some context-specific feeding practices that also endanger optimal IYCF practices. Pre-lacteal feeding was a common practice observed in DHS data from Cambodia and Indonesia, as well as a significant risk factor for not exclusively breastfeeding in adjusted analyses. This finding emphasises the importance of nutrition education interventions to teach mothers about the benefits of not providing pre-lacteal feeds and from the governmental perspective; enforcement of the Baby Friendly Hospital Initiative (BFHI) (WHO and UNICEF, 1991) which encourages early initiation of breastfeeding.

The double-sided effect of maternal employment was also evident throughout this thesis, as a high level of maternal labour force participation seemed to pose significant barriers to achieving exclusive or continued breastfeeding, as well as being a significant risk factor for children following a trajectory to overweight and obesity. Conversely, a high level of maternal labour force participation was significantly associated with meeting the requirements for minimum dietary diversity in Indonesia which can perhaps be explained by increased household income which can be spent on purchasing higher-quality and diverse food types. Using a composite indicator of maternal labour force participation, it was demonstrated that the type of employment (ie. occupation, wages, seasonality/regularity of work) was also important to consider, especially when accounting for the fact that in all three countries, more than two-thirds of women involved in the labour force are informally employed (ILOSTAT, 2018).

Overall, the research presented shed some light on the associations between selected infant and young child feeding practices and child growth, but also demonstrated significant socioeconomic barriers to achieving optimal feeding which is concerning, considering Southeast Asia was the only sub-region within the Asia Pacific region for which inequality had increased between 1990 and 2014 (UNESCAP, 2017). Regional-level improvements in socioeconomic status in recent decades have paved the way for a distinctive nutrition transition in Southeast Asia, which has also shaped an infant and young child feeding paradox which sees breastfeeding practices threatened by increasing wealth and the demands of maternal employment, whereas complementary feeding practices generally benefit from the increased financial resources.

7.4 Policy implications and recommendations

Maternal employment presented a significant barrier to achieving exclusive and continued breastfeeding in the Southeast Asian countries selected for this research, emphasising that maternity legislation should be adequate to allow for optimal breastfeeding practices. As it currently stands, maternity leave in these three countries ranges from 12-13 weeks (ILO, 2014), below the ILO recommended minimum of 14-weeks leave (ILO, Convention No.183, 2000). Moreover, evidence shows that mothers participating in informal employment are less likely to be entitled to paid maternity (Walters, 2016). Given the high share of informal employment in total female employment in these three countries (96% in Cambodia (2012) and 86% in Indonesia and Myanmar (2017) (UNESCAP, 2018)), working mothers and their new-born children are extremely vulnerable and should be targeted by government policies. Within LMIC contexts there seems to be an evident trade-off for mothers between paid employment and 'reproductive labour and care', which calls for governments to establish suitable forms of childcare that can be utilised by working mothers (regardless of involvement in formal or informal labour).

According to the first analysis presented in this thesis, birth by caesarean section was a significant risk factor for non-exclusive breastfeeding in both Cambodia and Indonesia, reinforced by existing research which has also highlighted the increasing trend of elective caesarean sections among more affluent, urban mothers within LMIC contexts (Robson, 2001; Vogel et al., 2015). In fact, in a study of 21 countries, the largest increase in caesarean sections was observed in Cambodia between 2010-2011 and 2007-2008/2010-2011 (Vogel et al., 2015) and in a qualitative study conducted by Schantz et al., (2016) in Phnom Penh, socio-cultural reasons and misconceptions about the benefits of caesarean sections were the most commonly reported factors for requesting delivery by caesarean section. This finding calls for a need to ensure the dissemination of accurate information by health care workers about the risks associated with caesarean sections through additional training programmes, and reinforcing a positive culture around child birth that promotes natural birth as a 'normal physiological process', with an end goal of improving breastfeeding initiation and duration of exclusive breastfeeding (Johanson, Newburn and Macfarlane, 2002, p.893).

There were clear socioeconomic differentials in dietary diversity among young children during the complementary feeding period, with children from the poorest households in rural areas the least likely to consume foods which met minimum dietary diversity requirements. Heavy reliance on staple food sources such as rice and the unpredictable nature of agriculture on which rural populations often depend, highlights a key responsibility of governments to ensure a regular supply of food, in particular fortified foods and lipid-based nutrient supplements in food insecure contexts (Lassi et al., 2013; Panjwani and Heidkamp, 2017). In settings where households possess the financial means to purchase a range of nutritious foods, community-based nutrition counselling and education may be a more suitable intervention to improve dietary diversity, especially programmes that focus on preparing nutritious meals with locally sourced ingredients. The success of such a programme can be attested by the Communication for Behavioural Impact (COMBI) strategy (FAO, 2015) established in Cambodia which successfully increased knowledge of appropriate child feeding practices through TV advertisements and community interventions.

In light of the double burden of malnutrition in LMIC contexts, it may also be recommended that surveys such as the DHS collect a wider array of information about the food groups children consume, to be able to assess the extent of the nutrition transition on children's diet. Currently, the majority of DHS surveys only collect data on the seven food groups as defined by the WHO and there is limited information about consumption of unhealthy food groups such as snacks, soft drinks and fast food. Such information would facilitate research on the links between unhealthy food consumption and prevalence of overnutrition in LMICs and the risk factors associated with such behaviours. Furthermore, upon exploration of MICS (Multiple Indicator Cluster Survey) datasets in other Southeast Asian countries in preliminary phases of this research, it was apparent that the data collection was not necessarily consistent and information that was required to compute key IYCF indicators was missing or defined differently depending on the country. This calls for a more standardized approach to data collection, especially datasets such as MICS which are funded by UNICEF, to strive to collect and disseminate data that allows for the calculation of WHO and UNICEF defined IYCF indicators (2010).

7.5 Strengths and limitations of the study

Overall, the quantitative research design of this thesis and the analysis of nationally representative secondary data from three countries, produced findings that may be generalizable to the broader LMIC study context. The nature of these quantitative analyses meant that although associations between variables could be drawn from models, causation could not be implied and underlying reasons for choices made by respondents could not be obtained without relevant qualitative research.

With reference to the first study (Chapter 4) which used DHS data from Cambodia, Myanmar and Indonesia to examine the factors associated with exclusive breastfeeding and minimum dietary diversity, the high response rates in each survey (over 96% among contacted women) lends itself to population-level analysis. However, limited sample sizes meant that the models for minimum dietary diversity could not be stratified by breastfeeding status, in order to account for the fact that the minimum dietary diversity indicator employed in this thesis did not include breast milk as an itemised food group. Therefore, consumption of breast milk was accounted for by including current breastfeeding status as an explanatory variable in adjusted models. Furthermore, the WHO IYCF indicators (2010) included in these analyses were computed using current-status data which on the one hand could lead to an overestimation of children exclusively breastfed or meeting minimum dietary diversity (Grummer-Strawn, 2011), but on the other hand reinforces the reliability of survey responses as it minimises recall bias. It is important to note that household wealth which was one of the main underlying socioeconomic variables utilised throughout this research was calculated as a household consumer durables index, in place of household income or expenditure, because DHS do not collect information on income or expenditure but moreover, because consumer durables are more likely to be an accurate representation of longstanding wealth (Howe, Hargreaves and Huttly, 2008).

The cross-sectional nature of the second study presented in Chapter 5 and the use of structural path analysis which is typically a form of causal modelling, required that the results be interpreted with some caution. Although structural path models may offer certain benefits over multivariable fixed effects models, as they allow for complex interactions between variables, the hypothetical model was built iteratively based on prior theory and the conceptual framework (Figure 2.1, p.55) and thus, is by no means an exhaustive representation of the pathways to children's HAZ scores. However, due to the ethical challenges associated with collecting data on the effect of selected IYCF practices on child growth, cross-sectional data is often the only viable data source and whilst causation cannot be determined, potential associations can be drawn. Similar to the first analyses presented in Chapter 4, the way in which continued breastfeeding and dietary diversity are reported using current-status data, may introduce measurement bias, however, use of standard instruments to measure height in DHS ensures accuracy of anthropometric measurements.

The final study presented in this thesis which modelled children's BMI trajectories using longitudinal data and GBTM, was one of the first studies of its kind to be conducted using data from an LMIC, which although adds value to this study, also meant that there were no existing empirical studies from similar country contexts to which the viability of results could be compared. A key strength of this study was the use of longitudinal data from the IFLS with long-term follow-up of children, which facilitated an analysis of change in BMI, as opposed to measuring BMI at one point in time, as would be the case with a cross-sectional study. However, comparison with WHO Child Growth References (2006) and Indonesian national synthetic growth charts, confirmed that the shape and height of identified trajectories were biologically plausible for this sample of Indonesian children. One of the main limitations of this study was the limited number of data points over the study period, particularly during infancy and the critical growth period from six months onwards when features of the early life environment are thought to play their most influential role. Survey attrition was also a major factor to consider when conducting the analysis, as with most longitudinal data, respondents were lost to follow-up over the study period, however this was accounted for by conducting sensitivity analyses to detect differences in baseline weight and height between the selected sample and assess whether data was missing at random. In order to make use of all available data, survey attrition was accounted for in the final modelling process by fitting models using maximum likelihood estimation which specifies that all available data be used, under the assumption that it is missing at random.

7.6 Recommendations for future research

Although the quantitative research design of this thesis permitted population level analysis using nationally representative data, the study could benefit from additional qualitative research to gain a more in-depth understanding of the drivers of sub-optimal IYCF practices within selected study contexts in order to unearth the perceived and actual barriers to achieving the recommended guidelines. The findings of previous research and the identification of certain sub-optimal feeding practices in this research such as pre-lacteal feeding which are often culturally defined, suggest that there are motivators for practices that cannot be gleamed from secondary, quantitative data.

Secondly, the results of the first study could be updated with the most recent Indonesian DHS data for 2017 which was released just two months prior to the finalisation of this thesis. Furthermore, to improve the generalizability of the first study, it could be expanded to include other countries within the Southeast Asia region using MICS data, provided that these datasets enable comparison to the DHS to be able to calculate key IYCF indicators, as so far the two data sources are not comparable.

Although missing data in each analysis chapter was accounted for by using techniques such as including a 'missing' category in categorical variables or by conducting sensitivity analyses to assess whether data were missing at random, imputation could also be explored in future work as an appropriate alternative method. In the third analysis, which modelled data from the Indonesian Family Life Survey, 25% of the eligible sample of children selected at wave one had incomplete anthropometric outcome data in subsequent waves. This was dealt with by using maximum likelihood estimation in group-based trajectory modelling, which uses all available information, however, the appropriateness of multiple imputation could also be explored in further research, since the missingness of data in this case affects the outcome variable of interest. Multiple imputation involves modelling distributions of each variable with missing values from multiple distributions, in order to account for the random variation between imputed datasets (Sterne et al. 2009). Imputation would allow for all observations with missing data to be included in analyses, therefore decreasing the bias associated with complete case analyses.Finally, it would be a valuable exercise to apply the hypothetical structural path model presented in Chapter 5 to other LMIC contexts, to examine whether these proposed pathways to stunting are consistent across geographical contexts.

7.7 Concluding remarks

Underlying socioeconomic inequalities in Southeast Asia are responsible for a paradoxical patterning of infant and young child feeding practices, as increasing household wealth, maternal employment and urbanization have led to the decline in optimal breastfeeding practices among richer, more educated, urban mothers. On the other hand, these same households are more likely to demonstrate better complementary feeding practices from six months onwards, as financial resources allow for the purchase of a diverse range of nutritious foods in adequate amounts. The findings from this thesis highlight that children from the poorest households in rural areas are the most disadvantaged in Southeast Asia when it comes to complementary feeding practices and undernutrition, but children of a higher socioeconomic status may be more exposed to obesogenic dietary intake and environments, leading to subsequent overnutrition. It is vital that policies and interventions to promote optimal IYCF practices reach both the poorest and richest sub-populations in these contexts, to ensure that no child is left behind, in line with the United Nations 2030 Sustainable Development Agenda (UNICEF,2019).

Appendix A Sensitivity analysis for Chapter 6 (survey attrition of IFLS)

Appendix A: Chapter 3.4: Sensitivity analysis to assess significant differences between living children and those who died over the course of the study period

	Alive (*n*=881)		**Died during study period** (*n*=25)		
Variables	***N***	**Mean / %**	***N***	**Mean / %**	**Test statistic**
Early child nutritional status (IFLS-1)					
Height (cm)	881	77.1	25	76.3	0.52
Weight (kg)	881	9.4	25	9.1	0.80
Length/Height-for-age z-score	881	-1.7	25	-1.5	-0.55
Weight-for-age z-score	881	-1.3	25	-1.5	0.64
Weight-for-height z-score	881	-0.6	25	-1.0	1.24
BMI-for-age z-score	881	-0.4	25	-0.8	1.35
Ever breastfed	866	98.4%	24	96.0%	0.87
Duration of EBF <3 months	650	73.9%	15	62.5%	1.55
Duration of continued BF <6 months	34	4.5%	0	0.0%	0.85
Into. of CFs <6 months	706	81.2%	16	66.7%	3.15
Household / maternal characteristics					
Household wealth (poorest quintile)	163	18.6%	11	44.0%	13.57**
Household wealth (richest quintile)	143	16.3%	3	12.0%	
Rural household	505	57.3%	19	76.0%	3.48
Mother's age (mean)	881	28.9	25	30.6	-1.33
Mother no education/primary	582	66.1%	17	68.0%	0.17
Mother's BMI (mean	866	21.5	24	20.7	1.12
Mother's height (mean)	866	150.0	24	149.8	0.16

Note: Independent group t-test for sample means is used for continuous variables and Chi-square tests used for categorical variables
*<0.05, **<0.01, ***<0.001

Appendix A: Chapter 3.4: Sensitivity analysis to assess missing at random for respondents who were lost to follow-up

	Followed for four waves with complete/plausible anthropometric data (*n*=660)		Lost to follow-up or missing/implausible anthropometric data in at least one wave (*n*=221)		
Variables	***N***	**Mean / %**	***N***	**Mean / %**	**Test statistic**
Early child nutritional status (IFLS-1)					
Height (cm)	660	76.9	221	77.6	1.24
Weight (kg)	660	9.3	221	9.5	0.93
Length/Height-for-age z-score	660	-1.7	221	-1.7	-0.56
Weight-for-age z-score	660	-1.3	221	-1.4	-0.54
Weight-for-height z-score	660	-0.6	221	-0.7	-0.48
BMI-for-age z-score	660	-0.4	221	-0.4	-0.20
Ever breastfed	646	98.0%	220	99.6%	2.44
Duration of EBF <3 months	492	74.7%	158	71.5%	0.86
Duration of continued BF <6 months	24	4.1%	10	5.9%	0.94
Into. of CFs <6 months	531	81.4%	175	80.3%	0.15
Household / maternal characteristics					
Household wealth (poorest quintile)	116	17.7%	47	21.5%	8.16
Household wealth (richest quintile)	98	14.9%	45	20.6%	
Rural household	387	58.6%	118	53.4%	1.86
Mother's age (mean)	660	28.9	221	29.2	0.72
Mother no education/primary	439	66.5%	143	65.0%	0.18
Mother's BMI (mean	647	21.4	219	21.6	0.56
Mother's height (mean)	647	150.2	219	149.6	-1.18

Appendix B Published paper

Appendix B: Chapter4: Published paper using the analysis from Chapter 4

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Socio-economic differentials in minimum dietary diversity among young children in South-East Asia: evidence from Demographic and Health Surveys

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Abstract
Objective: To investigate the socio-economic differentials underlying minimum dietary diversity (MDD) among children aged 6–23 months in three economically diverse South-East Asian countries.
Design: The outcome variable MDD was defined as the proportion of children aged 6–23 months who received foods from four of the seven recommended food groups within the 24 h prior to interview. The association between socio-economic factors and MDD, adjusting for relevant characteristics, was examined using logistic regression.
Setting: We used cross-sectional population data from recent Demographic and Health Surveys from Cambodia (2014), Myanmar (2015–16) and Indonesia (2012).
Subjects: Total of 8364 children aged 6–23 months.
Results: Approximately half of all children met the MDD, varying from 47·7 % in Cambodia (*n* 1023) to 58·2 % in Indonesia (*n* 2907) and 24·6 % in Myanmar (*n* 301). The likelihood (adjusted OR; 95 % CI) of meeting MDD increased for children in the richest households (Cambodia: 2·4; 1·7, 3·4; Myanmar: 1·8; 1·1, 3·0; Indonesia: 2·0; 1·6, 2·5) and those residing in urban areas (Cambodia: 1·4; 1·1, 1·9; Myanmar: 1·7; 1·2, 2·4; Indonesia: 1·7; 1·5, 1·9). MDD deprivation was most severe among children from the poorest households in rural areas. The association between mother's labour force participation and MDD was positive in all three countries but reached significance only in Indonesia (1·3; 1·1, 1·5).
Conclusions: MDD deprivation among young children was significantly high in socio-economically disadvantaged families in all three study settings. MDD requirements are not being met for approximately half of young children in these three South-East Asian countries.

Keywords
Young children
Minimum dietary diversity
Socio-economic
Demographic and Health Surveys
South-East Asia

Optimal nutrition during early life improves child survival[1] and reduces risk of chronic, lifestyle-related diseases[2 6]. Despite strong economic growth[7] and steady reductions in mortality among children <5 years of age (under-5s) in South-East Asia[8], child malnutrition continues to pose a serious public health challenge, with parts of the region now facing a double burden of malnutrition with increasing rates of overweight and obesity as well as persistent undernutrition in under-5s[9].

Globally, 3·1 million under-5s die each year because of poor nutrition[10]. The first 2 years of a child's life are the most sensitive period to growth faltering[11,12] and infant and young child feeding practices should adapt to evolving nutritional needs[5]. Exclusive breast-feeding is recommended for the first 6 months of life and appropriate complementary feeding between the ages of 6 and 23 months[12]. Further, adequate dietary diversity in early life may influence taste preference and dietary choice in adolescence and early adulthood[13,14].

Dietary diversity increases the intake of micronutrients and energy in young children[15,16]. Minimum dietary diversity (MDD) is defined as the consumption of at least four out of the following seven food groups: (i) grains, roots, tubers; (ii) legumes and nuts; (iii) dairy products; (iv) meats and fish; (v) eggs; (vi) vitamin-A rich fruits and vegetables; and (vii) other fruits and vegetables[17]. While 60 % of children aged 6–23 months in the South-East Asia region meet the MDD, the dietary diversity gap between

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Appendix B

rich and poor is the starkest globally[5]. Furthermore, dietary diversity is a particular concern due to the traditionally rice-based and vegetarian diets which contribute to micronutrient deficiencies throughout the region, specifically Fe, Zn, vitamin A, iodine and Ca deficiencies[18].

The associations between socio-economic status and growth during childhood have been well documented[15,19,20], with children from the richest households and usually those residing in urban areas typically exhibiting better growth; little is known about intra-urban and intra-rural socio-economic disparities. It is predicted that, by 2050, 64 % of the region's population will live in urban areas[21], which has the potential to exacerbate intra-urban socio-economic differentials in child nutritional status. In addition, with over two-thirds of females active in employment in this region, investigating the relationship between maternal employment and MDD in countries experiencing rapid urban transformation is a current and pressing issue[22].

In the present paper we examine the socio-economic differentials in MDD among children aged 6–23 months in three economically diverse countries of South-East Asia: Cambodia, Myanmar and Indonesia, which together account for 51 % of the total population of South-East Asia[23]. Myanmar and Cambodia are low-income countries[24], with just over one-third of under-5s being stunted (one of the highest rates among all ASEAN (Association of Southeast Asian Nations) countries[9]) and under-5 mortality rates that would need to be reduced further to meet the 2030 target[25]. Indonesia is the most populated lower-middle-income country in the region, with a per capita income approximately three times that of the other two countries[23] and confronted with both increasing obesity and persistent high rates of stunting in under-5s[26]. Indonesia is close to achieving the 2030 target of under-5 mortality with twenty-six deaths per 1000 live births[25]. All three countries are committed to achieving the UN Sustainable Development Goal (SDG-2) for ending all forms of malnutrition among under-5s by 2030 through improved food security, nutrition and sustainable agricultural production[10].

To the best of our knowledge, there are no systematic cross-national or sub-regional analyses of factors associated with dietary diversity among young children in South-East Asia. Analysing data from three economically and culturally diverse countries in this sub-region, we identify the cross-country similarities and differences in factors associated with infant feeding practices and dietary diversity, and contribute to strengthening the evidence base for policy makers at both the national and sub-regional level.

We hypothesised that: (i) socio-economic differences exist in meeting MDD requirements among under-5s; and (ii) the poorest children in rural areas are more vulnerable to MDD deprivation than their urban counterparts.

Methodology

Data for the present study were drawn from the individual women's questionnaire from the most recent Demographic and Health Survey (DHS) conducted in Cambodia[27] (2014), Myanmar[28] (2015–16) and Indonesia[29] (2012). All eligible mothers were asked about the types of food given to their youngest child aged <3 years in the day and night prior to survey[30], according to food groups as classified by WHO[17]. Mothers were read a list of different food types and were asked to respond 'yes' if the child had received the food item in the previous day or night, even if this food type was combined with other items. In addition, the surveys collected data on the household, socio-economic and demographic characteristics.

The analysis was based on one eligible woman per household reporting on her youngest, singleton child aged 6–23 months, living with the mother at the time of survey. Total sample size ranged from 2127 children in Cambodia to 1339 in Myanmar and 5193 in Indonesia. DHS surveys employed a standard, stratified, two-stage cluster probability sampling to identify households and respondents who are eligible for interview. The eligible respondents, women aged 15–49 years, were selected randomly from the sampled households within each cluster. Further details on DHS sampling design and survey methodology can be found in the relevant DHS reports for each country[27 29]. The women's response rate in the survey was 98 % in Cambodia, 96 % in Indonesia and 96 % in Myanmar. The item non-response for selected explanatory variables was minimal, and those with missing data at random were removed from the final analysis (<2 % of all cases).

MDD was defined as the proportion of children aged 6–23 months who received foods from four out of seven recommended food groups within the 24 h prior to interview[17].

Factors potentially associated with infant dietary diversity were identified based on the literature on complementary feeding in South-East Asia[31 34] and with reference to the WHO conceptual framework[35]. We defined socio-economic status at the level of the individual (mothers' education and level of participation in the labour force), household (wealth quintile) and spatial (urban/rural residence and geographical region). A composite indicator was created for female labour force participation using principal component analysis[36], which transformed five individual variables into one indicator, to account for different aspects of employment. These five variables included employment status in the past 12 months, who the mother reported working for, her occupation, type of earnings and whether she was employed all year, seasonally or occasionally. A household wealth index was also calculated separately for urban and rural areas using principal component analysis, to ensure that those from the poorest households in rural

Table 1 Geographical regions of the study context*

Geographical region	Cambodia	Myanmar	Indonesia
Region 1	Phnom Penh	North Myanmar	Sumatra
Region 2	Plain	East Myanmar	Java
Region 3	Tonle Sap	South Myanmar	Lesser Sunda Islands
Region 4	Coast	West Myanmar	Kalimantan
Region 5	Plateau/mountain	Lower Myanmar	Sulawesi
Region 6		Central Myanmar	Maluku Islands
Region 7			New Guinea

*Data from recent Demographic and Health Surveys in Cambodia (2014)[27], Myanmar (2015–16)[28] and Indonesia (2012)[29].

areas were effectively captured. In each country, the geographical regions were re-grouped to reduce the number of categories (Table 1).

Child characteristics included age in years, sex, birth order, birth interval and birth weight. In addition, we considered morbidity status of the child, defined as any symptoms of acute respiratory infection, diarrhoea or fever in the two weeks preceding the survey. Maternal characteristics included age in years, marital status and number of antenatal visits. Sex of the household head was included as a household characteristic. Maternal media exposure was computed using principal component analysis, which included how often the respondent read newspapers, listened to radio or watched television; the composite index was categorised as frequent, moderate and limited exposure.

We identified two relevant paternal characteristics likely to be associated with children's MDD requirement. These included father's highest education level achieved and his type of occupation (agricultural employment, non-agricultural employment and unemployed).

Statistical analysis

We used the statistical software package Stata version 14.0 for the statistical analyses. Descriptive statistics were calculated accounting for the complex survey design and applying relevant sample weights. The outcome variable was MDD categorized as a binary variable, coded 0 in cases where the child did not receive the MDD in the 24 h prior to interview and 1 in cases where the child did receive the MDD. We initially considered a two-level (individual and primary sampling unit or cluster) random-intercept model to account for the hierarchical nature of the data set. However, there was no difference in the outcome variable at the cluster level due to small sample size, and hence we considered a fixed-effect binary logistic regression for the multivariate analyses.

The variables that were significantly associated with the outcome variable in the bivariate analysis were included in the final multivariable logistic model. The model-building procedure considered a sequential approach to selecting variables, reflecting on evidence from existing studies. During this iterative process, variables that were not significant in the multivariable model were removed and added one by one to measure their effect on the other covariates. The most parsimonious model for all three countries was determined using the Hosmer–Lemeshow test for goodness-of-fit. To maintain comparability between models, the same explanatory variables were used for each country. Collinearity between variables was tested for using variance inflation factors, which measure the strength of pairwise correlations between variables. The final results are presented as adjusted OR (AOR), with 95 % CI.

Interactions based on theoretical assumptions were tested (between urban/rural residence and wealth; and urban/rural residence and mother's education). However, these were found to be insignificant and were thus excluded from the final adjusted models.

Results

Of the total 8364 children, approximately half were girls (49·3 % in Cambodia, 48·5 % in Indonesia and 46·2 % in Myanmar). In Myanmar, 21·4 % of children were fourth or higher births, in Cambodia 15·9 % and Indonesia 12·7 %. Just under half of children were reported with at least one symptom of morbidity in Cambodia and Indonesia, and a third of children in Myanmar (Table 2).

Cambodia had the highest proportion of children whose mothers were aged between 15 and 24 years (34·9 %), while this accounted for 28·1 % of children in Indonesia and 25·2 % of children in Myanmar. In all three countries, the proportion of mothers not currently in a partnership or marriage was below 5 %. The percentage of mothers who had achieved secondary or higher education was significantly higher in Indonesia (68·2 %) than in Cambodia (36·2 %) and Myanmar (40·2 %). In Cambodia, 33·3 % of mothers reported having high participation in the labour force, 29·3 % in Myanmar and 18·2 % in Indonesia. Only 1·0 % of fathers in Indonesia had no formal education, 8·8 % in Cambodia and 16·1 % in Myanmar; and over three-quarters were reported to be working in agricultural occupations in Myanmar and Indonesia, while in Cambodia this accounted for just over half of fathers (Table 2).

The majority of children in Cambodia (86·0 %) and Myanmar (74·6 %) resided in rural areas, in contrast to

Table 2 Characteristics of the study sample (unadjusted percentages and 95 % CI) of South-East Asian children (*n* 8364) aged 6–23 months and their families from three economically diverse South-East Asian countries*

	Cambodia (*n* 2127)		Myanmar (*n* 1339)		Indonesia (*n* 5193)	
Characteristics	%	95 % CI	%	95 % CI	%	95 % CI
Child						
Age (months)						
6–11	34·8	32·3, 37·4	32·6	29·6, 35·8	36·1	34·2, 38·1
12–17	31·4	29·0, 34·0	37·2	34·0, 40·4	32·7	30·9, 34·6
18–23	33·8	31·3, 36·4	30·2	27·3, 33·3	31·2	29·4, 33·0
Sex						
Male	50·7	48·0, 53·4	53·9	50·6, 57·1	51·5	49·5, 53·5
Female	49·3	46·6, 52·0	46·2	42·9, 49·4	48·5	46·5, 50·5
Birth order						
First-born	40·0	37·4, 42·7	35·5	32·4, 38·8	38·3	36·4, 40·3
Second to third	44·1	41·5, 46·8	43·1	39·9, 46·3	49·0	47·0, 51·0
Fourth or more	15·9	13·9, 18·0	21·4	18·9, 24·1	12·7	11·6, 13·9
Birth interval (months)						
No previous birth	40·5	37·9, 43·2	36·2	33·1, 39·4	38·7	36·8, 40·7
< 24	7·8	6·4, 9·4	7·3	5·8, 9·2	5·5	4·8, 6·4
≥ 24	51·7	49·0, 54·4	56·5	53·2, 59·8	55·7	53·8, 57·7
Perceived birth weight						
Smaller than average	10·5	9·0, 12·3	12·3	10·3, 14·6	13·0	11·7, 14·4
Average	55·7	53·0, 58·3	60·9	57·6, 64·1	56·5	54·4, 58·4
Larger than average	33·8	31·3, 36·4	26·8	23·9, 29·9	30·5	28·7, 32·4
Morbidity						
No symptoms	56·9	54·2, 59·6	67·3	64·2, 70·3	51·7	49·7, 53·7
At least one symptom	43·1	40·4, 45·8	32·7	29·7, 35·8	48·3	46·3, 50·3
Maternal						
Age (years)						
15–24	34·9	32·4, 37·5	25·2	22·4, 28·2	28·1	26·4, 29·9
25–34	53·0	50·3, 55·7	51·8	48·6, 55·1	52·2	50·3, 54·2
35–49	12·1	10·4, 14·0	23·0	20·4, 25·8	19·6	18·1, 21·3
Highest educational level						
No education	12·6	10·9, 14·5	15·1	12·9, 17·6	1·8	1·5, 2·3
Primary	51·2	48·5, 53·9	44·7	41·5, 48·0	30·0	28·1, 31·8
Secondary/higher	36·2	33·7, 38·8	40·2	37·0, 43·4	68·2	66·3, 70·1
Marital status						
Married/cohabiting	96·0	94·9, 96·9	96·7	95·3, 97·7	97·8	97·1, 98·3
Widowed/divorced/separated	4·0	3·1, 5·1	3·3	2·3, 4·7	2·2	1·7, 2·9
Active labour force participation						
Not working (past 12 months)	30·4	27·9, 33·0	41·3	38·1, 44·6	54·2	52·2, 56·2
Low	36·3	33·8, 38·9	29·4	26·5, 32·5	27·6	25·9, 29·3
High	33·3	30·8, 35·9	29·3	26·4, 32·4	18·2	16·7, 19·9
Exposure to mass media						
Frequent	39·1	36·5, 41·8	34·7	31·6, 37·9	36·0	34·1, 37·9
Moderate	32·0	29·5, 34·6	37·8	34·6, 41·0	31·4	30·0, 33·3
Limited	28·9	26·6, 31·4	27·6	24·8, 30·6	32·7	30·8, 34·5
Antenatal clinic visits						
0–1	6·4	5·2, 7·8	14·2	12·1, 16·7	3·9	3·3, 4·5
2–4	32·1	29·7, 34·7	38·0	34·8, 41·2	12·5	11·3, 13·7
≥ 5	61·5	58·9, 64·1	47·8	44·5, 51·1	83·7	82·4, 84·9
Paternal						
Highest educational level						
No education	8·8	7·4, 10·4	16·1	13·9, 18·7	1·0	0·8, 1·3
Primary	44·0	41·3, 46·7	39·5	36·3, 42·8	32·0	30·1, 33·9
Secondary/higher	47·2	44·5, 49·9	44·4	41·1, 47·7	67·0	65·1, 68·9
Occupation						
Not-working	0·3	0·0, 0·9	0·0	0·0, 0·0	1·4	1·1, 1·9
Agricultural	47·1	44·5, 49·8	24·8	22·1, 27·7	21·4	19·9, 22·9
Non-agricultural	52·6	49·9, 55·3	75·2	72·3, 77·9	77·2	75·6, 78·7
Household						
Household wealth						
Poorest	23·8	21·7, 26·2	26·6	23·9, 29·6	16·3	15·0, 17·7
Poorer	18·2	16·3, 20·2	22·9	20·3, 25·8	20·8	19·3, 22·5
Middle	19·7	17·6, 22·0	20·1	17·6, 22·9	20·7	19·1, 22·4
Richer	18·2	16·1, 20·5	5·5	13·3, 18·0	22·4	20·8, 24·2
Richest	20·1	17·9, 22·4	14·9	12·7, 17·4	19·7	18·2, 21·4
Sex of household head						
Male	77·5	75·2, 79·7	85·9	83·5, 88·0	91·4	90·2, 92·5
Female	22·5	20·4, 24·8	14·1	12·0, 16·5	8·6	7·5, 9·9

Table 2 *Continued*

Characteristics	Cambodia (n 2127) %	95 % CI	Myanmar (n 1339) %	95 % CI	Indonesia (n 5193) %	95 % CI
Spatial						
Residence						
Rural	86·0	84·3, 87·5	74·6	71·6, 77·5	50·8	48·8, 52·8
Urban	14·0	12·5, 15·7	25·4	22·6, 28·4	49·2	47·2, 51·2
Geographical region†						
Region 1	8·7	7·3, 10·3	12·8	10·9, 15·0	23·4	22·1, 24·8
Region 2	35·9	33·2, 38·7	15·5	13·1, 18·3	53·4	51·5, 55·3
Region 3	31·5	29·0, 34·0	9·8	8·6, 11·2	5·7	5·2, 6·3
Region 4	6·0	5·1, 7·0	8·3	7·0, 9·8	6·6	6·1, 7·2
Region 5	18·0	16·3, 19·8	34·1	30·9, 37·5	7·9	7·3, 8·5
Region 6	–	–	19·5	17·0, 22·2	1·2	1·1, 1·4
Region 7	–	–	–	–	1·8	1·5, 2·1

*Data from recent Demographic and Health Surveys in Cambodia (2014)[27], Myanmar (2015–16)[28] and Indonesia (2012)[29].
†See Table 1 for geographical regions of the study context.

Indonesia where approximately equal proportions resided in urban and rural areas (Table 2).

Dietary diversity

Overall, the proportion of children aged 6–23 months reported to be receiving MMD ranged from 24·6 % in Myanmar, to 47·7 % in Cambodia and 58·2 % in Indonesia (Fig. 1).

Foods consisting of grains, roots and tubers featured in the diets of children in all three countries, with over 50 % of children in Cambodia and Myanmar receiving this type of food at age 6 or 7 months respectively, and over 83 % in Indonesia by age 6 months (see online supplementary material, Fig. S1). Flesh foods such as meat and poultry featured in the diets of over half of Cambodian children aged 6–11 months, increasing to 94 % by age 18–23 months. However, only one-third of children aged 6–11 months in Myanmar and Indonesia received flesh foods which increased to 60 % in Myanmar and 70 % in Indonesia by age 18–23 months.

Factors associated with minimum dietary diversity

Pooling all data from Cambodia, Myanmar and Indonesia (see online supplementary material, Table S1) to quantify the difference between countries in the likelihood of children meeting MDD, with Cambodia as reference category, the odds of meeting MDD was 68 % lower (AOR = 0·32; 95 % CI 0·27, 0·38) in Myanmar and 22 % higher in Indonesia (AOR = 1·22; 95 % CI 1·08, 1·38). In this pooled analysis, children from the richest households (AOR = 2·78; 95 % CI 2·36, 2·92) and those living in urban areas (AOR = 1·83; 95 % CI 1·64, 2·04) were more likely to meet the MDD. High labour force participation was associated with a 25 % increased odds of meeting MDD (AOR = 1·25; 95 % CI 1·10, 1·42).

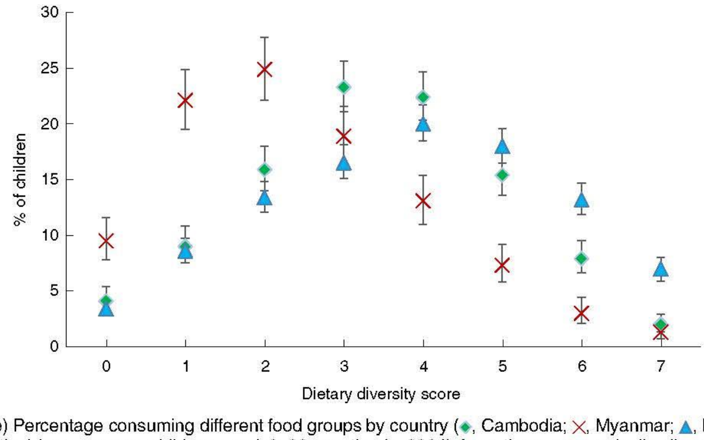

Fig. 1 (colour online) Percentage consuming different food groups by country (◆, Cambodia; ×, Myanmar; ▲, Indonesia), with 95 % CI indicated by vertical bars, among children aged 6–23 months (n 8364) from three economically diverse South-East Asian countries. Data from recent Demographic and Health Surveys in Cambodia (2014)[27], Myanmar (2015–16)[28] and Indonesia (2012)[29]

Country-level models

In both Myanmar and Indonesia, children of mothers with secondary education or higher were more likely to receive MDD (AOR = 1·39; 95 % CI 1·00, 1·94 and AOR = 1·37; 95 % CI 1·18, 1·59, respectively), but this association did not reach statistical significance in Myanmar. Mother's level of labour force participation was significantly associated with MDD only in Indonesia, with infants of mothers with high participation in the labour force having increased odds of meeting MDD (AOR = 1·28; 95 % CI 1·06, 1·53), whereas this association, although in the same direction, did not reach statistical significance in Cambodia and Myanmar (Table 3).

Consistently, children from the richest households experienced increased odds of receiving MDD, by approximately twofold or more in each country, while living in an urban area increased the odds (AOR = 1·43; 95 % CI 1·10, 1·88 in Cambodia; AOR = 1·69; 95 % CI 1·18, 2·42 in Myanmar; AOR = 1·66; 95 % CI 1·45, 1·90 in Indonesia; Table 3). Further exploration of the predicted probabilities for children receiving MDD across household wealth quintile, by urban/rural residence (see online supplementary material, Table S2 and Fig. S2), provided insight into intra-urban and intra-rural socio-economic differentials in meeting MDD. Although the differences between the predicted probabilities between children from the poorest and richest households were relatively similar among both urban and rural children, it was clear that the rural poor were consistently disadvantaged, compared with the urban poor.

By geographical region, children residing in households outside the capital city of Phnom Penh in Cambodia experienced decreased odds of meeting MDD. In Myanmar, residing in Central Myanmar (in the regions of Magway, Mandalay and Naypyitaw) was associated with approximately twofold increased odds of receiving MDD (AOR = 2·26; 95 % CI 1·38, 3·71; Table 3).

In all three countries children aged 18–23 months were over three times more likely to receive the MDD than those aged 6–11 months. In Myanmar, being a girl was associated with a 30 % decreased odds of meeting MDD (AOR = 0·70; 95 % CI 0·52, 0·93), but this association was minimal and not statistically significant in Cambodia and Indonesia (Table 3).

In all three countries, children who were still being breast-fed at the time of the survey were significantly less likely to receive the MDD, with decreased odds of 27 % in Cambodia, 39 % in Myanmar and 51 % in Indonesia, in models adjusting for age of child. Reported symptoms of recent child morbidity increased the odds of meeting MDD in Indonesia by 25 % (AOR = 1·25; 95 % CI 1·10, 1·42), but this association was not significant in Cambodia where the odds were decreased and in Myanmar where the odds were increased. A short preceding birth interval (<24 months) was associated with decreased odds of the child receiving MDD in both Cambodia and Myanmar, by approximately half (Table 3).

Children of mothers in the youngest age category (15–24 years) were most at risk for not meeting MDD in all three countries. The association between a composite measure of maternal exposure to media and MDD differed in Cambodia and Indonesia, with limited exposure significantly reducing the odds of meeting MDD by 40 % in Cambodia, non-significantly reducing the odds by 26 % in Myanmar and significantly increasing the odds by 58 % in Indonesia (Table 3).

Discussion

The findings of our research confirm that urban areas offer advantage over rural areas for meeting MMD in young children[37], although intra-urban and intra-rural socio-economic differentials remained.

The finding that maternal higher education was positively associated with MDD in Myanmar and Indonesia is supported by previous research in the Asia-Pacific region[31,38 41]. Although maternal education is often considered a proxy for socio-economic status, Ruel *et al.*[42] argue that the effect of maternal education on child health and nutrition is independent of socio-economic status, perhaps strengthening the guidance to improve maternal knowledge of optimal child nutrition. Although mother's labour force participation reached significance only in Indonesia, in all countries children of mothers with a high labour force involvement had an increased likelihood of meeting MDD. Rates of female labour force participation vary across the 6000 islands that constitute Indonesia, but have on the whole remained relatively high compared with other countries in South-East Asia[43]. Moreover, even among women participating in the labour force, only a very small proportion of women are formally employed in wage jobs[43]. Our findings highlight that children born to mothers actively engaged in the labour force in Indonesia, i.e. high-status employment in professional or skilled jobs, with job security, year-round employment and wages, were more likely to receive MDD. Unlike previous studies which considered the employment status (whether or not the mother was employed), our study used a composite indicator to understand the effect of maternal labour force participation on dietary diversity in children. This clearly suggests the importance of considering multiple dimensions of female participation in the labour force. This is especially pertinent in countries where many women participate in informal or seasonal employment.

At the household level, in a model allowing for urban/rural setting, there was consistent inequality in the odds of meeting MDD by household wealth quintile in all three countries, with children from the poorest households most at risk of not receiving the MDD, as also shown elsewhere in low- and middle-income countries[38 41]. We also showed a clear link between living in an urban area and

Appendix B

Table 3 Factors associated with meeting minimum dietary diversity (adjusted odds ratios (AOR) and 95 % CI) among children (*n* 8364) aged 6–23 months from three economically diverse South-East Asian countries*

	Cambodia (*n* 2096)			Myanmar (*n* 1336)			Indonesia (*n* 5160)		
Characteristics	AOR	95 % CI	*P*	AOR	95 % CI	*P*	AOR	95 % CI	*P*
Socio-economic									
Maternal educational level									
No education/primary	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
Secondary/higher	1·13	0·90, 1·42	0·277	1·39	1·00, 1·94	0·050	1·37	1·18, 1·59	0·000
Maternal active labour force participation									
Not working (past 12 months)	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
Low	1·00	0·78, 1·29	0·999	1·11	0·78, 1·59	0·550	1·08	0·93, 1·24	0·324
High	1·10	0·85, 1·41	0·475	1·17	0·82, 1·66	0·382	1·28	1·06, 1·53	0·009
Household wealth									
Poorest	1·00	Ref.	–	1·00	Ref.	–	1·00	v	
Poorer	1·26	0·96, 1·66	0·100	0·99	0·64, 1·53	0·970	1·27	1·05, 1·54	0·014
Middle	1·73	1·28, 2·35	0·000	1·24	0·80, 1·93	0·334	1·53	1·25, 1·87	0·000
Richer	1·16	0·83, 1·62	0·377	0·53	0·96, 2·45	0·075	1·89	1·53, 2·33	0·000
Richest	2·37	1·65, 3·39	0·000	1·81	1·10, 2·96	0·019	1·98	1·58, 2·47	0·000
Residence									
Rural	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
Urban	1·43	1·10, 1·88	0·008	1·69	1·18, 2·42	0·004	1·66	1·45, 1·90	0·000
Geographical region†									
Region 1	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
Region 2	0·31	0·18, 0·53	0·000	1·24	0·74, 2·09	0·415	0·97	0·81, 1·16	0·728
Region 3	0·38	0·22, 0·65	0·000	0·72	0·43, 1·21	0·220	0·63	0·49, 0·80	0·000
Region 4	0·33	0·18, 0·60	0·000	0·65	0·37, 1·14	0·131	0·83	0·67, 1·03	0·092
Region 5	0·28	0·16, 0·48	0·000	0·81	0·49, 1·34	0·417	0·55	0·46, 0·67	0·000
Region 6	–	–	–	2·26	1·38, 3·71	0·000	0·55	0·41, 0·73	0·000
Region 7	–	–	–	–	–	–	0·56	0·41, 0·77	0·000
Child									
Age (months)									
6–11	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
12–17	3·29	2·59, 4·18	0·000	3·28	2·22, 4·84	0·000	3·21	2·77, 3·72	0·000
18–23	3·38	2·60, 4·40	0·000	4·51	2·98, 6·84	0·000	4·74	4·05, 5·56	0·000
Sex									
Male	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
Female	0·96	0·80, 1·16	0·698	0·70	0·52, 0·93	0·013	1·00	0·88, 1·13	0·999
Breast-feeding status									
Not currently breast-fed	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
Currently breast-fed	0·73	0·58, 0·92	0·009	0·61	0·42, 0·89	0·010	0·49	0·42, 0·56	0·000
Morbidity									
No symptoms	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
At least one symptom	0·83	0·69, 1·01	0·065	1·15	0·86, 1·54	0·355	1·25	1·10, 1·42	0·000
Birth interval (months)									
No previous birth	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
<24	0·60	0·40, 0·89	0·011	0·54	0·30, 1·00	0·048	0·94	0·72, 1·23	0·656
≥ 24	0·76	0·60, 0·97	0·025	0·70	0·49, 0·98	0·041	0·83	0·71, 0·98	0·032

Table 3 *Continued*

Characteristics	Cambodia (*n* 2096)			Myanmar (*n* 1336)			Indonesia (*n* 5160)		
	AOR	95 % CI	*P*	AOR	95 % CI	*P*	AOR	95 % CI	*P*
Maternal									
Age (years)									
35–49	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
25–34	0·96	0·70, 1·30	0·773	0·57	0·40, 0·82	0·002	0·84	0·71, 1·00	0·044
15–24	0·69	0·48, 0·98	0·039	0·50	0·32, 0·80	0·003	0·73	0·58, 0·90	0·004
Exposure to media									
Frequent	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
Moderate	0·70	0·56, 0·89	0·004	0·90	0·65, 1·26	0·544	1·47	1·26, 1·72	0·000
Limited	0·60	0·46, 0·79	0·000	0·74	0·49, 1·11	0·147	1·58	1·34, 1·85	0·000

Ref., reference category.
*Data from recent Demographic and Health Surveys in Cambodia (2014)[27], Myanmar (2015–16)[28] and Indonesia (2012)[29].
†See Table 1 for geographical regions of the study context.

improved odds for meeting MDD in children in a model controlling for maternal education and household wealth. The role of urbanisation is important in South-East Asia, a region where 47 % of the population was living in urban areas in 2014, expected to rise to 64 % by 2050[21]. Urbanisation and the concurrent growth in incomes, employment opportunities and lower food prices perhaps provide advantage over rural areas, where there is a higher dependence on sometimes unpredictable natural resources to meet nutritional needs and lack of national integrated systems for food distribution[37].

Finally, we also found that girls were disproportionately at risk of not meeting MDD in Myanmar, despite previous research suggesting no gender differences in infant and young child feeding practices in this country[44]. Our findings also highlight the need to focus on increasing knowledge on infant and young child feeding practices among younger mothers[45]. This is particularly pertinent in the South-East Asia region where adolescent birth rates remain high[46] and 17·4 % of the population is made up of those aged between 15 and 24 years[47]. Regular media exposure had a positive effect on meeting MDD in Cambodia, perhaps reflective of the successfulness of the COMBI national campaign 2011–2013 to improve complementary feeding[48].

There are some methodological limitations of our study to consider. Limited sample sizes and consequent lack of disaggregated statistics prevented stratified modelling by breast-feeding status; as breast milk is not included in the itemised food groups, it is thus likely that MDD was underestimated among the subgroup of children who were still breast-fed[17]. Although the use of current-status data may result in overestimating the proportion of children meeting MDD[49], use of such data is considered to strengthen the reliability of survey responses due to the reduced recall bias. Finally, high response rates in each country (over 96 % among contacted women) demonstrate the value of DHS data for population-level analysis.

Conclusion

We confirm the role of urban/rural setting in complementary feeding practices of young children, and further show that socio-economic characteristics of households, mothers and children within both urban and rural areas are influential factors in meeting MDD. Using nationally representative data from three countries in South-East Asia, we have shown that the poorest households in both rural and urban areas are consistently the most disadvantaged and this result is consistent across the sub-region. Using a stratified wealth index that was calculated separately for urban and rural areas, we have tried to ensure that those from the poorest households in rural areas were effectively represented in the current study.

Regardless of location, children of mothers with higher education, better working conditions and higher economic status were more likely to receive MDD. As a result, policies to promote dietary diversity in young children should not only focus on geographical differences, but also target population subgroups from economically disadvantaged communities. Today's children will become adults by the end of 2030. Therefore, investing in child nutrition and thus development is crucial for achieving Goals 2 and 3 of the 2030 Agenda for Sustainable Development[5].

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Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.1017/S1368980018002173

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Appendix C Pooled adjusted multivariable analysis (exclusive breastfeeding)

Appendix C: Chapter 4.2.2: Adjusted odds ratios (95% CI) of factors associated with exclusive breastfeeding (pooled analysis), *n*=2793

Characteristics	AOR	95% CI	*P*
Country			
Indonesia	1.00	Ref.	-
Cambodia	2.33	1.82, 2.98	<0.001
Myanmar	2.13	1.41, 3.21	<0.001
Inherent (biological) factors			
Age (months)			
< 3	1.00	Ref.	-
≥ 3	0.35	0.30, 0.42	<0.001
Sex			
Male	1.00	Ref.	-
Female	1.34	1.13, 1.58	0.001
Proximate factors			
Received Pre-lacteal feeds			
No	1.00	Ref.	-
Yes	0.33	0.27, 0.40	<0.001
Never breastfed[a]	N/A	N/A	N/A
Missing[b]	0.54	0.34, 0.86	0.009
Intermediate factors			
Birth order			
First	1.00	Ref.	-
2-3	1.23	0.99, 1.51	0.060
4+	1.08	0.78, 1.49	0.653
Birth place			
At home	1.00	Ref.	-
Private facility	1.11	0.85, 1.45	0.452
Public facility	1.36	1.07, 1.72	0.012
ANC visits			
5+	1.00	Ref.	-
2-4	0.72	0.58, 0.90	0.003
0-1	0.72	0.52, 0.98	0.039
Delivery by caesarean section			
No	1.00	Ref.	-
Yes	0.71	0.55, 0.92	0.010
Mother's age			

Characteristics	**AOR**	**95% CI**	***P***
35-49	1.00	Ref.	-
25-34	1.13	0.86, 1.48	0.379
15-24	0.99	0.72, 1.36	0.942
Distal (underlying) factors			
Maternal education level			
No education/primary	1.00	Ref.	-
Secondary/higher	1.26	1.03, 1.55	0.023
Maternal active labour force participation			
Not working (past 12 months)	1.00	Ref.	-
Low	0.99	0.81, 1.22	0.930
High	0.71	0.57, 0.89	0.003
Household wealth			
Poorest	1.00	Ref.	-
Poorer	1.19	0.92, 1.55	0.177
Middle	0.88	0.67, 1.15	0.343
Richer	0.68	0.51, 0.90	0.007
Richest	0.98	0.72, 1.33	0.908
Residence			
Rural	1.00	Ref.	-
Urban	0.73	0.60, 0.90	0.003

[a] Category was omitted from multivariable models as there was this category predicted the outcome perfectly. Never breastfed infants were retained in the analysis by using the *asis* function in Stata

[b] Category should be interpreted with caution as 79% of the data was missing for this variable in Myanmar, however in order to make use of all available data, this category was retained in the models.

Appendix D Unadjusted models (exclusive breastfeeding)

Appendix D: Chapter 4: Unadjusted odds ratios (95% CI) of factors associated with exclusive breastfeeding in Cambodia, Myanmar and Indonesia

	Cambodia (*n* 688)			**Myanmar (*n* 468)**			**Indonesia (*n* 1,686)**		
Characteristics	**UOR**	**95% CI**	***P***	**UOR**	**95% CI**	***P***	**UOR**	**95% CI**	***P***
Inherent (biological) factors									
Age (months)									
<3	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
≥3	0.36	0.26, 0.50	<0.001	0.34	0.23, 0.49	<0.001	0.42	0.34, 0.51	<0.001
Sex									
Male	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Female	1.32	0.97, 1.81	0.078	1.66	1.15, 2.39	0.007	1.21	1.00, 1.48	0.055
Proximate factors									
Received pre-lacteal feeds									
No	1.00	Ref.	-	-	-	-	1.00	Ref.	-
Yes	0.37	0.26, 0.53	<0.001	-	-	-	0.33	0.27, 0.41	<0.001
Never breastfed	- [A]	-	-	-	-	-	- [A]	-	-
Missing	- [A]	-	-	-	-	-	0.11	0.03, 0.49	0.004
Intermediate factors									
Birth order									
First	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
2-3	1.17	0.83, 1.63	0.367	1.03	0.69, 1.54	0.886	1.51	1.21, 1.87	<0.001
4+	0.95	0.58, 1.55	0.826	1.01	0.61, 1.67	0.968	1.33	0.99, 1.79	0.055
Birth place									

Appendix D

	Cambodia (*n* 688)			Myanmar (*n* 468)			Indonesia (*n* 1,686)		
Characteristics	**UOR**	**95% CI**	***P***	**UOR**	**95% CI**	***P***	**UOR**	**95% CI**	***P***
At home	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Private facility	0.32	0.17, 0.62	0.001	0.80	0.38, 1.67	0.545	0.93	0.74, 1.17	0.515
Public facility	0.84	0.48, 1.48	0.558	1.19	0.81, 1.74	0.380	1.19	0.93, 1.53	0.166
ANC visits									
5+	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
2-4	1.05	0.76, 1.47	0.756	1.03	0.69, 1.56	0.869	0.68	0.52, 0.89	0.005
0-1	2.37	1.25, 4.51	0.009	0.52	0.31, 0.88	0.015	0.95	0.66, 1.37	0.785
Delivery by caesarean section									
No	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Yes	0.32	0.19, 0.52	<0.001	1.17	0.75, 1.83	0.479	0.52	0.38, 0.70	<0.001
Mother's age									
35-49	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
25-34	1.83	1.03, 3.27	0.040	1.10	0.67, 1.79	0.704	1.01	0.76, 1.34	0.933
15-24	2.00	1.11, 3.59	0.020	0.75	0.44, 1.27	0.283	0.96	0.72, 1.29	0.803
Distal (underlying) factors									
Maternal education level									
No education/primary	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Secondary/higher	0.61	0.44, 0.83	0.002	1.64	1.13, 2.37	0.009	0.96	0.78, 1.19	0.726
Maternal active labour force participation									
Not working (past 12 months)	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Low	1.40	0.93, 2.11	0.104	1.33	0.86, 2.07	0.206	0.83	0.65, 1.06	0.136
High	0.51	0.35, 0.74	<0.001	1.56	0.99, 2.47	0.055	0.60	0.46, 0.78	<0.001
Household wealth									
Poorest	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-

Characteristics	Cambodia (*n* 688)			Myanmar (*n* 468)			Indonesia (*n* 1,686)		
	UOR	95% CI	*P*	UOR	95% CI	*P*	UOR	95% CI	*P*
Poorer	0.94	0.58, 1.52	0.806	1.45	0.84, 2.50	0.185	1.19	0.89, 1.61	0.240
Middle	0.66	0.41, 1.08	0.098	1.67	0.97, 2.87	0.065	0.79	0.59, 1.08	0.139
Richer	0.55	0.34, 0.89	0.014	1.60	0.90, 2.84	0.110	0.57	0.42, 0.78	0.001
Richest	0.53	0.32, 0.88	0.014	2.19	1.22, 3.94	0.009	0.81	0.59, 1.10	0.178
Residence									
Rural	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Urban	0.32	0.23, 0.45	<0.001	0.97	0.63, 1.49	0.879	0.82	0.67, 1.00	0.046
Geographical region[B]									
Region 1	1.00	Ref.	-	1.00	Ref.	-	1.00	Ref.	-
Region 2	3.79	1.83, 7.84	<0.001	0.97	0.48, 1.97	0.936	1.41	1.07, 1.87	0.016
Region 3	7.29	3.57, 14.91	<0.001	0.59	0.32, 1.09	0.094	2.28	1.59, 3.27	<0.001
Region 4	8.67	3.68, 20.40	<0.001	0.92	0.49, 1.71	0.790	0.76	0.52, 1.10	0.149
Region 5	5.62	2.70, 11.69	<0.001	0.89	0.46, 1.74	0.741	1.55	1.15, 2.10	0.004
Region 6				1.03	0.54, 1.98	0.918	1.34	0.85, 2.12	0.202
Region 7							0.85	0.55, 1.33	0.481

[A] Variance in the outcome variable was 0 for this category, as this category mostly consisted of children who were never breastfed in Cambodia. However, this variable was still retained to maintain consistency between models and retain sample size.

[B] **Cambodia:** (1) Phnom Penh; (2) Plain; (3) Tonle Sap; (4) Coast; (5) Plateau/mountain. **Myanmar:** (1) North Myanmar; (2) East Myanmar; (3) South Myanmar; (4) West Myanmar; (5) Lower Myanmar; (6) Central Myanmar. **Indonesia:** (1) Sumatra; (2) Java; (3) Lesser Sunda Islands; (4) Kalimantan; (5) Sulawesi; (6) Maluku Islands; (7) New Guinea.

Appendix E Pooled adjusted multivariable analysis (minimum dietary diversity)

Appendix E: Chapter 4.3.2: Adjusted odds ratios (95% CI) of factors associated with minimum dietary diversity (pooled analysis), ***n*****=8,592**

Characteristics	**AOR**	**95% CI**	***P***
Country			
Cambodia	1.00	Ref.	-
Myanmar	0.32	0.27, 0.38	<0.001
Indonesia	1.22	1.08, 1.38	<0.001
Inherent (biological) factors			
Age (months)			
6-11	1.00	Ref.	-
12-17	3.17	2.82, 3.56	<0.001
18-23	4.08	3.61, 4.62	<0.001
Sex			
Male	1.00	Ref.	-
Female	0.94	0.85, 1.03	0.176
Proximate factors			
Breastfeeding status			
Not currently breastfed	1.00	Ref.	-
Currently breastfed	0.58	0.82, 0.65	<0.001
Morbidity			
No symptoms	1.00	Ref.	-
At least one symptom	1.14	1.04, 1.26	0.007
Intermediate factors			
Birth interval (months)			
No previous birth	1.00	Ref.	-
<24	0.73	0.60, 0.89	0.002
≥24	0.77	0.68, 0.87	<0.001
Maternal age (years)			
35-49	1.00	Ref.	-
25-34	0.84	0.74, 0.96	0.012
15-24	0.67	0.57, 0.80	<0.001
Distal (underlying) factors			
Maternal education level			
No education/primary	1.00	Ref.	-
Secondary/higher	1.34	1.20, 1.50	<0.001
Exposure to media			
Frequent	1.00	Ref.	-
Moderate	1.15	1.03, 1.29	0.017
Limited	1.15	1.02, 1.29	0.022

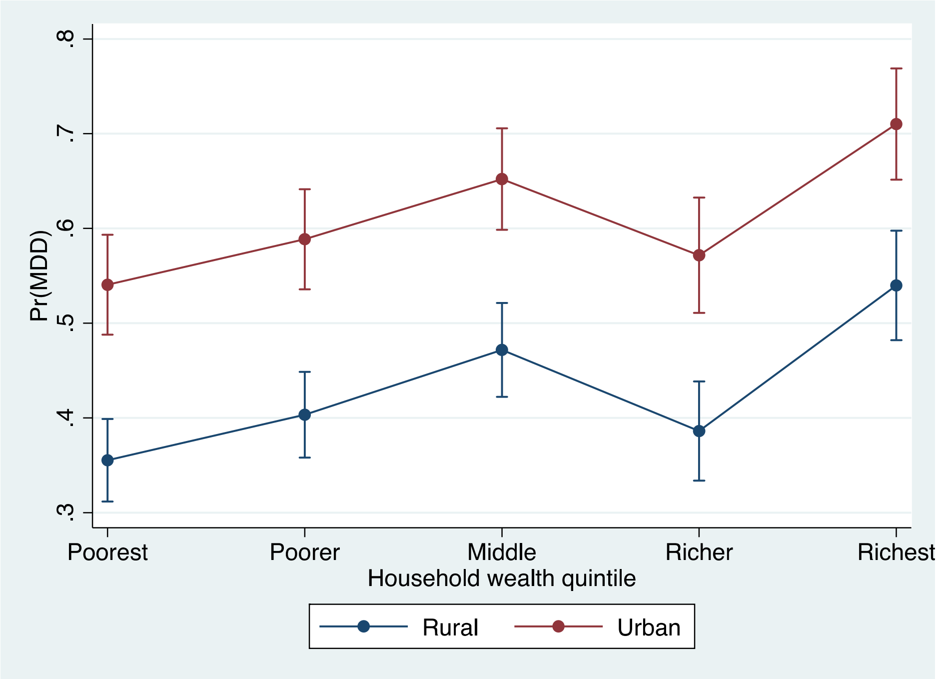
Maternal active labour force participation			
Not working (past 12 months)	1.00	Ref.	-
Low	1.07	0.96, 1.20	0.238
High	1.25	1.10, 1.42	0.001
Household wealth			
Poorest	1.00	Ref.	-
Poorer	1.41	1.22, 1.62	<0.001
Middle	1.87	1.61, 2.17	<0.001
Richer	2.09	1.79, 2.44	<0.001
Richest	2.78	2.36, 2.92	<0.001
Residence			
Rural	1.00	Ref.	-
Urban	1.83	1.64, 2.04	<0.001

Appendix F Predicted probabilities (minimum dietary diversity)

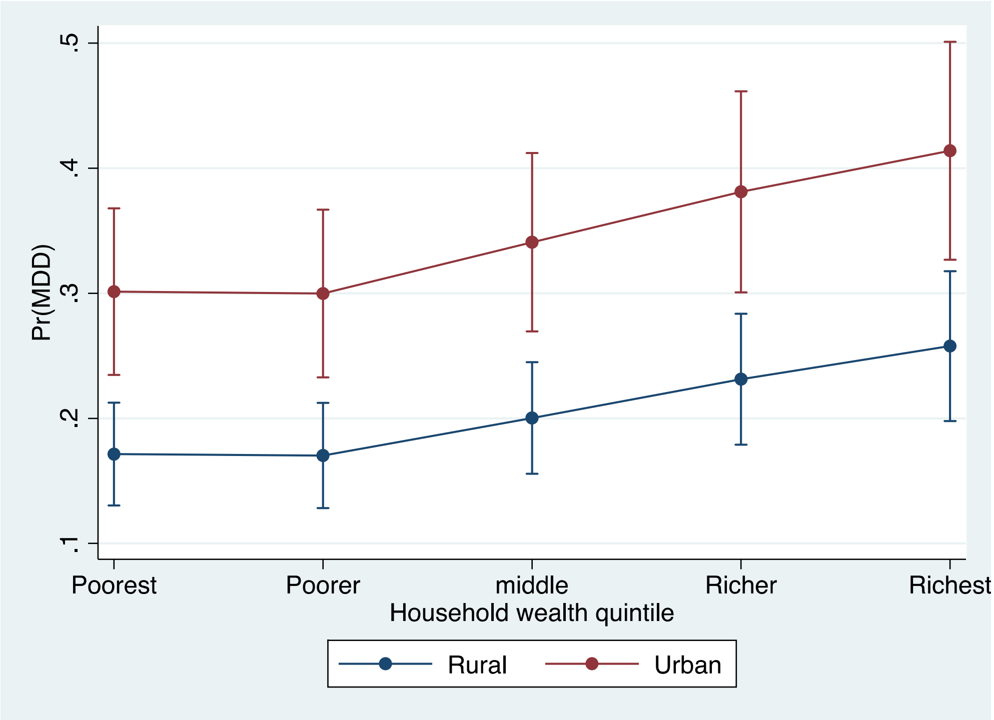
Appendix F: Chapter 4.3.2: Adjusted predicted probabilities (95% CI), for children meeting MDD by household wealth and residence

Variable	Cambodia, 2014 *(n=2096)*		Myanmar, 2015-16 *(n=1336)*		Indonesia, 2012 *(n=5160)*	
Rural						
Poorest	0.36	0.31, 0.40	0.17	0.13, 0.21	0.40	0.37, 0.43
Poorer	0.40	0.36, 0.45	0.17	0.13, 0.21	0.45	0.42, 0.48
Middle	0.47	0.42, 0.52	0.20	0.16, 0.24	0.49	0.46, 0.52
Richer	0.39	0.33, 0.44	0.23	0.18, 0.28	0.54	0.50, 0.57
Richest	0.54	0.48, 0.60	0.26	0.20, 0.32	0.55	0.51, 0.58
Urban						
Poorest	0.54	0.49, 0.59	0.30	0.23, 0.37	0.57	0.54, 0.61
Poorer	0.59	0.54, 0.64	0.30	0.23, 0.37	0.62	0.59, 0.65
Middle	0.65	0.60, 0.71	0.34	0.27, 0.41	0.66	0.63, 0.69
Richer	0.57	0.51, 0.63	0.38	0.30, 0.46	0.70	0.67, 0.72
Richest	0.71	0.65, 0.77	0.41	0.33, 0.50	0.70	0.67, 0.74

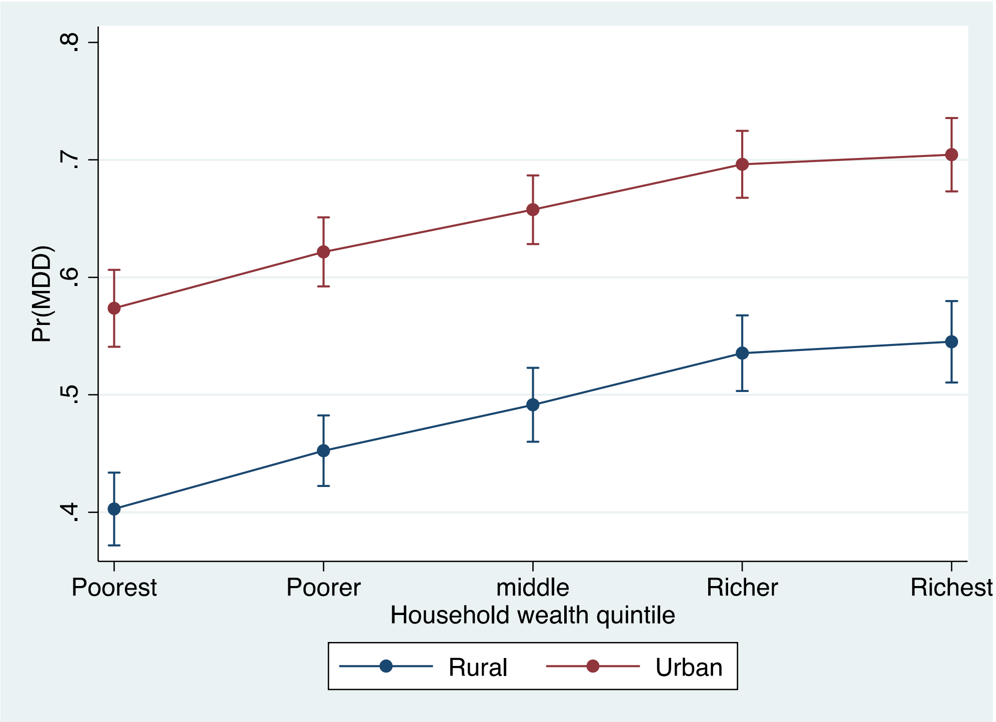
Appendix F: Chapter 4.3.2: Predicted probability plot of meeting MDD in children aged 6 to <24 months by household wealth and type of residence, Cambodia (2014)



Appendix F: Chapter 4.3.2: Predicted probability plot of meeting MDD in children aged 6 to <24 months by household wealth and type of residence, Myanmar (2015-16)

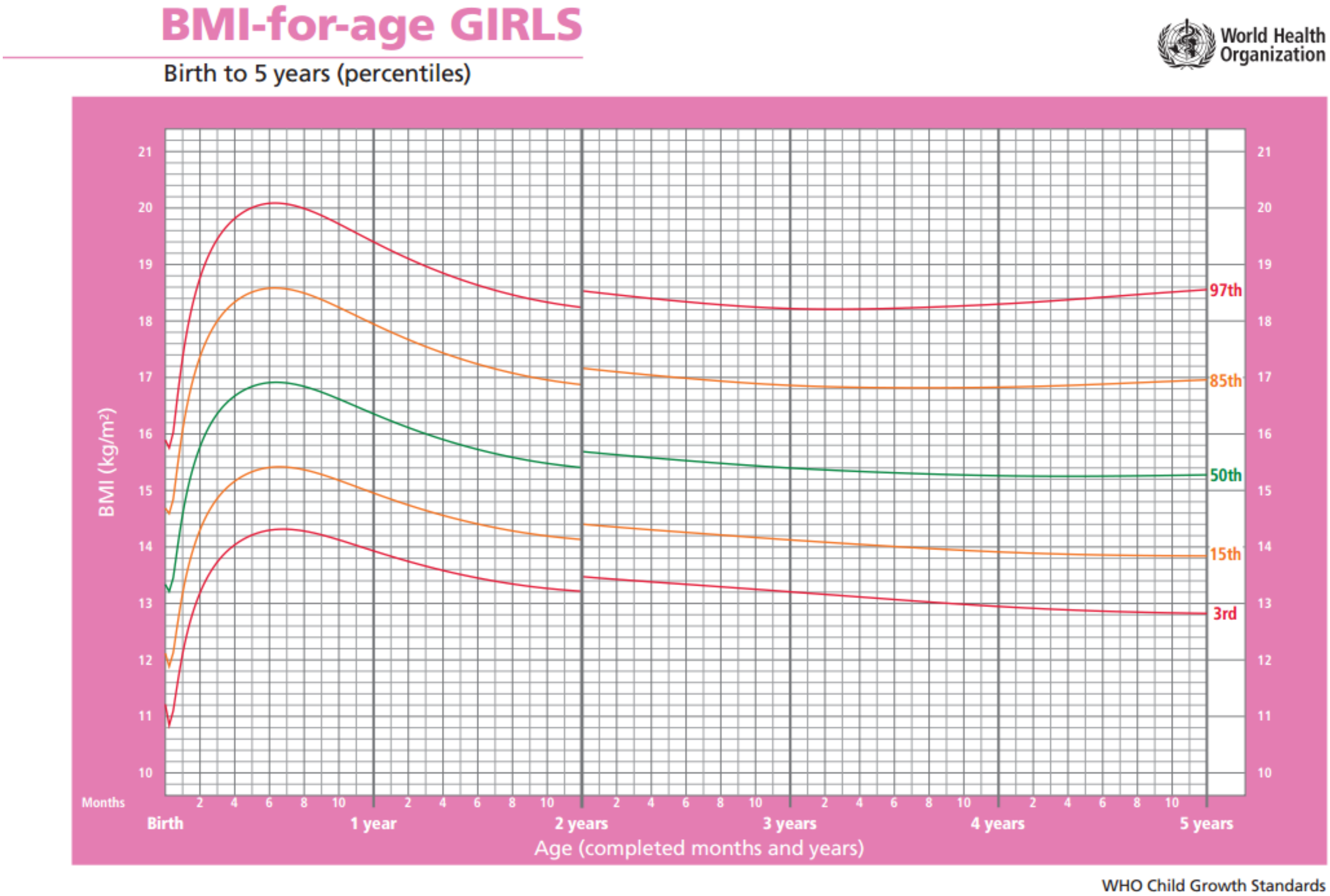


Appendix F: Chapter 4.3.2: Predicted probability plot of meeting MDD in children aged 6 to <24 months by household wealth and type of residence, Indonesia (2012)



Appendix G WHO Child Growth Charts

Appendix G: Chapter 6.3.3: WHO Child Growth Charts (2007), girls 0-5 years



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