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Why Are So Many Children Stunted in the Philippines?

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Abstract

Nearly one in three children under age five in the Philippines is stunted, a key marker of undernutrition. This rate is high for the country's level of income. This paper provides the first detailed multivariate analysis of potential drivers of stunting in the Philippines, using data from the 2015 National Nutrition Survey. Potential drivers are analyzed individually and grouped in major categories. The analysis finds that stunting between 24–60 months is principally associated with suboptimal prenatal conditions and inadequate food security and diversity. If the results are given a causal interpretation, they imply that if all Filipino newborns had adequate prenatal conditions, the fraction stunted at age 24–60 months would fall by 20 percent. Similarly, providing adequate food security and diversity to all Filipino children would reduce stunting by 22 percent. Other factors—including access to water, sanitation, and environmental conditions—have less strong associations with stunting. The results point to a series of policy priorities to reduce stunting: supporting the nutrition and health of expectant mothers, ensuring access to contraception to reduce adolescent pregnancy, and ensuring that children consume a variety of healthy foods, including protein-dense foods such as milk, meat, and eggs.

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1 Introduction

Despite recent economic growth, increased health spending and improved coverage of key health interventions, the Philippines continues to struggle with persistently high child undernutrition. In nationally representative 2015 survey data, nearly 1 in 3 children under age 5 were stunted, a principal marker of undernutrition, and that figure was essentially unchanged from a decade previous. The World Bank's Systematic Country Diagnostic highlights addressing the high level of undernutrition as a principal policy for the country. The government's core planning document, the Philippine Development Plan, also recognizes the undernutrition challenge, and the government's nutrition strategy, the Philippine Plan of Action for Nutrition, sets out an ambitious target of reducing stunting to 20 percent by 2022.[1]

Policy attention to the issue is motivated by a large body of international research which shows that undernutrition in utero and early childhood has severe consequences. Childhood undernutrition is associated with increased risks of morbidity, mortality and cognitive deficits.[2] Longitudinal studies show links between childhood undernutrition and reduced schooling, learning outcomes, and economic productivity as an adult. One of these studies is the Cebu Longitudinal Health and Nutrition Study, which has tracked children born in the Philippines in the early 1980s. Children in the Cebu study who were stunted between birth and age 2 were found to have on average lower cognitive test scores at the ages of 8 and 11 years, delayed enrollment in school, higher absenteeism and repetition of grades, and a lower likelihood of holding a formal job in early adulthood.[3] Recent studies suggest that the total costs of childhood undernutrition in the Philippines is in the range of 1.5 to 3 percent of GDP per year.[4,5]

There is growing evidence that cognitive, motor and socio-emotional deficits in early childhood, as well as schooling and learning outcomes later in life, are mediated through the brain's architecture as it develops in an environment cut off from adequate nutrition, stimulation and care. The vast majority of neural development occurs between conception and infancy and the neural circuits that underpin key functions such as seeing and hearing, speech production and higher cognitive ability are established before the age of two.[6] Key processes such as the creation of neurons, the growth of axons and dendrites, synapse formation and pruning as well as myelination are dependent on key micronutrients.[7] New studies that use neuroimaging technologies to measure brain size and structure show alarming differences in brain architecture associated with chronic malnutrition and sensory deprivation.[8]

While the Philippines has an excellent survey program that routinely monitors the nutritional status of children, there is limited published empirical evidence on the size, direction, interdependence and relative importance of stunting's risk factors and interventions. The objective of this paper is to help fill that knowledge gap by conducting a systematic analysis of potential drivers of stunting. The paper begins with a discussion of the data used for the analysis, and then reviews the broad patterns of stunting in the Philippines and across countries. It next describes a conceptual framework for understanding undernutrition and presents the analysis and discussion.

2 Data

The analysis in this report relies on the nationally representative 2015 National Nutrition Survey (NNS) conducted by the Department of Science and Technology's Food and Nutrition Research Institute (DOST-FNRI). The 2015 NNS is an 'updating' survey, meaning that it was implemented in the years intervening the more comprehensive NNS surveys which are conducted every 5 years. The 2015 NNS collected data across 9 topic areas: anthropometry, clinical and health, dietary, socioeconomic, food security, government nutrition and health program participation, maternal health and nutrition, infant and young child feeding and MDG health related outcomes. For the analyses in this report, 10 NNS modules made available from DOST-FNRI were used (Table 1), representing 42,310 households and 202,570 household members. Data on household income and consumption from the 2015 Family Income & Expenditure Survey (FIES) are also used, given that households in the 2015 FIES can be matched to the 2015 NNS, since both samples use the same sampling frame.

Table 1

Survey program	Module	Population	Observations
2015 Family Income & Expenditure Survey (FIES) (1st semester)	--	Households	43,882
2015 National Nutrition Survey	Form 1.1	Household members (all ages)	202,570
		Household members (fathers)	28,140
		Household members (mothers)	31,654
	Form 1.2	Households	42,310
	Form 1.3	Households	42,310
	Form 1.5	Households	42,310
	Form 1.6	Households	42,310
	Form 2.1	Anthropometry (children < 61 months)	18,629
		Anthropometry (fathers)	28,140
		Anthropometry (mothers)	31,654
	Form 3.1	Mothers & pregnant women with children	8,568
	Form 4.1	Children (0-71 months)	20,303
	Form 4.2	Children (0-71 months)	22,332
	Form 4.3	Children (0-23 months)	6,653

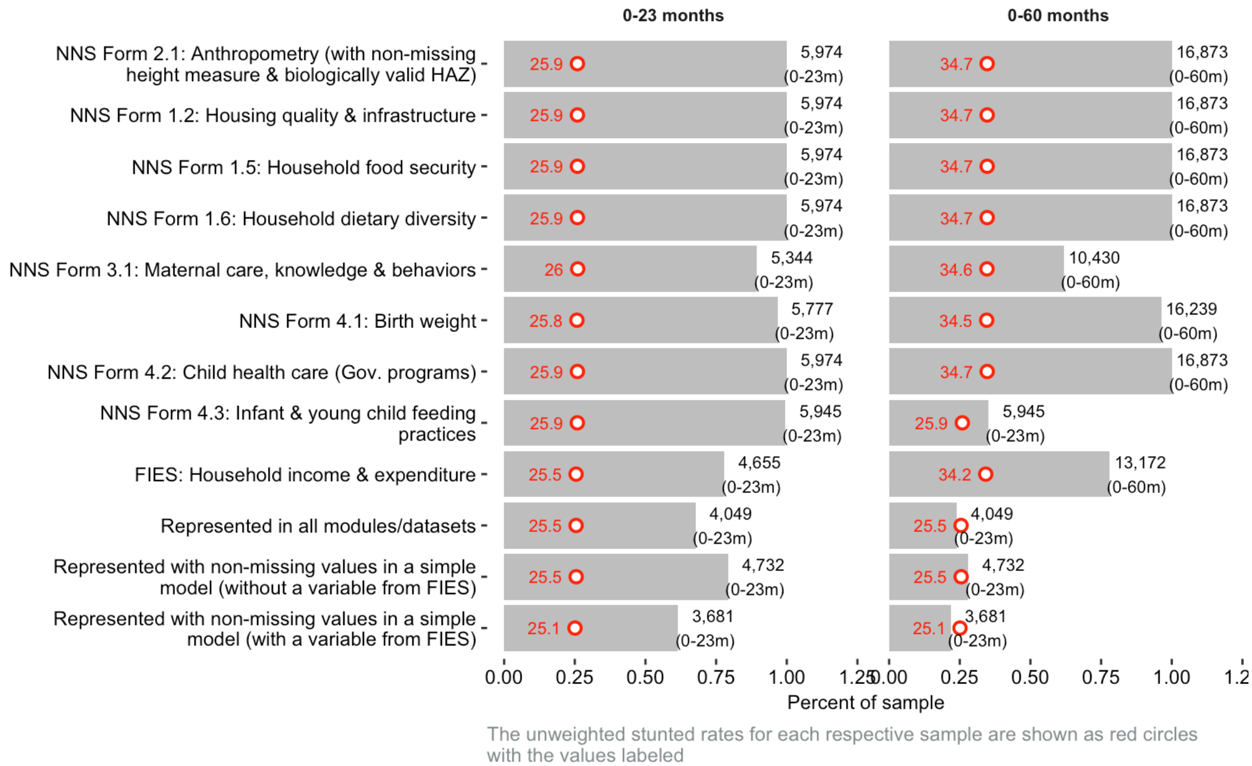
The NNS anthropometry module contains data on 18,629 children spanning the ages of 0 and 1,856 completed days of age (60.9 months) which can be matched to the WHO's international growth standards reference table. However, for 8.7 percent of these cases, height measurements are missing, leaving 17,014 children for whom height-for-age z-scores (HAZ) can be computed.[9] Of these children, 141 had biologically implausible z-scores (> 6 sds or < -6 sds), leaving 16,873 children under the age of 61 months with valid HAZ measurements (Table 2).

Table 2

Data	Children under 61 months of age	Children under 61 months of age with height measurement	Children under 61 months of age with height measurement & biologically plausible height for age z-scores	Children under 61 months of age with height measurement & biologically plausible height for age z-scores & in the 2015 FIES
Observations (unique individuals)	18,629	17,014	16,873	13,172
Females (%)	48.3	48.4	48.4	48.7
Males (%)	51.7	51.6	51.6	51.3
Urban (%)	33.6	33.4	33.4	31.5
Cases with missing age (%)	0	0	0	0
Age range (completed months)	0-60	0-60	0-60	0-60
Mean age (completed months)	32	32	32	32
Median age (completed months	33	33	33	33
Cases with missing height (%)	8.7	0	0	0
Height range (cm)	24.5-144.55	24.5-144.55	41.9-131.45	41.9-131.45
Mean height (cm)	85.2	85.2	85.3	85.3
Median height (cm)	86.9	86.9	87	87.1

Given that different modules of the NNS focus on specific segments of the population, there is a trade-off between the scope of nutrition drivers included and the size and age-composition of the sample considered in the analysis (Figure 1). For example, a total of 16,873 children have valid HAZ scores in the NNS and while all of these children are represented in each of the household-level modules of the NNS (Form 1.2, Form 1.5 and Form 1.6), only 10,188 (around 60 percent) are represented in Form 3.1, which captures variables on maternal health care, and only 5,945 (around 35 percent) are captured in Form 4.3, which captured data on infant and young child feeding practices for children under the age of 2. If data from the FIES are matched to the NNS sample, a total of 4,049 children with valid z-scores (all under the age of 2 years due to the inclusion criteria of Form 3.1) have information from all of the available NNS and FIES modules. There is no evidence that factors that influence stunting other than age are being affected as a result of inclusion/exclusion criteria of the different NNS modules, as the unweighted stunting rates for children under the age of 24 completed months do not vary with the sample size.

Figure 1. Representation across datasets and NNS modules



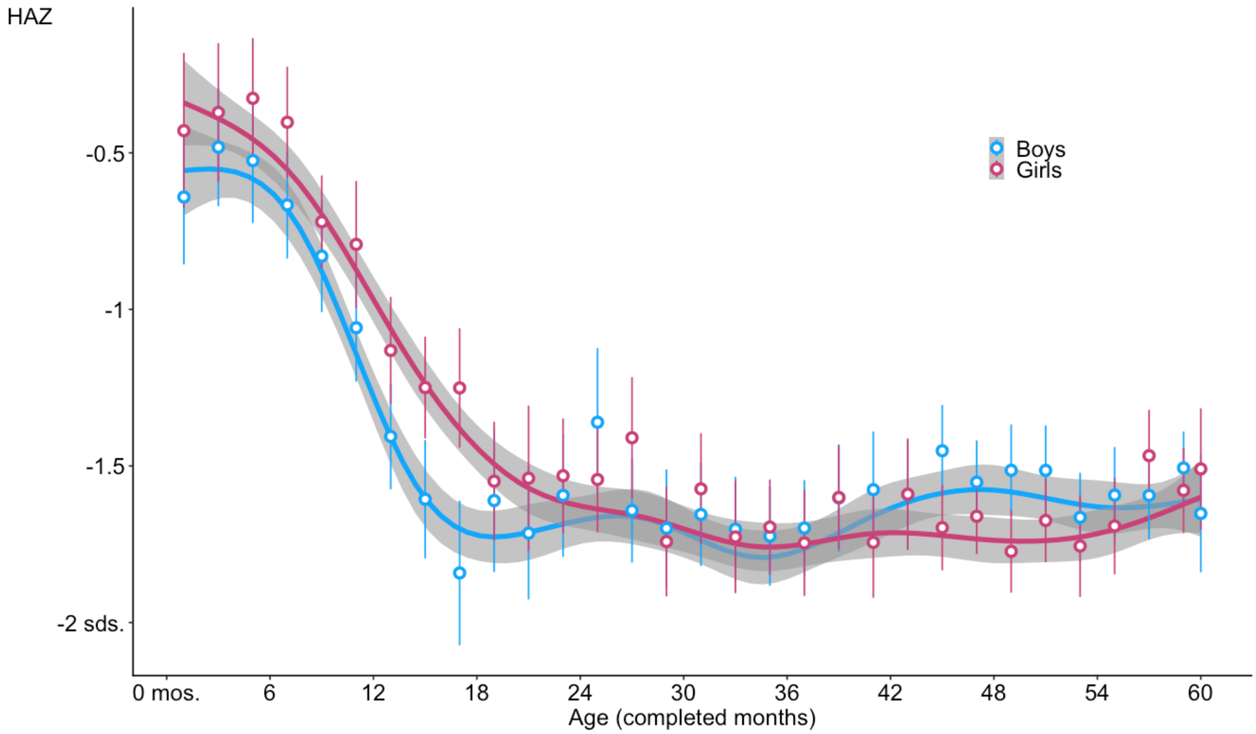
3 Stunting Levels and Trends Globally and in the Philippines

One important measure of the burden of severe undernutrition at a population level is the share of children that are stunted. Stunted children are more than two standard deviations shorter than the WHO median for their exact age and gender. Globally 1 in 5 children under the age of 5 (151 million) are stunted. While the scale of child undernutrition remains vast, progress is being made. Between 2000 and 2017, global stunting rates fell from 32.6 to 22.2 percent.[10] A number of countries with stunting prevalence higher than 25 percent in 2000 made remarkable progress. For example, stunting prevalence in Mongolia, Ghana, Côte d'Ivoire, Peru and Bolivia fell by over 5 percent per year on average with an overall reduction in stunting of between 64 percent (Mongolia) and 47 percent (Ghana).

In the Philippines, 1 in 3 children under the age of 5 (3.8 million) are stunted, placing it fifth among countries in the East Asia & Pacific region with the highest stunting prevalence, and among the 10 countries globally with the highest number of stunted children (Figure 3). While stunting prevalence fell from 44.7 to 33.8 percent between 1987 and 2003, no progress was made in the ensuing 13 years (Figure 4). The Philippines is not a regional anomaly in this regard. Malaysia's stunting rate has persisted at 20.7 percent since 1999 and Indonesia's stunting rate only marginally declined at an annual rate of 0.5 percent per year - from 41.6 percent in 2001 to 36.4 percent in 2013. Ten of 13 countries in South Asia or Southeast Asia with stunting levels higher than 25 percent in 2000 still have stunting rates higher than 25 percent today. A few countries in the region, such as China, Vietnam and Cambodia, have managed to sustain steady declines in stunting at rates of 6.7 (1987-2013), 3.8 (1998 - 2015) and 2.8 (1996-2014) percent per year, respectively.

Figure 2. Mean height for age z-scores (HAZ) by age and sex, children under-5

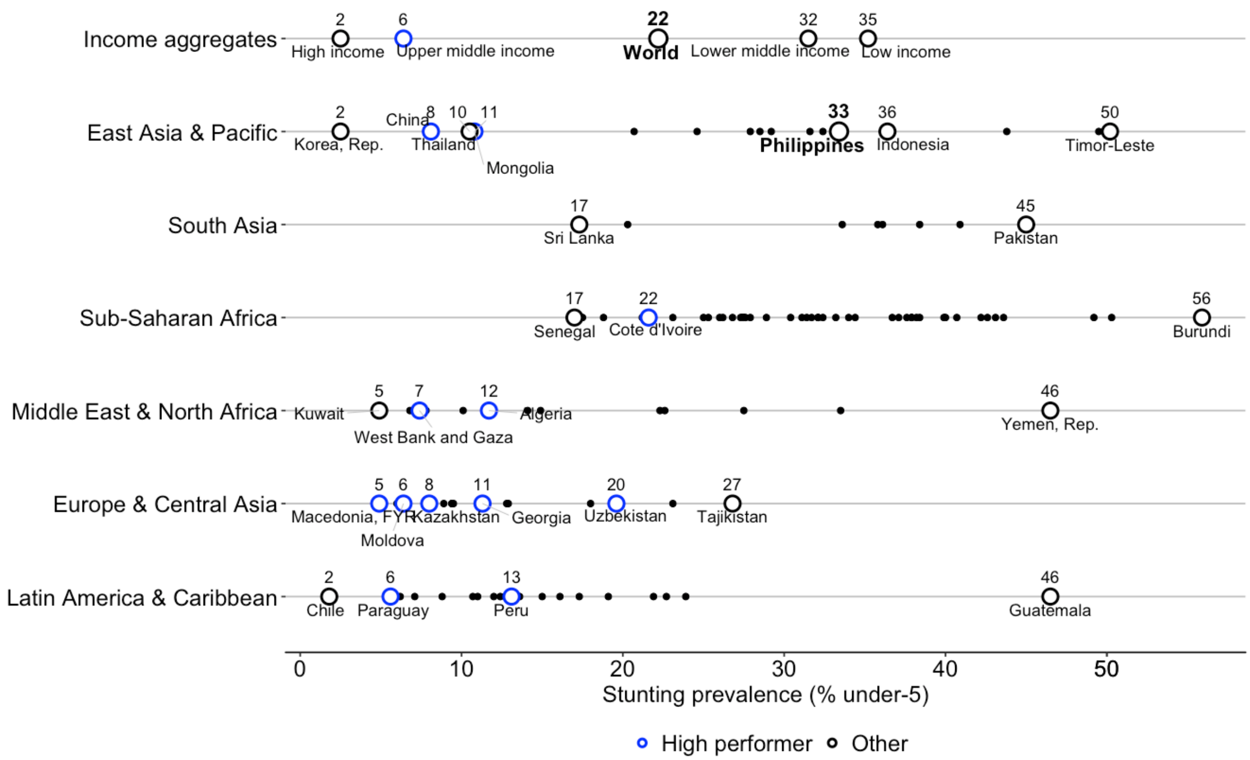
On average, Filipino newborns are about 0.5 standard deviations (SDs) shorter than WHO's international norm of healthy length. This gap rises to a maximum of 1.75 SDs for boys just before 18 months of age and for girls at around 36 months of age, with most of the growth slowdown occurring between the age of 6 and 18 months.



Source: Author's own calculation based on 2015 National Nutrition Survey (NNS). Notes: HAZ = Height-for-age z-score. Point estimates for the mean and 95% confidence intervals are based on groups of children defined by complete age in months. This analysis uses 2 month intervals where, for example, 1 represents children with between 0 and 2 completed months of age. The line represents a non-linear prediction of the age-conditional HAZ fitted with a generalized additive model (gam) using on all observations. The 95% confidence interval around the predictions from the gam smoothed line is shown as a grey area.

Figure 3. Stunting prevalence, by region and country (latest available estimate)

1 in 3 children under the age of five are stunted in the Philippines, 50 percent higher than the global average & just below the average for low income countries.

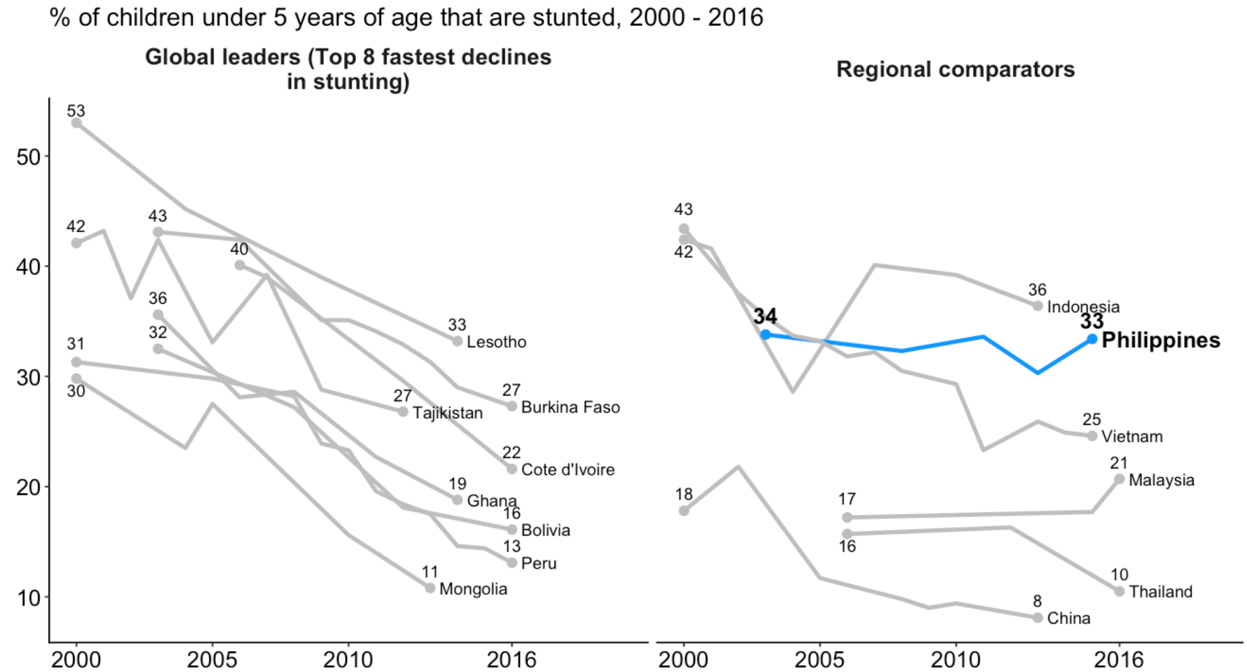


Source: UNICEF, WHO, The World Bank Group: Joint child malnutrition estimates. Notes: Countries within each region with the highest & lowest stunting rates as well as those who have achieved more than 6 percent per year reductions in stunting (high performers) are labeled. Data correspond to the year with the most recently available stunting estimate for each country (the mean year for all estimates shown is 2013), the oldest estimate is from 2002 (Romania) and the most recent estimates are from 2016.

The variation in stunting across countries and between population groups within countries highlights the importance of socio-economic factors in child nutrition outcomes (Figure 5). In the Philippines, under-5 children in families with incomes that rank among the poorest 20% nationally are more than twice as likely to be stunted than children from the richest 20% of families. That said, it is important to note that even among families with incomes in the top fifth of the distribution stunting prevalence is still common - almost 1 in 5 children in these families are stunted.

Figure 4. Stunting prevalence since 2000 in select countries

A number of countries from a variety of regions and income levels that had high levels of stunting in 2000 have been able to rapidly reduce stunting prevalence since. In contrast, countries in South and Southeast Asia are making much slower progress.

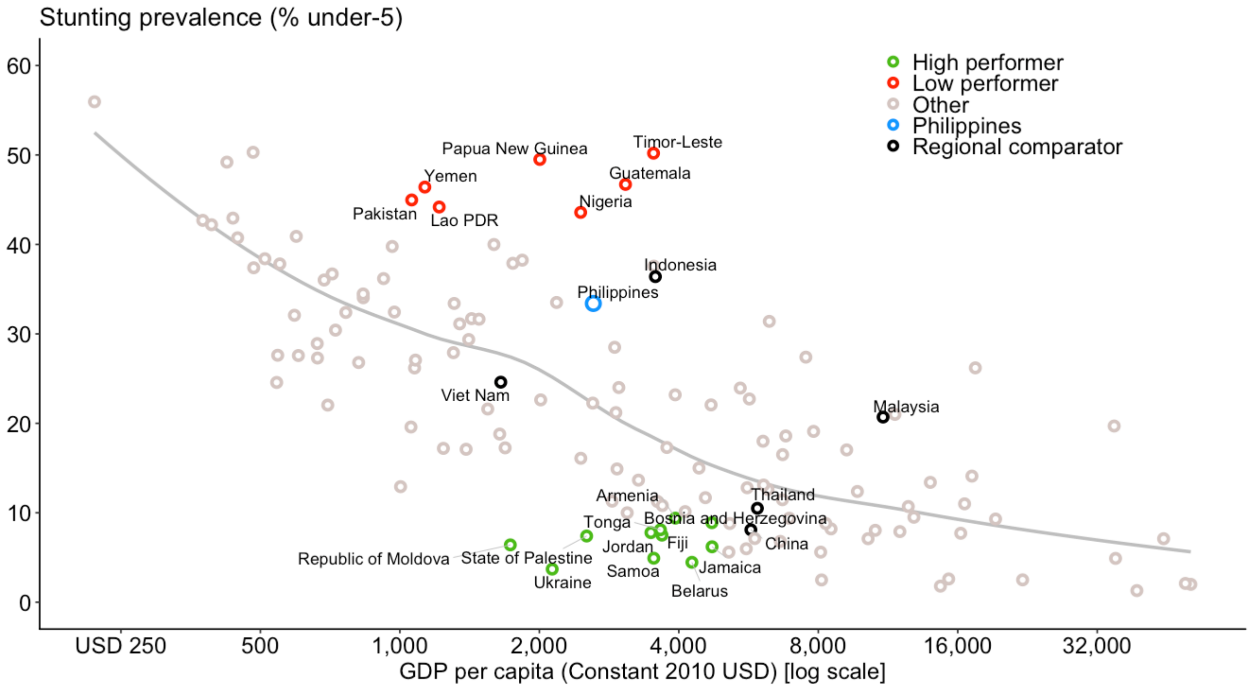


Source: UNICEF, WHO, The World Bank Group: Joint child malnutrition estimates. Only countries with the following criteria are considered for inclusion in the 'Global leaders; group: (1) had stunting prevalences higher than 25% at the start of the period, (2) have at least three stunting estimates that cover more than a 5 year interval between 2000 and 2016, (3) Have populations exceeding 1,000,000.

Globally, average stunting rates tend to decline as countries get richer (Figure 6), but the relationship is very weak, suggesting the key role that policy decisions and other social factors play in the evolution of stunting over time. Among countries that sustained average real GDP per capita growth rates in the range of 4 percent since 2000, for example, some countries, such as Paraguay and Kazakhstan, had stunting rates decline by over 7 percent per year, while others, like the Philippines, saw no or very small changes in stunting rates.

Figure 5. The relationship between stunting prevalence and GDP per capita

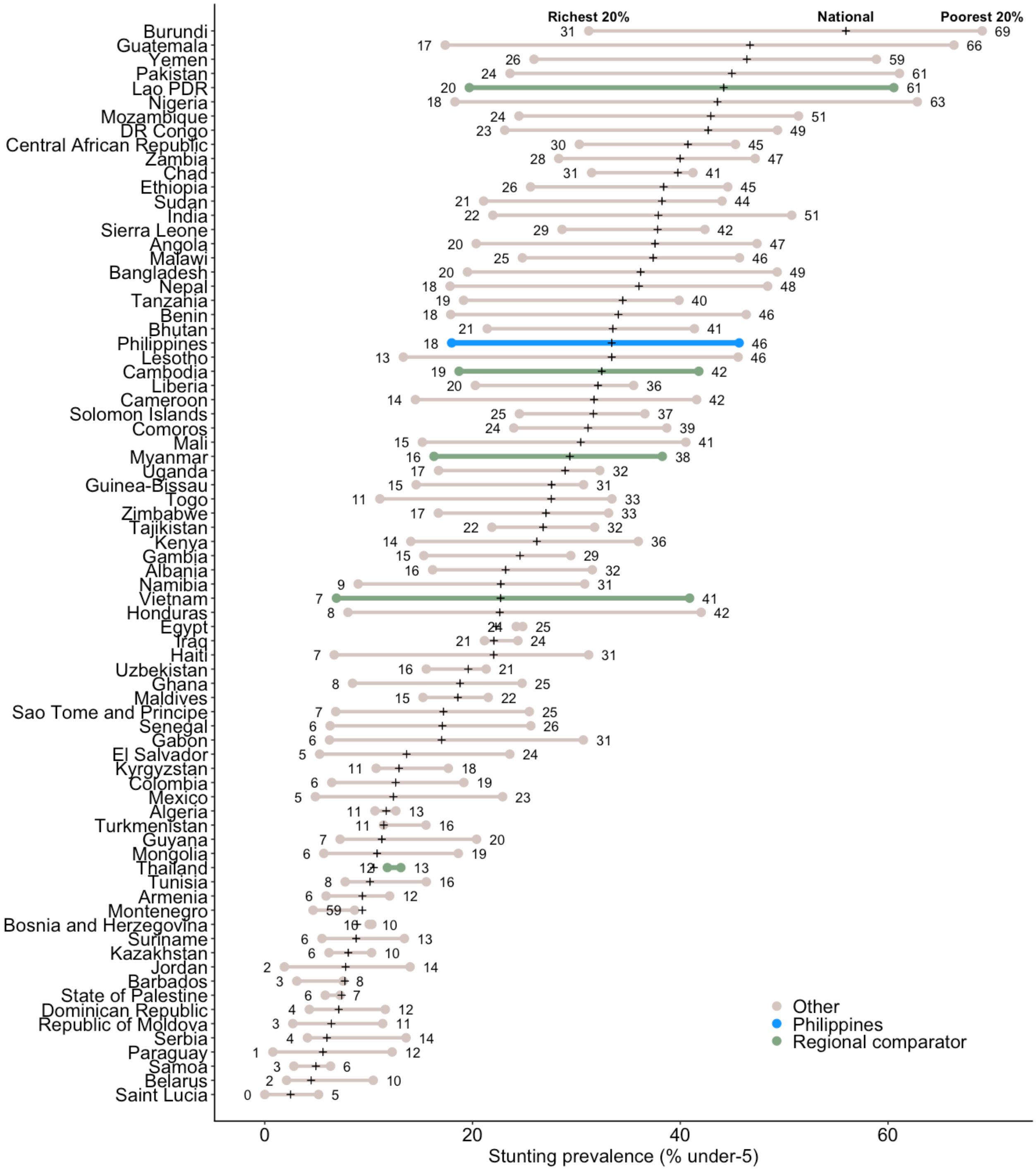
The large differences in stunting associated with income both across and within countries highlights the importance of socioeconomic factors in determining nutrition outcomes for children.



Source: UNICEF, WHO, The World Bank Group: Joint child malnutrition estimates. Notes: 'High performers' denotes countries with GDP per capita in the USD 1,000 to 5,000 range whose national stunting rates are below 10 percent. 'Low performers' denotes countries in the same GDP per capita range whose national stunting rates are above 40 percent. Data correspond to the year with the most recently available stunting estimate for each country (the mean year for all estimates shown is 2013), the oldest estimate is from 2001 (Czech Republic) and the most recent estimates are from 2016. The line shown is based on a locally weighted scatterplot smoothing algorithm (loess) to more clearly show the average relationship between stunting and average income per capita levels across countries.

Figure 6

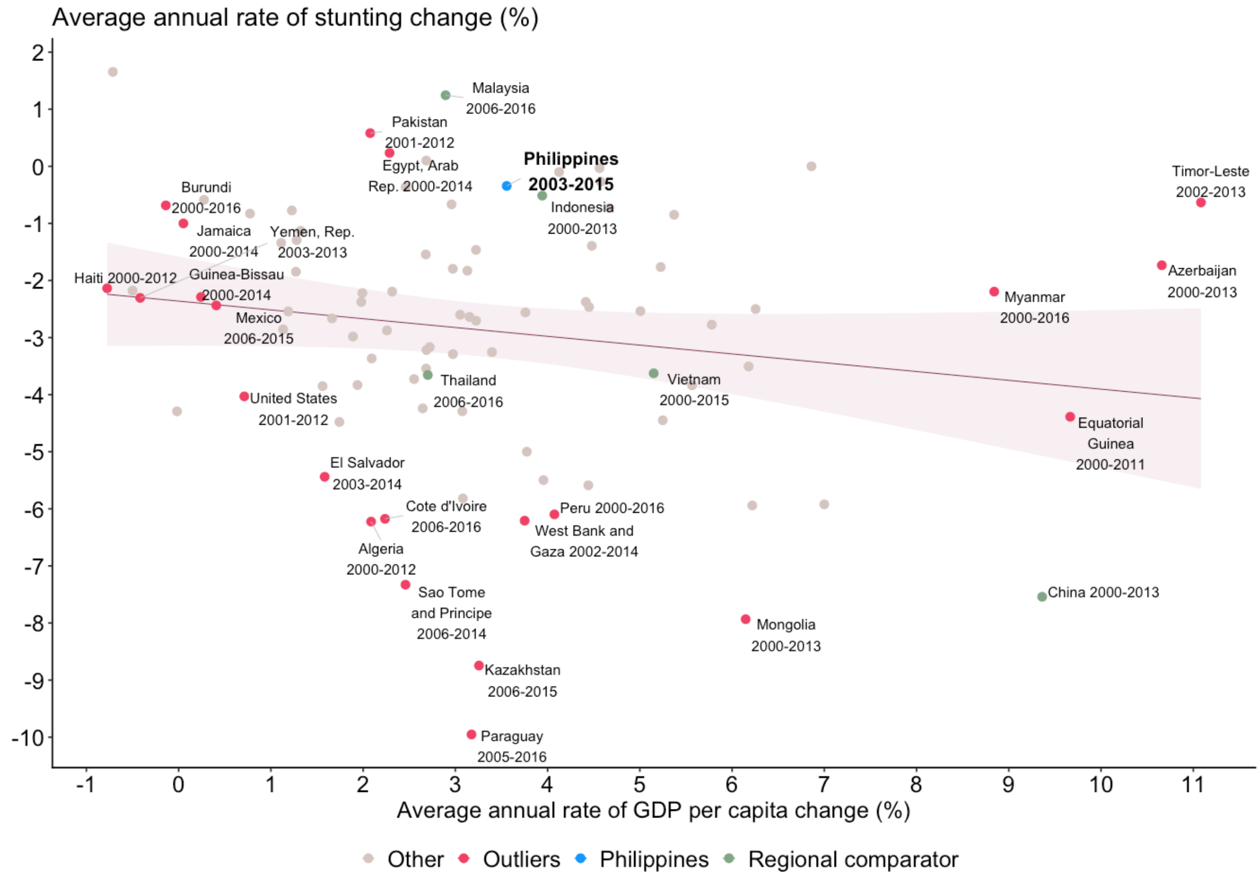
The large differences in stunting associated with income both across and within countries highlights the importance of socioeconomic factors in determining nutrition outcomes for children.



Source: UNICEF, WHO, The World Bank Group: Joint child malnutrition estimates. Data by income quintile for the Philippines are from the 2015 National Nutrition Survey. Data for Vietnam and Thailand are from World Bank country programs. Countries are sorted by the overall national stunting prevalance. Data correspond to the year with the most recently available stunting estimates by wealth quintile for each country (the mean year for all estimates shown is 2013), the oldest estimate is from 2005 (Belarus) and the most recent estimates are from 2016.

Figure 7. The relationship between changes in stunting prevalence and changes in per-capita GDP globally, 2000-2016

Declines in stunting tend to go hand in hand with economic growth, but high rates of economic growth do not guarantee progress on child nutrition, signaling the important role of public policy and other social factors.



Source: World Bank World Development Indicators. Notes: Only countries with at least 3 stunting estimates between 2000 and 2016 are considered. Labeled countries are either Philippines' regional comparators or 'outliers' - countries with the 5 highest and 5 lowest growth elasticities of stunting as well as those with average annual reductions in stunting of below -6% per year and average annual increases in per capita growth of 8% per year. The line indicates the average relationship between changes in growth and changes in stunting based on ordinary least squares (OLS) fit of the data points, the shaded area represents the 95% confidence interval of the OLS line.

3.1 Patterns of Stunting in the Philippines

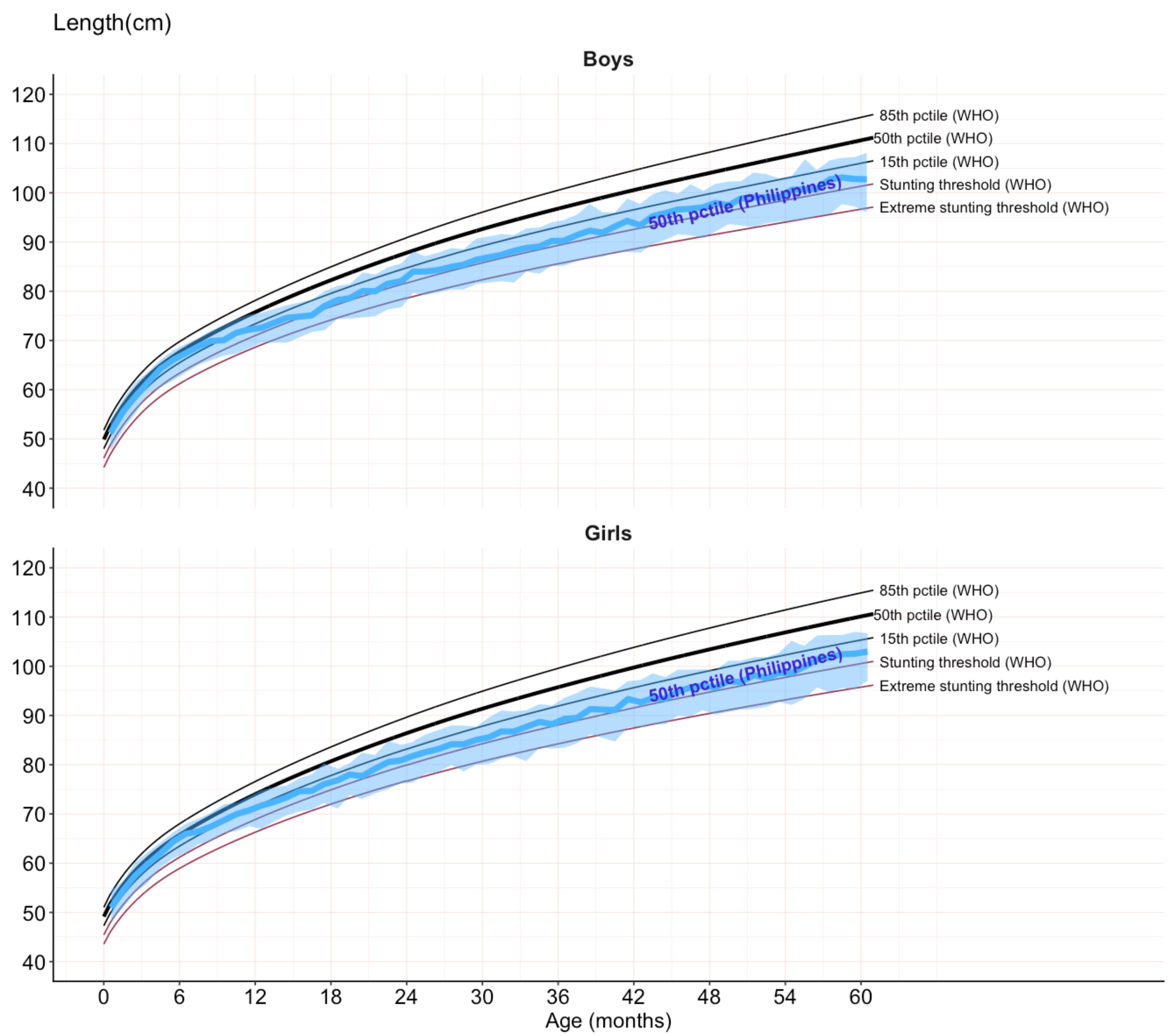
Undernutrition slows the linear growth of children beginning in utero. The timing and pattern of growth faltering that follows birth is well established. In low- and middle-income countries (LMICs) height-for-age z-scores (HAZ) decline soon after birth, reaching a nadir of around -1.75 to -2 standard deviations (SDs) at 2 years of age. There is little, if any, subsequent catch-up growth between 2 and 5 years of age. The key implication is that there is a very narrow window of time during which stunting is responsive to, or preventable by, interventions.[11]

In the Philippines, the average height of children follows this pattern and begins to fall rapidly relative to the World Health Organization (WHO) child growth standards[12] at around 6 months of age. For example, at the age of 6 months, the mean height of Filipino boys is 66.7 cm, 0.9 cm (or 0.78 SDs) below the WHO median. By the age of 18 months, Filipino boys are about 3.8 cm (or 1.55 SDs) shorter than the WHO median and by the age of 5, they are 7.5 cm (1.65 SDs) shorter (Figure 8). Starting at about 12 months of age, the average Filipino boy and girl is shorter than the shortest 15 percent of healthy children in the WHO's reference population.

Stunting in the Philippines follows an age and sex pattern that mirrors average height-for-age z-scores. In the first six months of life, stunting prevalence is around 12 percent for both girls and boys. Between 6 and 18 months of age, linear growth in boys falters faster than among girls, such that stunting prevalence is 29 percent for boys and 20 percent for girls in this age range (Figure 9). While linear growth does not continue to falter for boys after 18 months, it does for girls, so that between the ages of 19 and 60 months, stunting prevalence for both girls and boys equalizes at 38 percent.

Figure 8. Height by age and size, children under-5

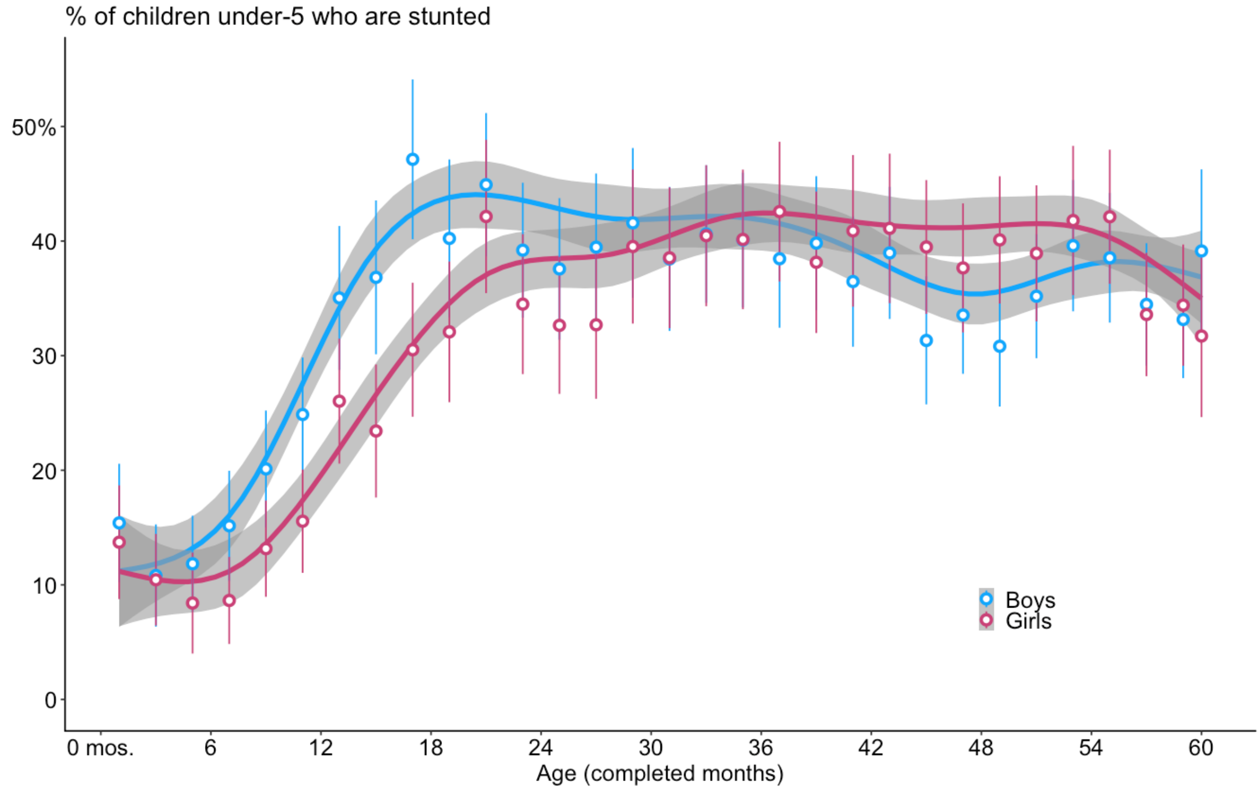
The average attained height of children under the age of 5 in the Philippines begins to noticeably diverge from WHO standards at the age of 6 months. The total difference in height between Filipino children and the WHO's healthy reference reaches 7cm by the age of 5.



Source: WHO growth standards & 2015 National Nutrition Survey (NNS). Notes:

Figure 9. Stunting prevalence by age and sex, children under-5

Stunting prevalence rises most rapidly between the ages of 6 and 18 months and does not reverse in later ages. As a result, stunting prevalence among children between 19 and 60 months of age provides a more complete indication of the burden of malnutrition in the Philippines.

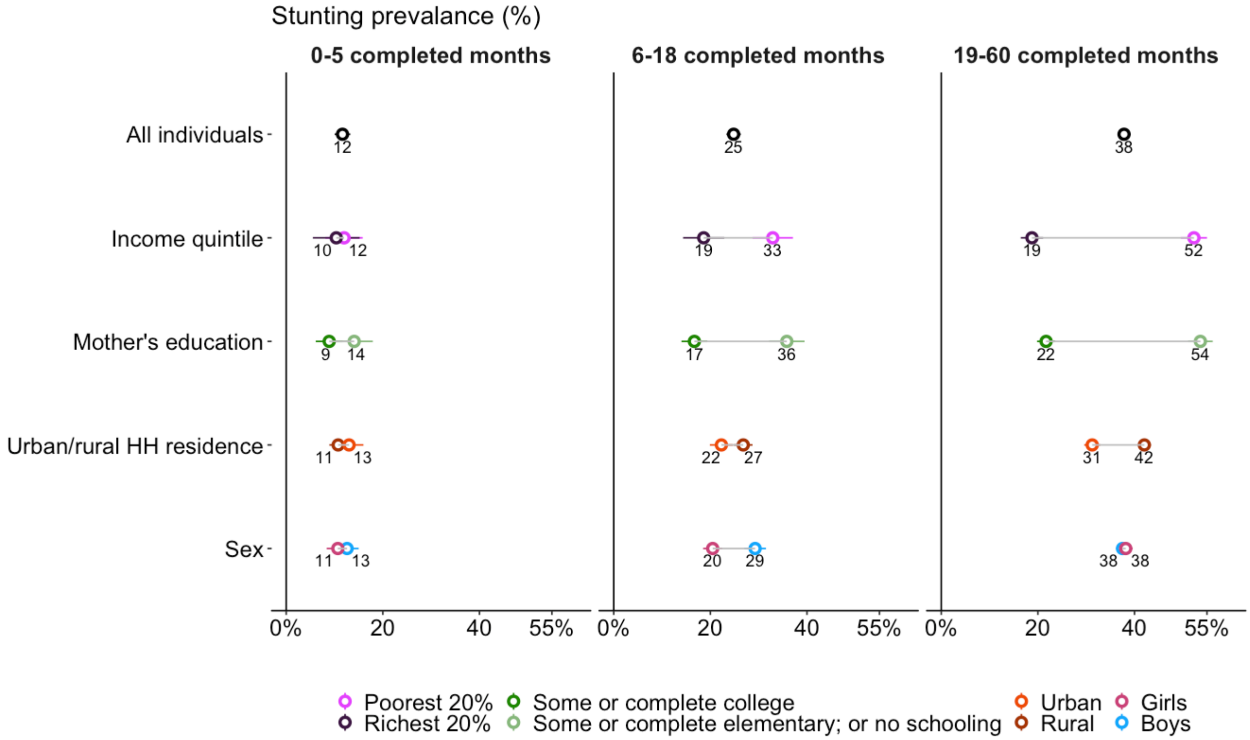


Source: Author's calculations using 2015 NNS anthropometry data and WHO's 'igrowup' software for R. Notes: Point estimates and 95% confidence intervals are based on groups of children defined by complete age in months. This chart uses 2 month intervals where, for example, 1 represents children with between 0 and 2 completed months of age. The line represents a non-linear prediction of the age-conditional HAZ fitted with a generalized additive model (gam) using all observations. The 95% confidence interval around the predictions from the gam smoothed line is shown as a grey area.

Family income is most strongly associated with stunting prevalence among children between the ages of 19 and 60 completed months and not associated with stunting prevalence among children between the ages of 0 and 5 months (Figure 10). Together with the fact that stunting prevalence conditional on income varies little between the ages of 19 and 60 months (Figure 11), these patterns suggests two things. Firstly, income influences how far linear growth falters between the ages of 6 and 18 months (Figure 12) but high incomes do not prevent growth faltering altogether. Secondly, high income does little to reverse the growth deficits sustained between 6 and 18 months of age.

Figure 10. Stunting prevalence by age-group and socio-economic background

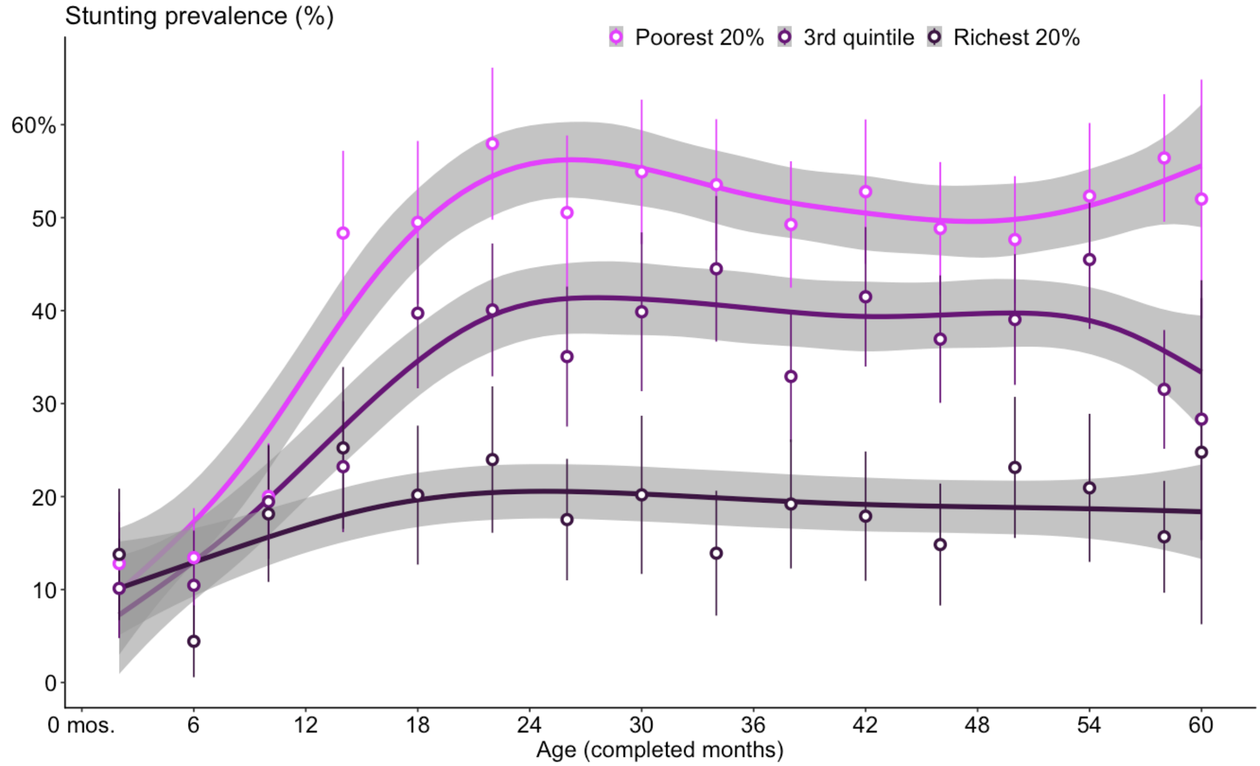
Inequalities in stunting associated with income, education and household residence only manifest after 6 months of age and are largest after the age of 18 months.



Source: Author's calculations using 2015 NNS survey data. Notes: 95% confidence intervals of the stunting prevalance by age group and population subgroup are displayed.

Figure 11. Stunting prevalence by child's age and household income quintile

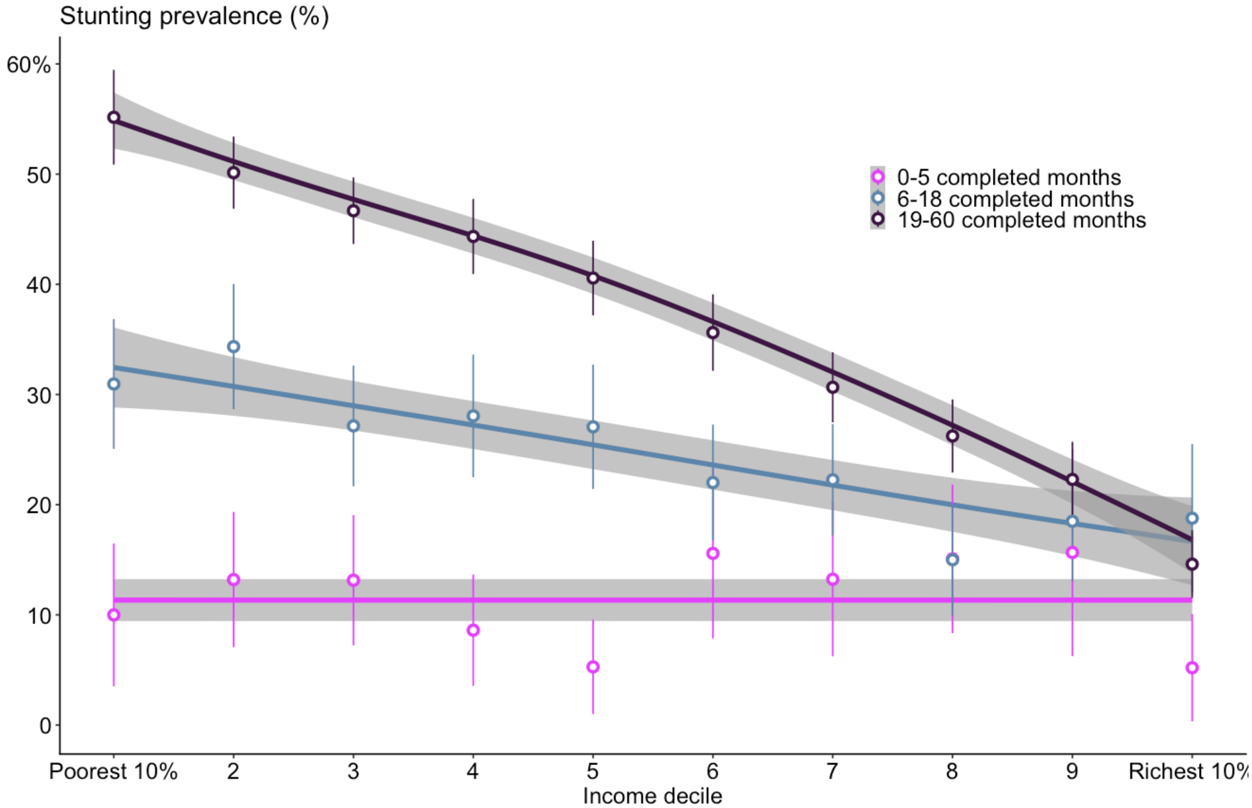
Stunting prevalence rises with age for children in families from all income quintiles and begins to statistically diverge according to income at around 12 months of age.



Source: Author's calculations using 2015 NNS anthropometry data and WHO's 'igrowup' software for R. Income groups based on the 2015 FIES matched to households in the NNS. Notes: Stunting prevalance point estimates and 95% confidence intervals correspond to groups of children defined by complete age in months. This chart uses 4 month intervals where, for example, 2 represents children with between 0 and 4 completed months of age. The line represents a non-linear prediction of the age-conditional HAZ fitted with a generalized additive model (gam) using all observations. The 95% confidence interval around the predictions from the gam smoothed line is shown as a grey area.

Figure 12. Stunting prevalence by age group and income decile

Family income is most strongly associated with stunting among children between the age of 19 and 60 completed months, suggesting that income is most effective at decelerating the relative decline of linear growth only after infancy.



Source: Author's calculations using 2015 NNS anthropometry data and WHO's 'igrowup' software for R. Notes: Income deciles are based on monthly household income from the 2015 FIES matched to households in the NNS. The line represents a non-linear prediction of the stunting rate by income decile fitted with a generalized additive model (gam) using all observations. The 95% confidence interval around the predictions from the gam smoothed line is shown as a grey area.

Eleven of the Philippines' 17 regions have conditions that will eventually expose between 40 and 50 percent of children to stunting. These regions are concentrated in the Visayas and Mindanao island groups, representing just over half of the under-5 population and 60 percent of all stunted children under the age of 5 (Figure 13). At the regional level, stunting prevalence is correlated with poverty most strongly among children between ages 19 and 60 months (Figure 14). Across provinces, stunting prevalence among children between 18 months and 5 years of age ranges from a low of 20 percent in Bataan province (Central Luzon region) to a high of around 64 percent in Cantanduanes province (Bicol region). Clusters of two or more provinces where more than 1 in 2 children are stunted by the age of 5 exist in ARMM, Zamboanga Peninsula, Western Visayas, Bicol, Eastern Visayas and SOCCSKSARGEN (Figure 14).

Figure 13. Prevalence of stunting by region

11 of Philippines 17 regions have growth environments that are so deficient, that 40 to 50 percent of children will eventually be stunted. These regions are concentrated in the Visayas and Mindanao island groups, representing just over half of the under-5 population and 60 percent of all stunted children under the age of 5.

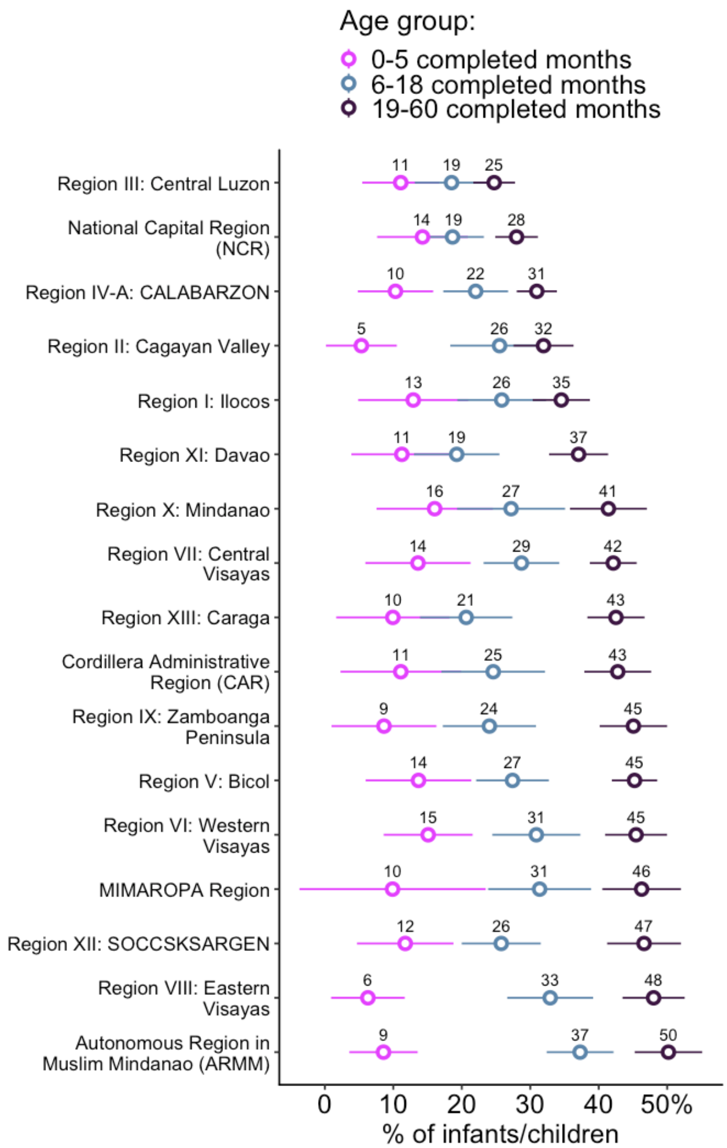
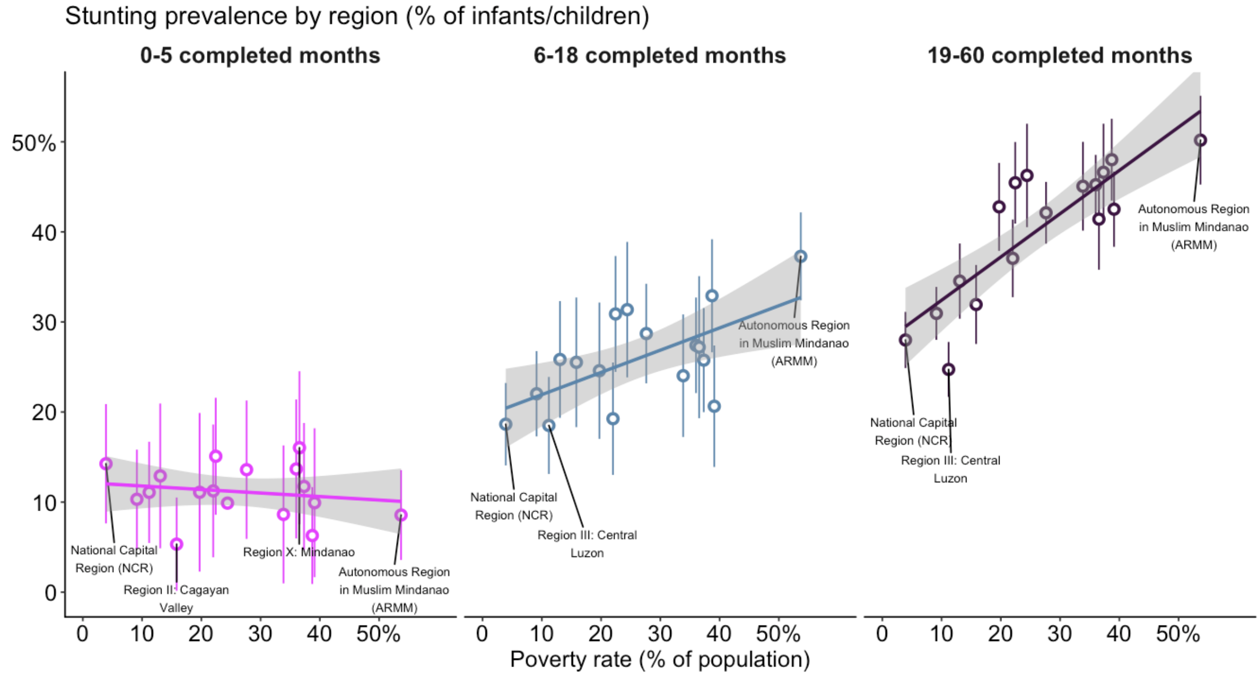


Figure 14. The relationship between regional stunting prevalence and poverty rates, by age group

The association between regional stunting prevalence and poverty is strongest among children between the ages of 19 and 60 months of age.



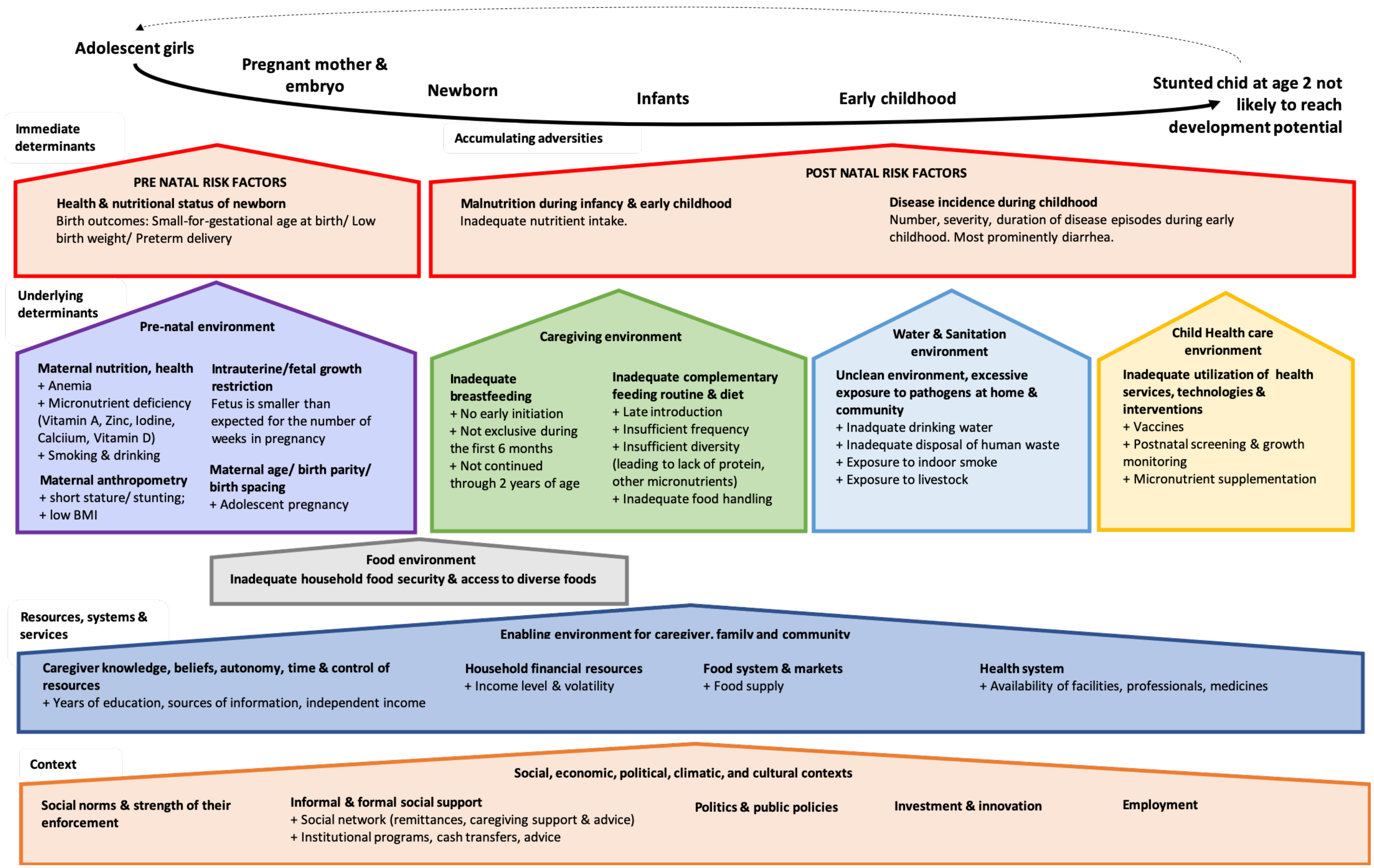
Source: Author's calculations using 2015 NNS and official poverty statistics. Notes: Poverty rates are based on the Philippines national poverty line. The 95% confidence intervals for regional estimates of stunting prevalence are displayed. In addition, the line indicates the average relationship between regional poverty and stunting prevalance based on ordinary least squares (OLS) fit of the data points, the shaded area represents the 95% confidence interval of the OLS line.

4 Drivers of Stunting: Overview of Evidence and Conceptual Framework

A complex web of inter-linked factors determines the suboptimal growth and development outcomes of children. At the most immediate level, linear growth failure in the first few years of childhood is caused by prenatal factors that affect the development of the fetus and birth outcomes; and postnatal factors that affect a child's dietary intake and exposure to infectious disease. At the farthest end of the causal chain are the social, economic and political factors that shape the resources, opportunities and behaviors families use for childcare, eating and health care (Figure 15).[13]

Figure 15. A modified extension of UNICEF's "CHEF" conceptual framework

Stunting is related to multiple and inter-linked causal pathways and risk factors.



4.1 Prenatal risk factors

In the prenatal period, fetal growth is governed by the mother's nutrition, endocrine and metabolic signals, and placental development. Newborn birth weight and gestational age reflect the intrauterine environment. While low birth weight (LBW, defined as < 2500g) is used as a proxy for undernutrition in utero, it really encompasses two related phenomena that have distinct underlying causes: small for gestational age (SGA)[14] and preterm delivery. SGA describes a fetus that is smaller than expected for the number of weeks in pregnancy and is closely associated with fetal growth restriction (FGR). Preterm denotes live births that occur before 37 weeks of completed gestation. Filipino newborns are among the world's most likely to be born too small or too soon. An estimated 15 percent of live births in LMICs are LBW, with LBW prevalence highest in South Asia (25.6 percent), Sub-Saharan Africa (14.2 percent) and Southeast Asia (12.2 percent).[15] In the Philippines, the 2017 Demographic and Health Survey (DHS)[16] estimated 14.5 percent of live births were LBW, suggesting a significant drop since 2011 when LBW prevalence was estimated at 21.4 percent. Using data from the INTERGROWTH-21st project,[17] a recent study examined the global prevalence and burden of small-for-gestational-age (SGA) and estimated that in 2012, 25.6 percent of Filipino newborns were SGA and that 22.7 percent of neonatal deaths were attributable to SGA (either term or preterm), placing the Philippines among the 10 countries globally with the highest SGA burden.[18]

Recent global and national estimates[19] suggest preterm birth prevalence in the Philippines was in the range of 13.3 percent in 2014 and more than doubled since 2000.[20] Among SGA live births, 7 percent (or 1.8 percent among all live births) were also delivered preterm. The Philippines ranks 9th globally for the share of live births that are preterm and 3rd for the share of live births that are both SGA and preterm.

Using data from 19 birth cohorts and longitudinal studies representing countries in 3 LMIC regions (including the Cebu, Philippines cohort), Christian et al. explore the relationship between SGA and preterm birth with stunting between the ages of 12 and 60 months.[21] The study finds that the risk of stunting associated with LBW, SGA and preterm – even when adjusting for characteristics of the mother - is significantly elevated compared to appropriate for gestational age (AGA) and term births, with the risks being compounded for births that are both SGA and preterm. For example, for birth cohorts in the Southern/Eastern Asia region, the odds ratios (ORs) for stunting associated with LBW, SGA and preterm were 2.64, 2.13 and 1.34. Babies born both SGA and preterm had even higher odds of stunting (OR 3.63) compared to babies born AGA and term. Given that the study did not find significant variation in these associations by region, the authors consider highly plausible that the associations are biological. The combined population attributable risk for stunting from SGA was 0.16, suggesting that close to one-fifth of childhood stunting could have its origins in the fetal period.

Available evidence suggests that SGA (both term and pre-term) is strongly associated with maternal height and low BMI which are in turn associated with adolescent health and pregnancy. A pooled analysis of DHS data from 109 countries adjusting for socioeconomic characteristics, such as the wealth of the household and education of the mother, found a strong relationship between maternal height and stunting[22]: children of mothers measuring 145 cm or less had an 80.5 percent probability of being stunted, compared to 18.9 percent for children of mothers measuring 160 cm or more, controlling for other factors. Other studies have established links between maternal birth outcomes – such as birthweight and SGA – with offspring outcomes including stunting. A study using the Cebu longitudinal health and nutrition survey conducted between 1983 to 1995 in the Philippines reinforces this evidence, finding that the likelihood of stunting is inversely related to mother's height and low birth weight.[23]

Risk factors for LBW include maternal anemia. A meta-analysis that included 11 experimental trials identified a significant 20% reduction in the risk of LBW associated with antenatal iron supplementation.[24] Risk factors for preterm births include zinc deficiency, parity and maternal age.

4.2 Postnatal risk factors

During infancy and childhood, epidemiological studies point to suboptimal complementary feeding, recurrent infections and micronutrient deficiencies as important proximal determinants of stunting. Findings from the Cebu longitudinal study, for example, show that the likelihood of stunting is increased by diarrhea, febrile respiratory infections and early supplemental feeding.[25] Notably, the study finds a clear risk of early weaning off of breastmilk, identifying protective effects of breast-feeding and negative effects of supplementary feeding that were strongest in the first year of life, suggesting that among breast-fed infants *"high quality nutrients from breast milk are replaced with lower quality nutrients from weaning diets based on corn or rice"*.

The existing experimental evidence suggests that nutrient supplementation, counseling for maternal, infant and young child feeding and the promotion of complementary feeding have been marginally successful at boosting linear growth (none have been able to normalize early childhood growth) and reducing the incidence of stunting. Experimental studies on breastfeeding promotion that included nutritional status outcomes did not show any effect on the length of infants (though the beneficial impact of breastfeeding in reducing mortality risk underpins why it is strongly promoted).[26]

In response to the underwhelming effect of nutrient supplementation and counseling interventions on linear growth, three recent randomized controlled trials in Kenya, Bangladesh and Zimbabwe tested whether reduced exposure to pathogens in the environment are a key constraint to early growth among children. More specifically, these studies tested the hypothesis that environmental enteric dysfunction – a condition of the gut caused by fecal contamination which impairs nutrient absorption- is a key bottleneck for childhood growth, thus constraining the impact of nutrition interventions in settings with poor environmental conditions. In each of the studies, respondents were randomly assigned to receive water, sanitation, hygiene and nutrition interventions in isolation and in combination, testing whether synergies across different interventions exist.[27] In the Kenya study, none of the interventions reduced the incidence of diarrhea and only the nutrition intervention improved the growth of children.[28] In the Bangladesh study, all interventions reduced the incidence of diarrhea and again, only the nutrition intervention improved the growth of children, correcting one-sixth of the growth deficit compared to international norms of healthy growth. These studies were all consistent in their failure to find any effect of WSH interventions in isolation or in combination on the linear growth of children.

While not well established, there is some empirical evidence that points to the role of animal-sourced foods (ASFs) in the promotion of early childhood growth. Randomized control studies in Jamaica, China and Ecuador, for example, supplemented children's usual diets with high protein milk, minced pork and eggs and in all cases found that treated children had grown taller than the control. In the Ecuador study, stunting prevalence among randomly assigned children who were provided one egg per day over a 6-month period declined by 47 percent relative to the to the control group of children who followed their usual diet.[29] A cluster randomized evaluation of the Philippines' conditional cash transfer program, Pantawid Pamilyang Pilipino Program (PPP),[30] found the program reduced severe stunting among children (ages of 6 and 36 months) in the treated group by 10 percentage points, relative to children in the control.[31] To try and understand the possible mechanisms contributing to the large reduction in severe stunting, the study also reports the effects of Pantawid on the use of health services for children and on parenting practices, finding large impacts on the utilization of growth monitoring check-ups, vaccination and treatment for illness as well as an 8.2 percentage point (pp) increase in egg consumption and a 6.9 pp increase in dairy consumption relative to children in the control group. While utilization of child health care was a key condition to receive cash benefits, the greater exposure to nutrient rich ASFs among children participating in the program would have resulted from either the income effect of the cash transfer (relaxing budget constraints), Pantawid's family development sessions which emphasized infant and young child feeding and nutrition, or both. In addition research using the 2013 NNS data - which collected detailed data on children's nutrient intake and food sources through a 24 hour recall module - found that the diets of children aged 6-60 months were concentrated primarily to foods with low nutrient density such as refined rice with little contribution to total energy or nutrients from vegetables, meats, fruits and eggs.[32]

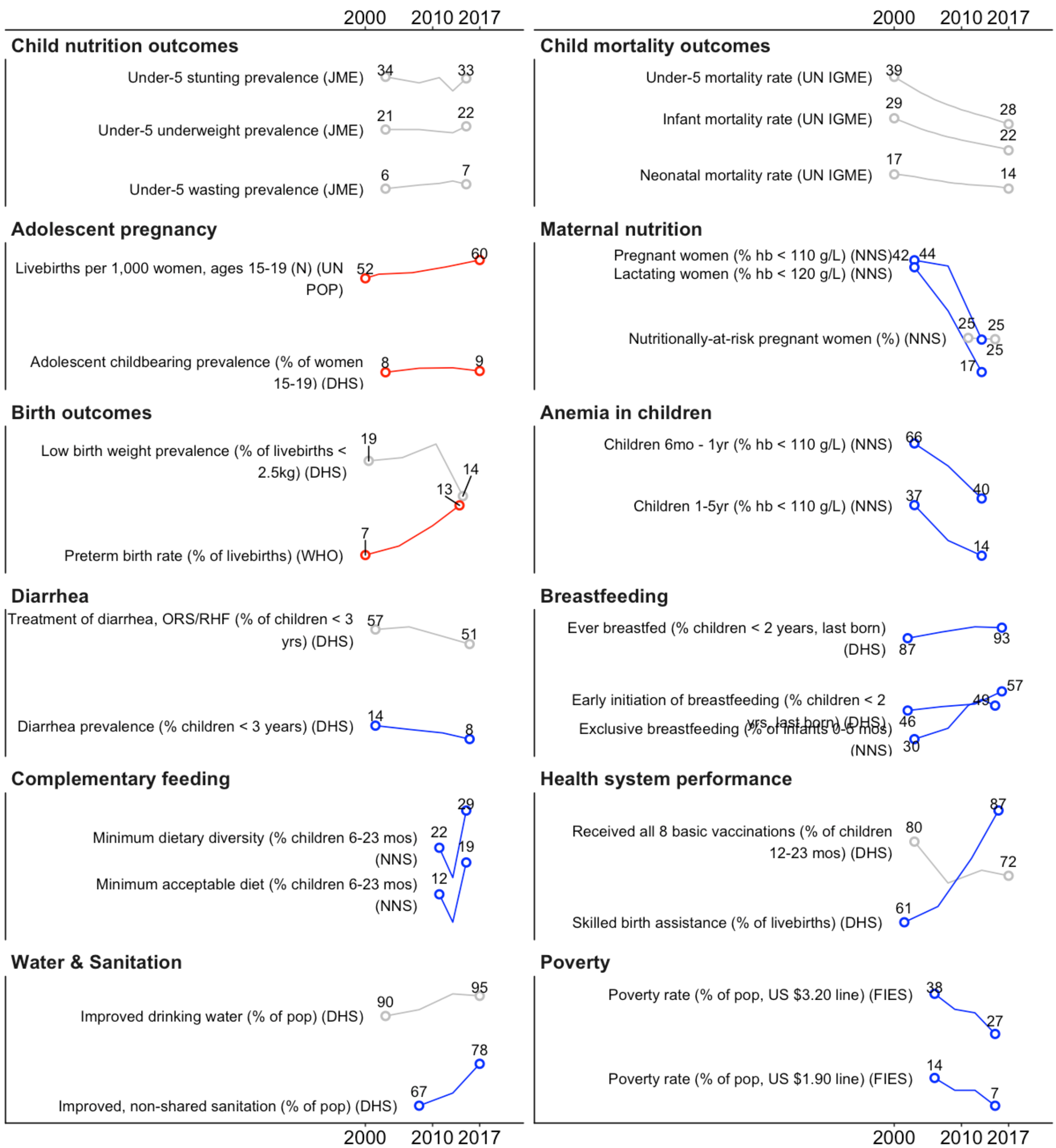
A recent observational study looking at the relationship between ASF consumption and stunting globally using DHS data finds that children between the ages of 18 and 23 months who consume 2 or 3 types of ASFs the previous day are around 6 pp less likely to be stunted compared to children who do not consume any ASFs, controlling for other child and household factors.[33] In South, Central and Southeast (SE) Asia, 56.8 percent of children (6-23 months) consumed any ASF the prior day (compared to a high of 83 percent in Latin America & Caribbean and a low of 49.3 percent in Eastern & Southern Africa). Of the children who consumed any ASF, the vast majority (75 percent) only consumed 1 type of ASF - the highest rate across all regions - suggesting relatively low exposure to different kinds of ASFs among children in South, Central and SE Asia. High prices may be a key constraint to relatively low levels of ASF consumption. The prices per-calorie of ASFs relative to the prices per-calorie of the cheapest staple cereal in South, Central and SE Asia, range from a high of 7.8 for fresh cow's milk to a low of 5.3 for fish; chicken eggs are 6.5 times more expensive, on average, per calorie than the cheapest staple cereal.[34]

4.3 Stunting risk factor trends in the Philippines

In the Philippines, population-level trends for key prenatal and postnatal stunting risk factors are positive and creating a more favorable environment for children (Figure 16). The fact that under-5, infant and neonatal mortality have all declined since 2000 at least partly reflects this.

Figure 16. Trends in key nutrition, health, caretaking and economic risk factors for stunting in the Philippines, 2000-2017

With the exception of adolescent fertility and preterm birth, many conditions that favor child nutrition are improving.



Source: The source of each indicator is indicated in parentheses. DHS = Demographic & Health Survey, NNS = Philippines National Nutrition Survey, Food & Nutrition Institute, Department of Science & Technology (FNRI-DOST), WHO = World Health Organization, WB = World Bank. Notes: Risk factors labeled as showing a clear improvement/ clear worsening are those with average rates of change greater than 0.5% per year or less than -0.5% per year, depending on the indicator.

Average living standards in the Philippines have improved markedly since 2000. GDP per person (adjusted for inflation) rose at greater than 4 percent per year in nine of the 18 years between 2000 and 2017, contributing to an overall increase in real income per capita of close to USD 1,300 over this period. Overall, the distribution of income growth since 2006 has been inclusive and pro-poor, but especially so between 2012 and 2015 when income per capita among the poorest 20% of households increased by 16 percent.[35] As a result, between 2006 and 2015, poverty rates estimated on the basis of the national poverty line fell from 26.6 to 21.6 percent (and from 14.5 to 6.6 using the USD 1.90 international or "extreme" poverty line).

Other risk factors or interventions closely associated with stunting that clearly improved between 2000 and 2017 and that now affect less than 25% (or cover at least 75%) of the population, include anemia prevalence among women (pregnant or lactating), anemia prevalence among children between the ages of 1 and 5 years, diarrhea prevalence among children under the age of 3, breastfeeding prevalence, the share of births assisted by a skilled health practitioner and the share of the population with access to an improved, non-shared sanitation facility.

Risk factors or interventions that improved but still affect more than 25% (or cover less than 75%) of the population include anemia prevalence in children between 6 months and 1 year of age, exclusive breastfeeding prevalence among infants between 0 and 5 months of age, and children between 6 and 23 months of age receiving a diverse or acceptable diet.[36]

Amid these positive trends are a few key areas of concern, some of which were pointed out previously. Adolescent fertility and childbearing prevalence are on the rise. Preterm births are estimated to have more than doubled since 2000[37] and DHS surveys conducted between 1993 and 2015 found that LBW prevalence (among all live births in the 5 years preceding the survey) increased from 14.7 to 21.4 percent. However, the most recent DHS estimate from 2017 found LBW prevalence to have fallen significantly to 14.5 percent. Estimates from the NNS of the share of children under the age of 4 whose mother reported (with or without a written record) a low birth weight was 15.9 percent in 2011, 11.1 percent in 2013, and 14.5 percent in 2015.[38] While not deteriorating, a measure of maternal nutrition used by the Department of Science & Technology's Food and Nutrition Research Institute (DOST-FNRI) in its last three NNS reports - the percentage of pregnant women who are 'nutritionally-at-risk' - has not improved. In 2011, 2013 and 2015, around 1 in 4 pregnant women were estimated to be nutritionally-at-risk. Further, in 2015, pregnant women under the age of 20 were twice as likely to be nutritionally-at-risk than women above the age of 20 (39.6 vs. 21.9 percent). The relative risk of having deficient nutrition during pregnancy associated with adolescent age is greater than the risk associated with wealth.

Coverage of all 8 basic vaccinations according to the government's vaccination schedule slipped from 79 to 71 percent between 2000 and 2003 and has remained around that level since.

The overall child nutrition picture in the Philippines presents a puzzle. Why did the country's stunting rates stagnate between 2000 and 2015 amid improving living standards, improved child survival, expanding coverage of key health interventions, the implementation of a targeted cash transfer scheme and sustained progress against stunting elsewhere in the region?

Examination of the trends in key risk factors provides some clues. For example, combined with the fact that adolescent fertility is increasing, lower nutritional status among pregnant adolescents is a major headwind for child nutrition even as economic conditions improve. Closely associated is the rise of preterm birth and low birth weight prevalence, which signals a broader challenge with maternal health and nutrition. In addition, given that preterm births also face a significantly higher risk of neonatal mortality,[39] one implication of rising preterm birth rates in a context of improving care for vulnerable neonates – which appears to be the case in the Philippines – is that as more preterm newborns survive past the first 30 days of life, the composition of children at older ages will include a larger share who are at a greater risk of stunting.

It is not clear how important these factors are in the Philippines' overall stunting story. A major objective of the sections that follow is to more precisely identify which pathways seem to drive stunting, through an empirical assessment of the relationship between stunting and its known risk factors.

5 Methods

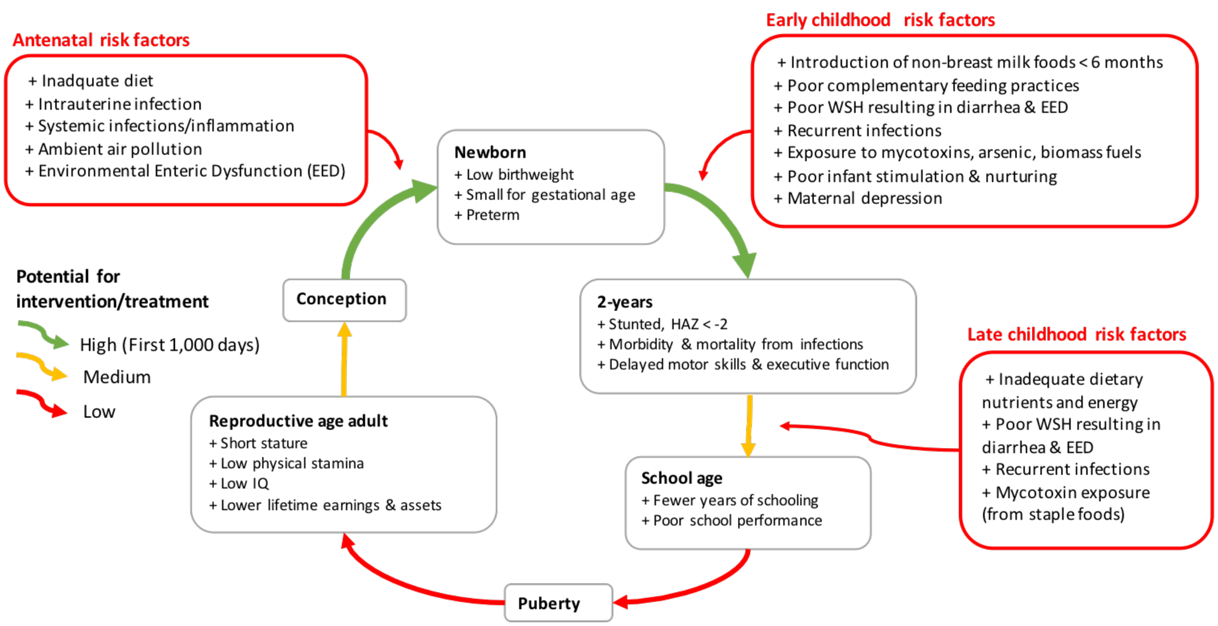
5.1 Conceptual framework

The underlying environmental conditions and risk factors that influence stunting in the ante-natal and postnatal period can be grouped into five categories : (1) maternal anthropometry, health and nutrition (such as whether a pregnant women is stunted or has anemia) and birth outcomes, (2) the care and feeding practices that a child receives at home (such as breastfeeding and timely transition to complementary foods), (3) the degree of household food security and access to diverse foods, (4) the ability of the household to prevent transmission of infectious disease with adequate water, sanitation and hygiene (WSH) infrastructure and (5) the utilization of child health care services, technologies and interventions to prevent disease and boost nutrition. While building off the original UNICEF conceptual framework, this categorization, and the analyses that follow also draw on two recent reports by the World Bank examining the drivers of stunting in Indonesia[40] and across Sub-Saharan Africa.[41, 42]

The multiplicity and interlinked nature of stunting's potential causal pathways carries at least three implications. The first is that the specific factors that most heavily influence growth failure in one context may not prevail in another. For example, stunting among children in poor, low-lying coastal neighborhoods affected by floodwater may be in large part caused by increased exposure to infectious disease in a setting without adequate WSH infrastructure. Whereas in neighborhoods without flood risk and good WSH infrastructure stunting may prevail due to inadequate dietary diversity caused by the high prices or limited supply of nutritious foods. The second implication is that presence of one driver (such as exclusive breastfeeding) may not necessarily prevent stunting without the presence of another driver (for example, if the mix of complementary foods introduced at 6 months inadequately meets the caloric needs of the child). In other words, there may be a subset of drivers that are strictly necessary for healthy growth that cannot be substituted for by the presence of other drivers. The third implication is that stunting is cyclical (Figure 17). Several studies have established a link between maternal anthropometry – such as the birthweight, SGA status and height of the mother – with offspring outcomes including stunting. Some frameworks make the cyclical nature of stunting explicit and suggest that making sustained progress against stunting requires interrupting its intergenerational causal pathways.[43]

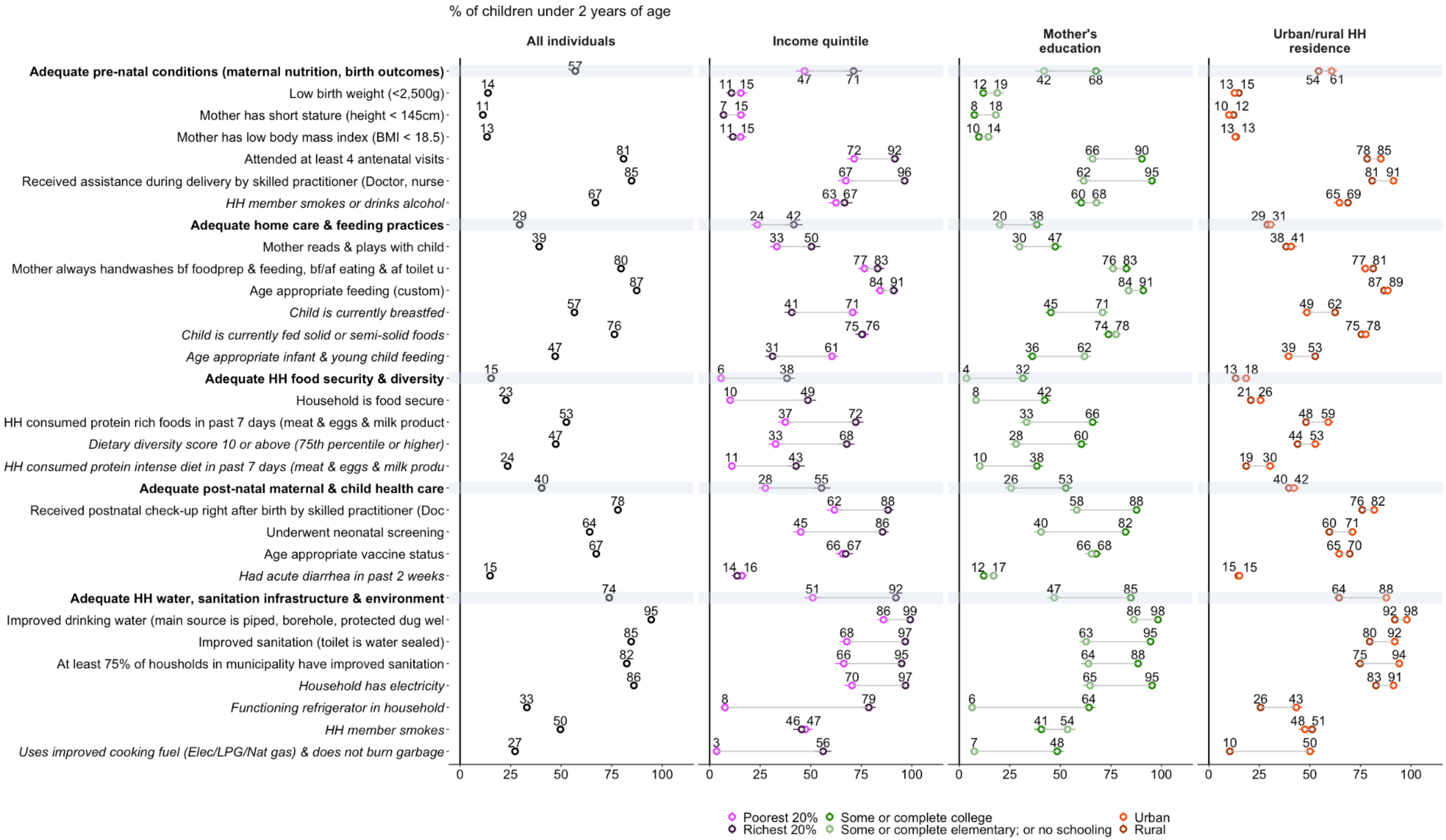
Figure 17. A stunting framework which emphasizes its cyclical nature

Stunting is cyclical because women who were themselves stunted in childhood tend to have stunted children, interventions in the first 1,000 days have the greatest power to interrupt that cycle.



The following sections discuss the availability of measures for key risk factors and interventions for childhood stunting in the NNS data and the rationale for selecting a subset of those for inclusion in an aggregate indicator of adequate access to each of the five nutrition driver categories. The discussion also references estimates for the prevalence of available risk factors and interventions among children nationally as well as differences between children defined by household income, the education of the mother and the household's urban/rural setting (Figure 18).

Figure 18. Prenatal and postnatal risk factors and interventions, nationally and by key population subgroups



Source: Author's calculations using 2015 NNS and FIES data. Notes: Indicators in italics are not used as components of the aggregate indicators of overall adequacy in each of the five nutrition driver categories.

5.2 Prenatal environment: Measures of maternal health, nutrition and care

Given extensive evidence about the importance of the prenatal environment for subsequent child nutrition and health outcomes, a set of 10 indicators that are proxies for the likely nutritional status of the mother during pregnancy as well as the health care services that were available to - and used by - mothers during their pregnancy were identified in the NNS. Of these, five are considered necessary evidence for an adequate prenatal environment for the child: normal birthweight (greater than or equal to 2.5kg),[44] maternal height above 145 cm, mother's BMI > 18.5 and at least four prenatal visits and birth assistance during delivery. Three additional ideal measures in this domain that were not available in the data include whether the child was born preterm, whether the child was born small for gestational age and whether the mother had anemia while she was pregnant.

Table 3

Category	Dataset	Driver	Definition	Available in NNS dataset?	Required for adequacy in domain?
Birth outcomes	NNS Form 1.6	**Low birth weight**	**Child weighted less than 2.5kg at birth**	**Yes**	**Yes**
	Not in questionnaire	Preterm delivery	Child is born before 37 weeks of completed gestation	No	No
	Not in questionnaire	Small for gestational age	Child is as smaller than the 10th centile for fetal growth.	No	No
Maternal nutrition	NNS Form 2.1	**Short maternal stature**	**Mother's height is less than 145 cm**	**Yes**	**Yes**
		Mother has low BMI (underweight)	**Mother's BMI is less than 18.5**	**Yes**	**Yes**
	Not in questionnaire	Maternal anemia	NA	No	No
Utilization of antenatal maternal health care	NNS Form 3.1	**Use of prenatal services**	**At least four prenatal visits**	**Yes**	**Yes**
		Neonatal tetanus	Received tetanus toxoid during prenatal visit	Yes	No
		Prenatal nutrition counseling	Received nutrition counseling during prenatal visit	Yes	No
		Micronutrient supplements taken during pregnancy	Took iron or other vitamin supplements during pregnancy	Yes	No
	NNS Form 3.1/NNS Form 4.1	Birth assisted by a skilled health care professional	Birth assisted by skilled practitioner (Doctor, nurse or midwife)	Yes	Yes

Separate indications of low maternal nutritional and health status during pregnancy - low birth weight of child during birth, maternal short stature and low BMI - are evident in 11 to 14 percent of children under the age of 2 and are strongly associated with mother's education and family income. For example, the prevalence of LBW is 19 percent among children whose mothers completed elementary school at most, compared to 12 percent of children whose mothers went to college. The association of educational attainment and maternal short stature is even stronger. Of these three indicators, the prevalence of low BMI is most weakly associated with income and mother's education.

Nationally, the utilization of antenatal health care and care during delivery is common. The mothers of over 80 percent of children under-2 attended at least four antenatal visits and 85 percent received assistance during delivery by a skilled practitioner. Disparities in maternal prenatal care associated with income and education, however, are very high. For example, while 95 percent of mothers with college education had skilled assistance during delivery, only 62 percent of mothers with elementary education or less had skilled assistance.

Overall, 57 percent of children under-2 have strong evidence of an adequate antenatal environment leading up to their birth. Children in the richest income quintile are about 1.5 times as likely to have adequate prenatal conditions than children in the poorest income quintile. Children whose mothers have college education are 1.6 times as likely to have adequate prenatal conditions than children whose mothers had at most an elementary education.

5.3 Measures of childcare and feeding practices at home

Early childhood nutritional intake is directly dependent on the feeding practices adopted by parents in the home, including whether mothers decide to breastfeed, for how long, and for older children, what kinds of solid foods are given, how frequently and how diverse they are. The WHO recommends exclusive breastfeeding for children between the ages of 0 and 5 completed months of age, the introduction of solid or semi-solid foods between the ages of 6 and 8 completed months and continued breastfeeding along with complementary foods through 2 years of age. The WHO also has guidelines on dietary frequency and diversity for children above the age of 6 months. Other important and related aspects of childcare in the home include the hygienic preparation of food and whether the child receives cognitive stimulation. A set of six indicators were identified in the NNS data that map to childcare and feeding practices at home, of these two are considered necessary evidence of an adequate childcare and feeding environment at home: the child is age-appropriately (breast) fed and the mother always handwashes before food preparation and feeding, before and after eating and after toilet use (Table 4). Three ideal indicators of child feeding practices that were not available for this study include minimum meal frequency, minimum dietary diversity and minimum acceptable diet for children 6 months and older.

Table 4

Category	**Dataset**	**Driver**	**Definition**	**Available in NNS dataset?**	**Required for adequacy in domain?**
Hygiene	NNS Form 3.1	**Handwashing habit**	**Mom always handwashes before food prep and feeding, before and after eating and after toilet use**	**Yes**	**Yes**

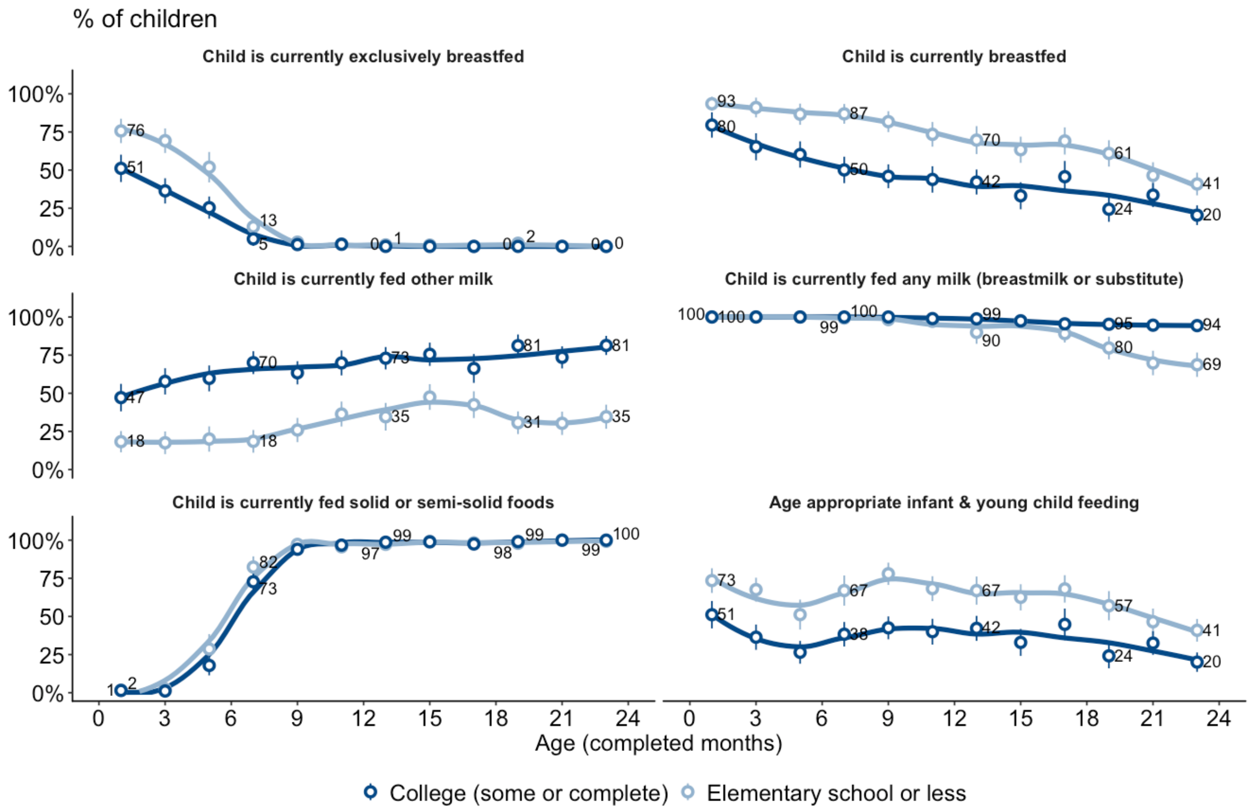
Stimulation	NNS Form 3.1	Cognitive stimulation	Caretaker reads & plays with child	Yes	No
Feeding	NNS Form 3.1	Child is currently breastfed		Yes	No
		Child is currently eating complementary foods		Yes	No
		Age appropriate breastfeeding (WHO)	**Children up to 6 months are exclusively breastfed, at or above 6 months receive complementary foods along with breastmilk**	**Yes**	**Yes**
	NNS Form 4.3	Early initiation of breastfeeding		Yes	No
	NNS 24 hour-recall	Minimum dietary diversity (6m & older)		No	No
		Minimum meal frequency (6m & older)		No	No
		Minimum acceptable diet (6m & older)		No	No

Good hygiene habits are quite common, 4 in 5 children under-2 have mothers who report always handwashing before and after food handling and toilet use, with only minor differences associated with family income or education. In contrast, only 39 percent of children are read to and played with by the caretaker, with moderate differences associated with family income and the mother's education. Less than 1 in 2 children under-2 are appropriately fed for their age. Age appropriate feeding is the only nutrition intervention indicator that is negatively associated with family income and mother's education. For example, children under-2 from the poorest quintile are twice as likely to be breastfed according to WHO standards for their age than children from the richest quintile. The reason is that women in higher earning households are less likely to breastfeed and more likely to use breast-milk substitutes. Overall, 16 percent of children under-2 are in a home environment which provides good hygiene, cognitive stimulation and WHO recommended breast- and complementary- feeding practices.

A closer examination of the age-profile of different infant and young child feeding practices reveals that women with elementary educational attainment or less (EE) are increasingly more likely to be breastfeeding their child compared to women with college education (CE) as the child gets older (Figure 19). For example, in the first two months of life, children of EE women are 16 percent more likely to be breastfed compared to children of CE women. At just over a year old, children of EE women are 66 percent more likely to be breastfed compared to children of CE women. EE women are both more likely to breastfeed and breastfeed for longer than CE women. The same is true for exclusive breastfeeding, though by 8 months of age, very few children are still exclusively breastfed. EE women are also more likely to introduce complementary foods earlier than CE women. For example, between the age of 4 and 6 completed months, 29 percent of children of EE women are being fed solid or semi-solid foods, compared to 18 percent of CE women. As CE women transition away from breastfeeding, not only do they introduce complementary foods, they also introduce breastmilk substitutes, such that by the age of 2, almost all children of CE mothers are drinking milk of any kind, whereas the proportion of children of EE women near the age of 2 drinking milk of any kind is only 69 percent.

Figure 19. Prevalence of infant and young child feeding practices by age & mother's education

Mothers with less formal education are more likely to breastfeed their children and do so for longer. Mothers with more formal education have a clear preference to use breast-milk substitutes.



Source: Author's calculations using 2015 NNS. Notes: Point estimates and 95% confidence intervals for the prevalence of feeding practices are shown for 2 month-interval age groups, where for example, children between the ages of 0 and 2 are positioned at 1 on the x-axis. The line shown is based on a locally weighted scatterplot smoothing algorithm (loess) to more clearly show the average relationship between child feeding practices and child's age.

Given these issues, this study uses an alternative age appropriate infant and young child feeding indicator based on whether the child is consuming any milk (breastmilk or breastmilk substitute). Using this indicator, 29 percent of children under-2 are in a home environment which provides good hygiene, cognitive stimulation and age appropriate feeding practices that include only breastmilk or breastmilk substitutes up to the of age 6 months, and milk and solid or semi-solid foods thereafter.

5.4 Household food security and diversity

Another key factor shaping the nutritional environment that children are exposed to is the degree to which the household experiences food insecurity and the range of foods the family has access to and consumes regularly. A set of 12 indicators were identified in the NNS and FIES surveys that measure household food security and diversity (Table 5). Of these, two are considered necessary evidence of adequate household food security and access to diverse foods: the household is food secure based on its Household Food Insecurity Access (HFIAS) status and the household consumed protein rich foods (meat and eggs and milk) at least once in the past 7 days. A status of food secure, based on the HFIAS methodology, means that the household does not frequently worry about having enough food, does not give up on preferred foods or cut back on quantity by reducing meal size or number of meals and does not run out of food, go to bed hungry or go a whole day or night without eating.

Table 5

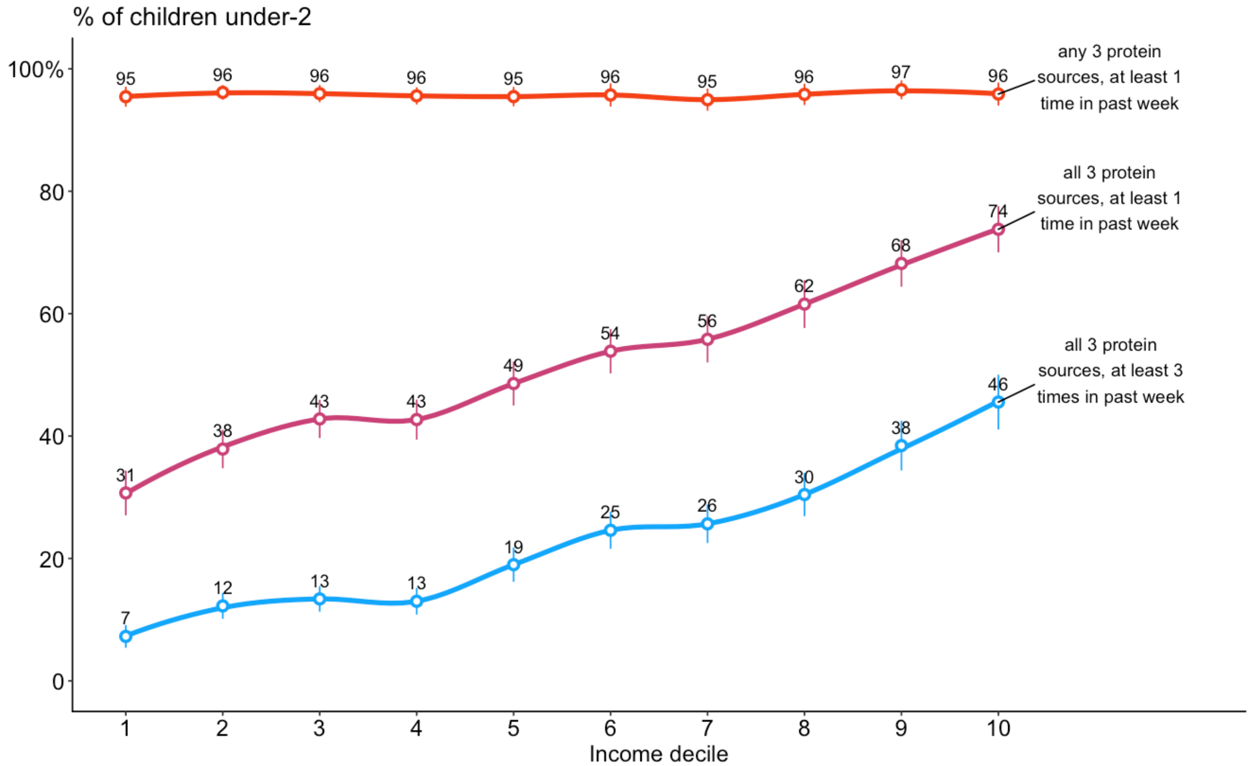
Category	**Dataset**	**Driver**	**Definition**	**Available in NNS dataset?**	**Required for adequacy in domain?**
Household food security	NNS Form 1.5	Household food insecurity (access) scale score (HFIAS)	Scale score (numeric, 0-27) based on HFIAS questionnaire	Yes	No
		Food insecurity status: Food secure	**A food secure household experiences none of the food insecurity (access) conditions, or just experiences worry, but rarely.**	**Yes**	**Yes**
		Food insecurity status: Mildly food insecure	A mildly food insecure (access) household worries about not having enough food sometimes or often, and/or is unable to eat preferred foods, and/or eats a more monotonous diet than desired and/or some foods considered undesirable, but only rarely. But it does not cut back on quantity nor experience any of three most severe conditions (running out of food, going to bed hungry, or going a whole day and night without eating).	Yes	No
		Food insecurity status: Moderately food insecure	A moderately food insecure household sacrifices quality more frequently, by eating a monotonous diet or undesirable foods sometimes or often, and/or has started to cut back on quantity by reducing the size of meals or number of meals, rarely or sometimes. But it does not experience any of the three most severe conditions.	Yes	No
		Food insecurity status: Severely food insecure	A severely food insecure household has graduated to cutting back on meal size or number of meals often, and/or experiences any of the three most severe conditions (running out of food, going to bed hungry, or going a whole day and night without eating), even as infrequently as rarely. In other words, any household that experiences one of these three conditions even once in the last four weeks (30 days) is considered severely food insecure.	Yes	No

Household access to diverse foods/diet	NNS Form 1.6	Household Dietary Diversity Score (HDDS)	The HDDS is based on 12 aggregated food groups proposed by FANTA and the score ranges from 0 to 12. The NNS has 16 food groups: Cereals & products, Vitamin A rich vegetables & tubers, white tubers & roots, dark leafy green vegetables, other vegetables including wild vegetables; vitamin A rich fruits; other fruits including wild fruits; meat (fresh and processed); organ meats (iron-rich); eggs; fish and shellfish; legumes, nuts and seeds; milk and milk products, oils and fats; sweets; spices condiments and beverages. Aggregate groups are created for vegetables, fruits and meats.	Yes	No
		Household with HDDS >= 10	Household has a total HDDS score of at least 10	Yes	No
		Household with protein rich diet	**Household consumed protein rich foods any number of times in past 7 days (meat & eggs & milk products)**	**Yes**	**Yes**
		Household with protein intense diet	Household consumed protein rich foods at least 3 times in past 7 days (meat & eggs & milk products)	Yes	No
		Household with vitamin A rich diet	Household consumed vitamin A rich food in past 7 days	Yes	No
Mother's access to diverse foods/diet	NNS 24 hour-recall	Mothers dietary diversity score (MDDS)	NA	No	No
Household access to diverse foods/diet	Not in questionnaire	The fraction of household calories derived from starchy stables	NA	No	No

Compared to other groups of factors associated with childhood undernutrition, indicators of household food security and food diversity have the greatest differences associated with family income and mother's education. Overall, 1 in 5 children under-2 live in food secure households, and children in the richest quintile are five times as likely to be food secure than children in the poorest quintile. Children in the richest quintile are also nearly twice as likely to live in households with access to a greater diversity of foods compared to children in the poorest quintile. Household access to animal source foods is also associated with income: 72 percent of children under-2 among the richest quintile are in households that consumed protein rich foods in the past week, compared to 37 percent of children in the poorest quintile. Even fewer children under-2, less than 5 percent in the poorest two deciles, live in households that regularly consume protein-rich food sources (from meat, eggs and milk, at least 3 times in the past week) compared to over 30 percent in the richest two deciles (Figure 20). The average number of times weekly that the poorest 20% of households consume milk or milk products is 2.7, compared to 4.8 times for the richest 20% of households. For eggs, the difference is 2 versus 3.7 times per week among the poorest 20% and richest 20% respectively, and for meat, the difference is 1 versus 3.1 (Figure 21).

Figure 20. Household weekly consumption of animal sourced foods (milk, eggs and meat, including fish) by income decile

Given early evidence of a link between low intake of animal-sourced foods (ASF) and stunting, the large inequality in access to ASFs associated with income should be looked at more closely.



Source: Author's calculations using 2015 NNS data (Household Dietary Diversity Module).

Figure 21. Weekly consumption of food groups by population sub-group

The poorest households are about 50 percent less likely to consume milk, eggs and meat during the week than richer households. Across the population, Vitamin A rich fruit and vegetables are not consumed very often.

Average number of days food is consumed in past week by household

	All individuals	Poorest 20%	Richest 20%	Some or complete elementary; or no schooling	Some or complete college	Rural	Urban
Cereals (eg rice bread noodles)	6.9	6.8	6.9	6.8	6.9	6.9	6.8
Oils & Fats (eg. butter)	4.6	4	5.5	3.9	5.2	4.4	4.9
Milk & milk products (eg milk, cheese, yogurt)	3.7	2.7	4.8	2.4	4.7	3.4	4.1
Fish & shellfish (fesh, dried, processed)	3.1	3	3.3	3.2	3.3	3.2	3.1
Dark leafy green vegetables (eg kangkong, malunggay)	3.2	3.5	3	3.4	3.1	3.4	2.8
Eggs	2.8	2	3.7	2	3.3	2.5	3.2
Other fruits	2.3	2	3.2	1.7	2.9	2.1	2.5
Other vegetables (eg eggplant, bamboo shoot)	2.1	2.1	2.2	2	2.2	2.2	2
Meat, fresh & processed (eg beef pork, chicken)	1.9	1	3.1	1	2.8	1.5	2.5
Vitamin A rich vegetables & tubers (eg carrots, squash)	1.7	1.6	2	1.5	1.9	1.6	1.9
White tubers & roots (eg potato, cassava)	1.1	1.1	1.3	1	1.3	1	1.2
Vitamin A rich fruit (eg ripe mangos, papayas)	1	1	1.1	0.9	1.1	1	0.9
Legumes, nuts & seeds (eg beens, peas, lentils)	0.9	0.8	1.1	0.8	0.9	0.8	1
Organ meats (iron-rich) (eg liver, kidney)	0.2	0.1	0.3	0.2	0.3	0.2	0.3

Source: Author's calculations using 2015 NNS data.

Nationally, only 15 percent of children under-2 are in an environment that provides secure access to food over time and some degree of nutritional diversity. Children from the richest families are seven times as likely to have adequate food security and diversity compared to children from the poorest families. The difference is of a similar magnitude with respect to mother's education and not very substantial between urban and rural areas.

5.5 Postnatal maternal and child utilization of health care

The postnatal health and well-being of the mother and child are important factors that enable childhood nutrition. A set of 8 indicators from the NNS survey were identified as measures of postnatal maternal and child health care, of which three are considered necessary evidence of adequate health care: the mother received a postnatal check-up after birth by a skilled practitioner, the child underwent neonatal screening and the child received vaccinations according to the recommended WHO age-schedule: BCG, oral polio, DPT (or pentavalent) and measles.[45]

Table 6

Category	Dataset	Driver	Definition	Available in NNS dataset?	Required for adequacy in domain?
Utilization of postnatal maternal health care	NNS Form 3.1	**Postnatal care**	**Received postnatal check-up right after birth by skilled practitioner (Doctor, nurse or midwife)**	**Yes**	**Yes**
		Postnatal breast & complementary feeding counseling	After birth, received counseling on breast & complementary feeding	Yes	No
Health status	NNS Form 3.1	Acute diarrhea in past 2 weeks	Child experienced acute diarrhea in prior two weeks	Yes	No
Health screening	NNS Form 4.2	**Neonatal screening**	**Child underwent neonatal screening**	**Yes**	**Yes**
		Postnatal growth control visit	Child participated in operation Timbang Plus or other growth monitoring government program	Yes	No
Health interventions	NNS Form 4.2	**Age appropriate vaccinations**	**Child vaccinated according to WHO schedule. BCG, Oral Polio, DPT (or pentavalent), Measles (allowance for delayed vaccinations)**	**Yes**	**Yes**
		Dewormed	Child received deworming medication from government program	Yes	No
Nutrition supplementation	NNS Form 4.2	Vitamin A supplementation	Child participated once or twice in Vitamin A supplementation government program	Yes	No

Nationally, skilled postnatal care for the mother, neonatal screening and up to date vaccinations, cover 78, 64 and 67 percent of the target population. With the exception of vaccinations, differences in coverage associated with family income and maternal education are wide. For example, 86 percent of children in the richest quintile underwent neonatal screening shortly after birth, compared to 45 percent of children in the poorest quintile. About 40 percent of children under-2 nationally show evidence of having access to all three sub-indicators of postnatal care. While differences in coverage of adequate postnatal care associated with income and mother's education are wide, it is not significant between urban and rural areas.

5.6 Household environment: Water, sanitation and hygiene infrastructure

Whether a child comes into contact with infectious diseases or other environmental pathogens is partly determined by the conditions of the dwelling and of the surrounding community. A set of 6 indicators from the NNS were identified as measures of the sanitary and hygienic conditions of the household, of which three are considered necessary evidence of adequate WSH conditions for the child: the household uses drinking water from an improved source, the household uses a toilet facility that is water sealed and at least 75% of households in the municipality have improved sanitation (Table 7).

Table 7

Category	Dataset	Driver	Definition	Available in NNS dataset?	Required for adequacy in domain?
Household facilities that support hygiene, sanitation and disease prevention	NNS Form 1.2	**Access to improved drinking water**	**Main source of drinking water is piped, from a borehole, from a protected dug well or spring, rainwater, bottled water or truck**	**Yes**	**Yes**
		Access to improved sanitation	**Toilet facility is water sealed (either flush or pour with septic tank)**	**Yes**	**Yes**
		Access to clean cooking fuels	Uses clean cooking fuel (electricity, LPG or natural gas) and does not burn garbage	Yes	No
		Exposure to farm animals	Household member owns or manages livestock	Yes	No
	Not in questionnaire	Handwashing facilities	Availability of handwashing facilities, water, soap & detergent	No	No
Community-level environment	NNS Form 1.2	**Community level sanitation**	**At least 75% of households in municipality have improved sanitation**	**Yes**	**Yes**
Behaviors that support hygiene, sanitation and disease prevention	NNS Form 1.2	Safely manages drinking water	Boils, chlorinates or filters water or purchases bottled mineral water	Yes	No
	Not in questionnaire	Feces disposal	Child's stools are disposed into an improved sanitation facility	No	No

Access to improved WSH infrastructure is in general very high: 95 percent of children under-2 have access to improved drinking water, 85 percent have access to improved sanitation and 82 percent live in a municipality where at least three-quarters of the households have improved sanitation. Nationally, close to 3 in 4 children under-2 live in a household with adequate WSH infrastructure.

Several indicators associated with the household environment but not related to water and sanitation were identified in the NNS data. Whether the household has access to electricity or uses improved cooking fuel and does not burn garbage has a bearing on indoor air quality, and how efficiently food can be prepared. Whether there is a functioning refrigerator has a bearing on the household's ability to preserve foods that are prone to spoilage, including meat, eggs, animal milk, and breastmilk. Nationally, only about 1 in 3 children under that age of 2 live in households that use improved cooking fuels and or have a functioning refrigerator. Use of improved cooking fuel and refrigerator ownership are even lower for the poorest quintile, 3 and 8 percent, respectively, compared to 56 and 79 percent for the richest quintile. And of all the indicators considered, the urban-rural difference is largest for the use of improved cooking fuel: Urban households are five times as likely to burn cleaner fuels for cooking than rural households. Given the lack of evidence in the literature of the impact of these resources on child undernutrition, they are omitted from the overall measure of access to an adequate household environment but are explored independently in the analyses that follow.

5.7 Resources for food security, home care and health care

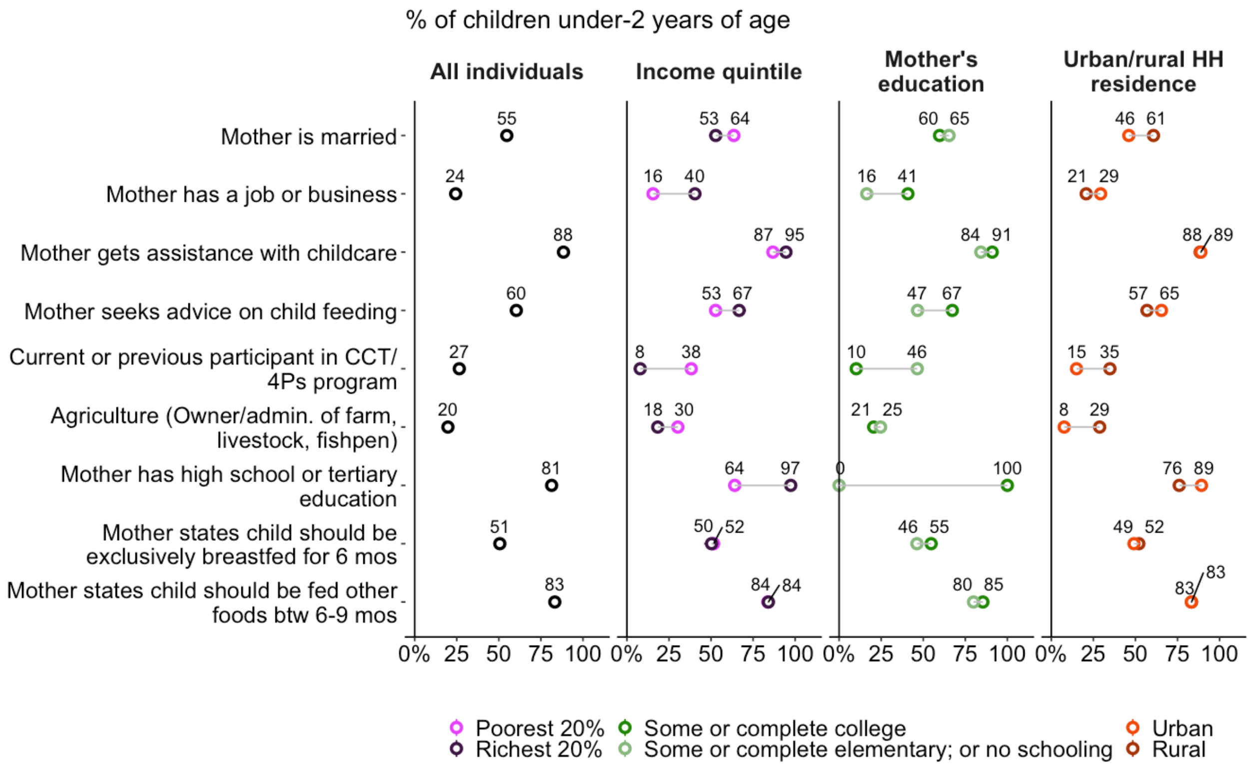
A women's ability to access sufficient nutrition and health care for herself and her child prior-to, during and after pregnancy; provide sufficient food and care for her child and a housing environment that facilitates hygiene, requires financial, social and knowledge resources. Several measures from the NNS that capture the resources available to families for childcare, nutrition and health were identified (Table 8).

Table 8

Category	Dataset	Driver	Definition	Available in NNS dataset?
Caregiver knowledge & beliefs	NNS Form 3.1	Mother states child should be exclusively breastfed for 6 months		Yes
	NNS Form 3.2	Mother states child should be fed other foods starting at 6 months		Yes
	NNS Form 1.1	Mother's educational attainment	Mother has high school or tertiary education	Yes
	NNS Form 3.1	Mother seeks advice for child's nutrition	Mother seeks advice from others on child feeding timing, consistency, type or amount	Yes
Income	FIES	Total household income		Yes
Expenditure	FIES	Total household expenditure		Yes
Social support	NNS Form 1.3	Government cash transfers		Yes
	NNS Form 3.1	Assistance with caretaking from social network		Yes
	NNS Form 1.1	Mother is married		Yes
Food production	NNS Form 1.2	Household has ability to produce food	Household member is the owner or administrator of a farm, livestock or fish pen	Yes
Food preservation	NNS Form 1.2	Refrigerator	Household has a functional refrigerator	Yes
Caregiver behaviors	FIES	Smokes or drinks	A household member smokes or drinks alcohol	Yes
Household setting	NNS Form 1.1	Urban or rural location of household		Yes
Time use	Not in questionnaire	Workload & time availability for caregiver		No
Access to services	Not in questionnaire	Distance to closest health facility		No

Measures that proxy for the level of social support and time available for caretaking are mixed (Figure 22). Nationally 55 percent of children under-2 have married mothers which implies a relatively high share of children who live with a single parent. Additional assistance for childcare is prevalent. Over 8 in 10 mothers report they get help with childcare duties, with little differences associated with family income, education or the urban/rural context of the household. Children in the poorest 20% of households are about half as likely to have mothers who work or run a business compared to children in the richest 20% of households. Children under-2 in poorer, rural households or whose mothers have little formal education are more likely to receive assistance from the government's conditional cash transfer (CCT). Over 8 in 10 children have mothers with some high school or tertiary education. Knowledge of breastfeeding "best practices" is mixed. Nearly 1 in 5 children whose mothers have relatively little formal education believe children should be exclusively breastfed for less than 6 months and nationally, nearly 1 in 3 children have mothers who believe exclusive breastfeeding should extend beyond 6 months. Average household income per month in 2015 was PHP 20,047 (USD 440) nationally, PHP 5,436 (USD 120) among the poorest 20% and PHP 51,874 (USD 1,138) among the richest 20%. Urban household incomes were about 45 percent higher than rural household incomes. The differences between total household incomes and household expenditure per month also point to the greater ability of richer households to save and the greater propensity for poorer households to borrow. For example, while the average total household expenditure among the poorest 20% is 15 percent *higher* than average total income, average total expenditure is 27 percent *lower* than total income among the richest 20%.

Figure 22. Financial, knowledge and social resources that support feeding and care, nationally and by key population sub-groups



Source: Author's calculations using 2015 NNS.

5.8 Stunting and simultaneous access to drivers of nutrition

Across the five nutrition driver categories, access to adequate care and feeding at home, and adequate household food security and diversity are the least common among children under-2, and therefore act as an upper limit on the proportion of children that have simultaneous access to all drivers. The likelihood of simultaneous access to nutrition drivers is strongly associated with family income. For example, 70 percent of children under-2 in the richest quintile have adequate access to 3 or more drivers, compared to only 28 percent of children in the poorest quintile. Only 16 percent of children nationally have access to any 4 or 5 drivers, with children in richer households 5 times as likely to have access to 4 or 5.

Figure 23. Composite and simultaneous measures of access to drivers of child nutrition, nationally and by key population sub-groups

5.9 Statistical model

Three sets of analyses to model the association of nutrition drivers with stunting are explored in this section. The first set (Models 1a-1c) uses a wide set of risk-factors and interventions for three different age-groups: newborns and infants between the ages of 0 and 5 completed months, infants and young children between the ages of 6 and 23 completed months and older-children between the ages of 24 and 60 completed months of age. The second set (Models 2a-2c) assesses the association of stunting with five aggregate indicators that measure adequate access to the five nutrition driver categories, while the third set (Model 3) explores whether there are synergies between these broad categories in their association with stunting. While all analyses control for biological factors of the child (age, sex and twin status), the results are presented separately for regressions that adjust for additional socio-economic and demographic characteristics (household size, number of children, household income, mother's education, occupational status, marital status and the mother's age when the child was born) and those that do not. A modified Poisson regression model[46] is used where child i has an underlying risk of stunting π that is a function of x_i, a set of risk factors and interventions a child is exposed to.

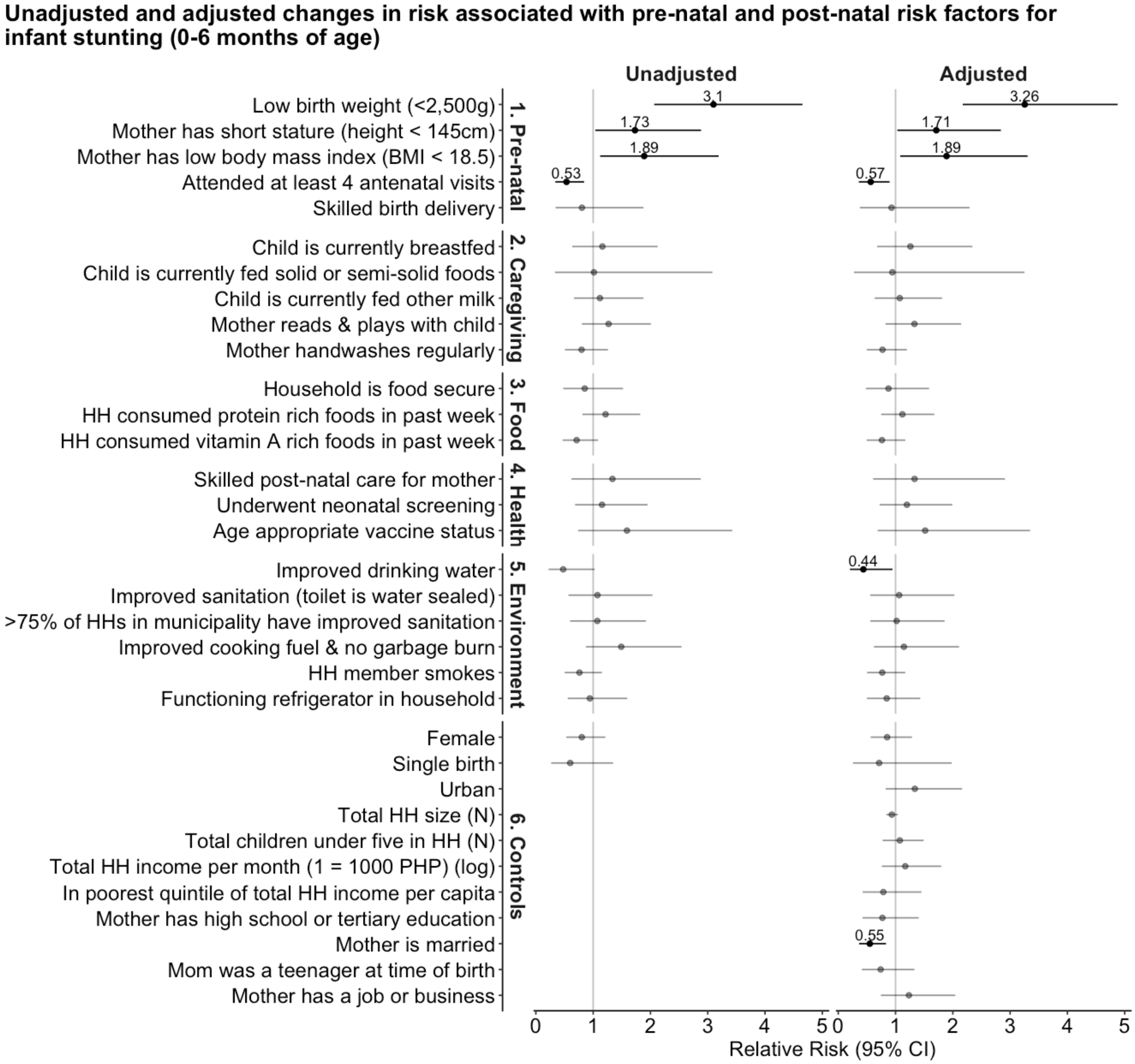
$$\log(\pi(x_i)) = \alpha + \beta x_i$$

All models account for the clustering of children by primary sampling units. Results are presented as changes in the risk of stunting (relative to 1) given by e^{β}. Models are estimated using R's "geeglm" package and expected conditional probabilities (predicted probabilities) are computed using the "Zelig" package.

6 Results

Model 1a draws on data from 693 infants between 0 and 5 completed months of whom 11.7 percent are stunted (Figure 24). The direction and magnitude of the association for each of the predictors is consistent in both the unadjusted and adjusted model. Infants with low birth weight (LBW) have 3.3 times the risk (adjusted RR) of stunting compared to infants with a normal birth weight, LBW infants have a predicted probability (PP)[47] of stunting of 21.3 percent compared to 6.6 percent among normal birth weight infants. To a lesser degree, maternal short stature and a low body mass index are also associated with an increased risk of stunting (adjusted RR of 1.7 and 1.9, respectively). Infants whose mothers attended at least 4 antenatal care visits are almost half as likely to be stunted compared to infants whose mothers did not attend at least 4 visits (adjusted PP of stunting of 7.3 vs 12.8 percent, respectively). Only one postnatal factor is associated with stunting: Infants with access to improved drinking water are 0.44 times as likely to be stunted compared to infants without access to improved drinking water (adjusted PP of stunting of 7.5 vs 17.2 percent, respectively). Only one socio-economic predictor - whether the mother is married - is significantly associated stunting. Married women are almost half as likely to have infants who are stunted than single women, all else equal.

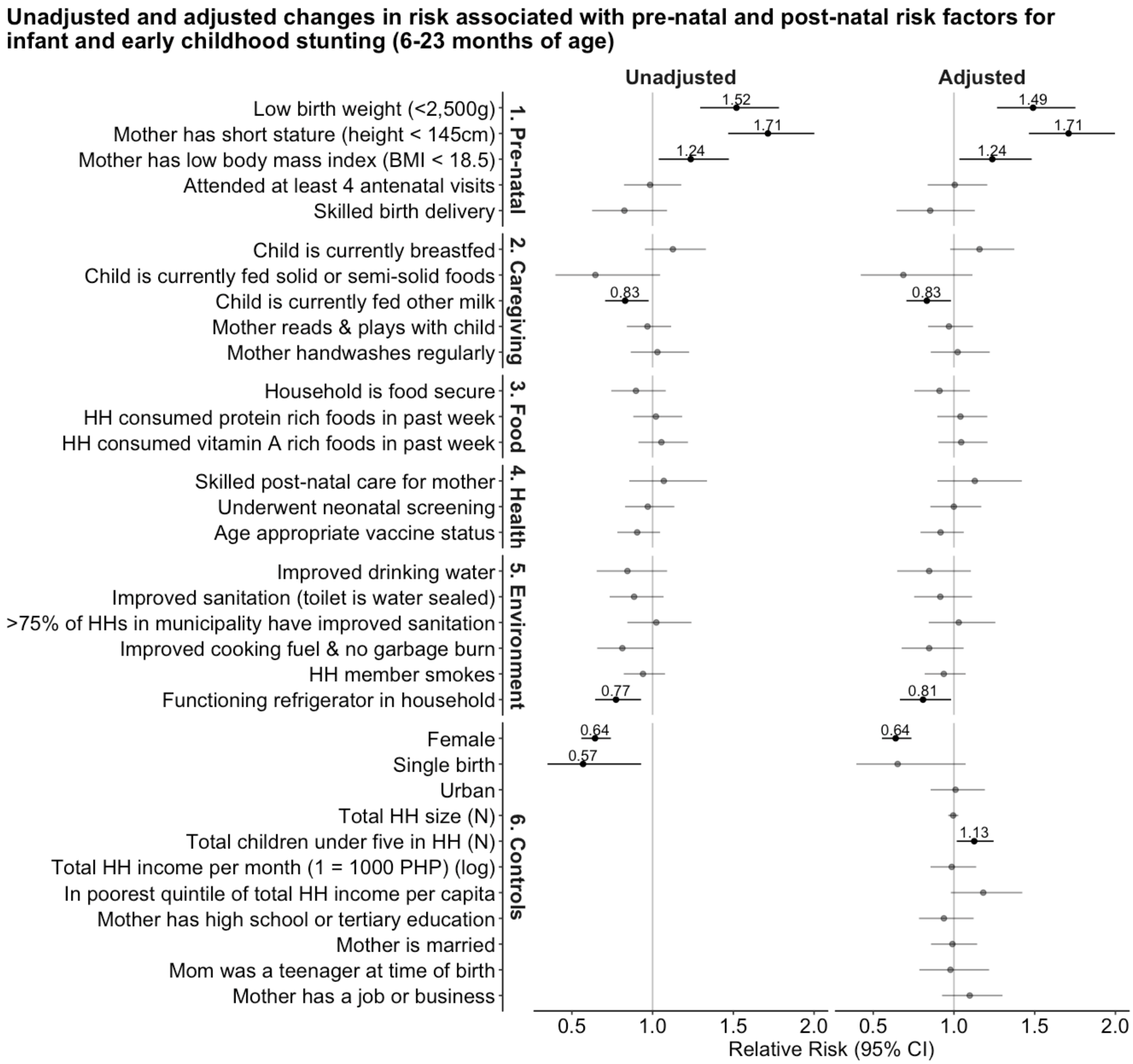
Figure 24. Model 1a, relative risk of stunting by risk (protective) factor, children 0-6 months



Source: Author's calculations based on 2015 National Nutrition Survey (NNS). Notes: Only the relative risk estimates for significant risk factors are labeled. Age, age squared and age cubed (in months) is also used as a control but is not shown in the chart. Unadjusted regression models do not control for socio-economic factors.

Model 1b uses the same set of predictors as model 1a and draws on data from 2,021 infants and young children between the ages of 6 and 23 completed months of whom 29.7 percent are stunted (Figure 25). Maternal short stature is associated with the largest increase in the risk of stunting among children in this age group (adjusted RR of 1.71), followed by low birth weight (adjusted RR of 1.49) and maternal low BMI (adjusted RR of 1.24). Two postnatal factors are associated with reductions in the risk of stunting of between 17 and 19 percent, whether the child is fed other milk (adjusted RR of 0.83) and whether the household has a functioning refrigerator (adjusted RR of 0.81). With the exception of the number of children under 5 in the household, no other socio-economic control variable, including income, is statistically significant in its association with stunting. The association with these factors is likely transmitted primarily through the more proximal prenatal and postnatal health and nutrition determinants.

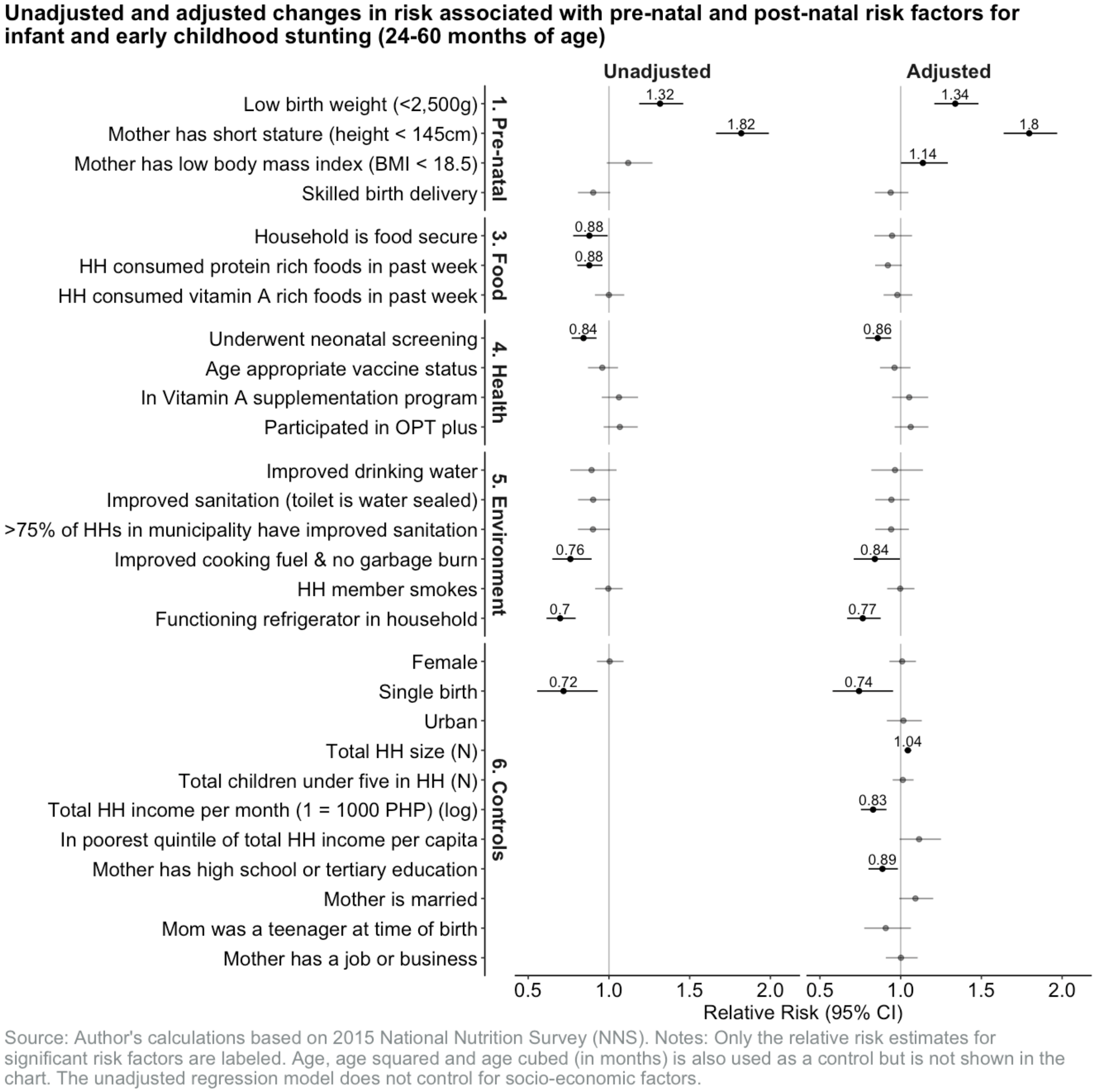
Figure 25. Model 1b, relative risk of stunting by risk (protective) factor, children 6-23 months



Source: Author's calculations based on 2015 National Nutrition Survey (NNS). Notes: Only the relative risk estimates for significant risk factors are labeled. Age, age squared and age cubed (in months) is also used as a control but is not shown in the chart. The unadjusted regression model does not control for socio-economic factors.

Model 1c draws on data from 3,703 children between the ages of 24 and 60 completed months (2 and 5 years of age) of whom 37.6 percent are stunted (Figure 26). The set of predictors included in this model is narrower than those used in models 1a and 1b given that several modules of the NNS did not cover children in this age group. Omissions include access to prenatal care, access to skilled postnatal care and handwashing and feeding practices. While the association of maternal short stature with stunting persists for this older age group (adjusted RR of 1.8), the association of LBW and maternal low BMI diminishes (adjusted RR of 1.34 and 1.14, respectively). Several postnatal factors are associated with a reduced risk of stunting. Children in food secure households and with access to animal sourced foods (ASFs) are around 10 percent less likely to be stunted compared to children with weaker food security and access to ASFs (unadjusted RRs of 0.88), though the inclusion of socio-economic factors in the adjusted model attenuates these associations, likely reflecting the role of income in mediating access to food. Neonatal screening is associated with a 14 percent reduction in the risk of stunting (adjusted RR of 0.86) and use of improved cooking fuel and access to a functional refrigerator are associated with reductions in stunting on the order of 15 and 25 percent (adjusted RR of 0.84 and 0.77, respectively). Children whose mothers have high school or tertiary education are 11 percent less likely to be stunted (RR of 0.89) compared to children whose mothers have lower educational attainment.

Figure 26. Model 1c, relative risk of stunting by risk (protective) factor, children 24-60 months

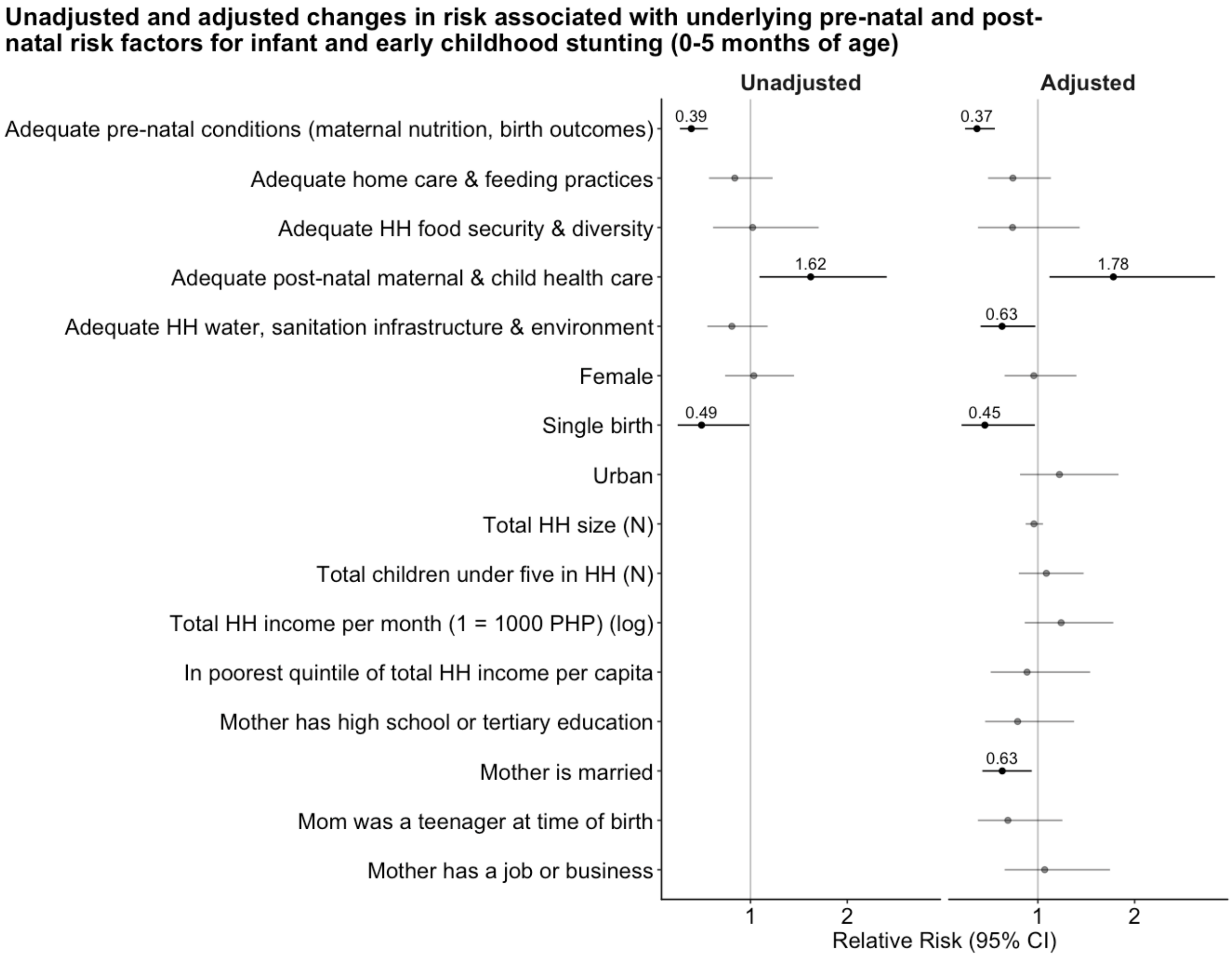


By aggregating individual risk factors and protective interventions, model 2a examines the relationship between adequate access to the five nutrition driver categories (antenatal environment and maternal health care, childcare and feeding practices at home, household food security and diversity, postnatal maternal and child health care and the household's water and sanitation environment) and stunting for children between the ages of 0 and 5 completed months (Figure 27). Evidence of an adequate prenatal environment is associated with a 63 percent reduction in stunting risk (adjusted RR of 0.37) and evidence of access to adequate water, sanitation and hygiene is associated with a 37 percent reduction in stunting risk (adjusted RR of 0.63).

For children between the ages of 6 and 23 completed months (model 2b, Figure 28), an adequate prenatal environment is associated with a nearly 40 percent reduction in stunting risk (adjusted RR of 0.62) and adequate household food security and diversity is associated with a 25 percent reduction in stunting risk (adjusted RR of 0.75).

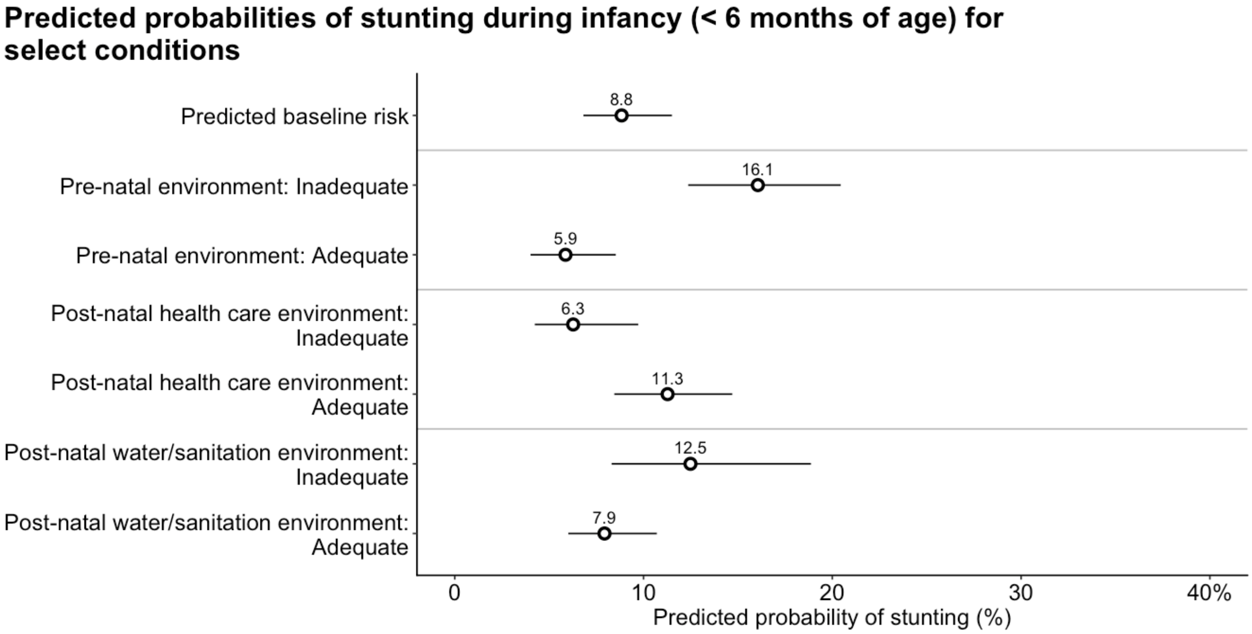
Results for children over the age of 23 completed months that exclude measures of adequate caretaking at home (since these data were not collected for older children) show comparable reductions in stunting risk associated with prenatal conditions and food security as well as reductions in stunting risk associated with water and sanitation infrastructure and postnatal child health care (model 2c, Figure 29). To the extent that linear growth retardation by- and extending beyond- the age of 2 reflects the accumulated impact of environmental insults during the child's first 1,000 days, this model may provide the most comprehensive general description of the relative importance of the drivers of stunting in the Philippines. The relatively large attenuation of the relative risks of stunting associated with food security, water and sanitation and health care in the unadjusted versus adjusted model also points to the importance of current income as a key mediating factor enabling households to secure favorable environments in those domains.

Figure 27. Model 2a, relative risk of stunting (0-5 months of age) by aggregated risk factors and interventions



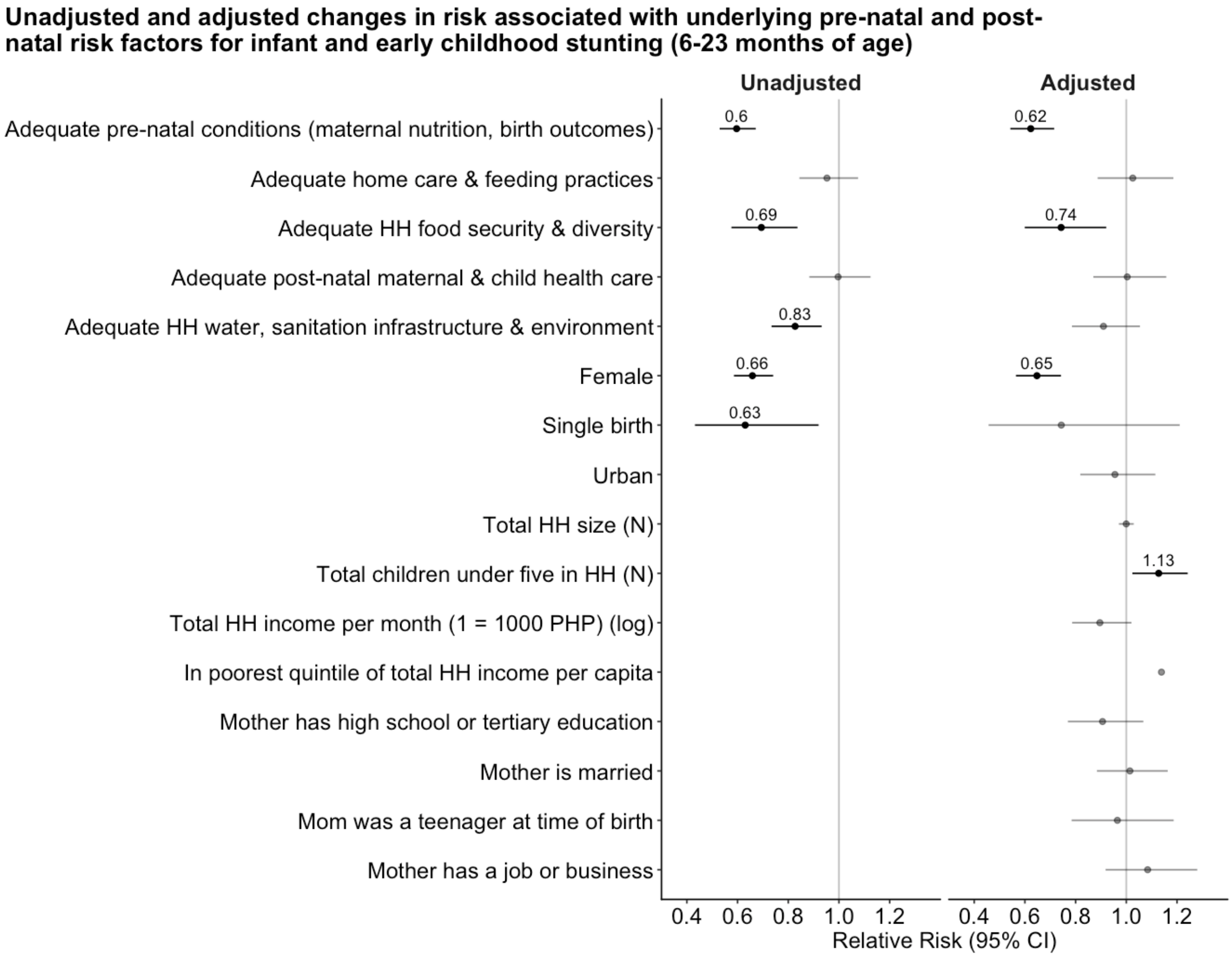
Source: Author's calculations based on 2015 National Nutrition Survey (NNS). Notes: Only the relative risk estimates for statistically significant predictors are labeled.

Figure 28. Model 2a, relative risk of stunting (0-5 months of age) by aggregated risk factors and interventions



Source: Author's calculations based on 2015 National Nutrition Survey (NNS). Notes: The predicted probabilities are based on model 2a (adjusted) and calculated at the means for all other predictors. 95% confidence intervals are shown.

Figure 29. Model 2b, relative risk of stunting (6-23 months of age) by aggregated risk factors and interventions



Source: Author's calculations based on 2015 National Nutrition Survey (NNS). Notes: Only the relative risk estimates for statistically significant predictors are labeled.

Figure 30. Model 2b, predicted probability of stunting (6-23 months of age) by aggregated risk factors and interventions

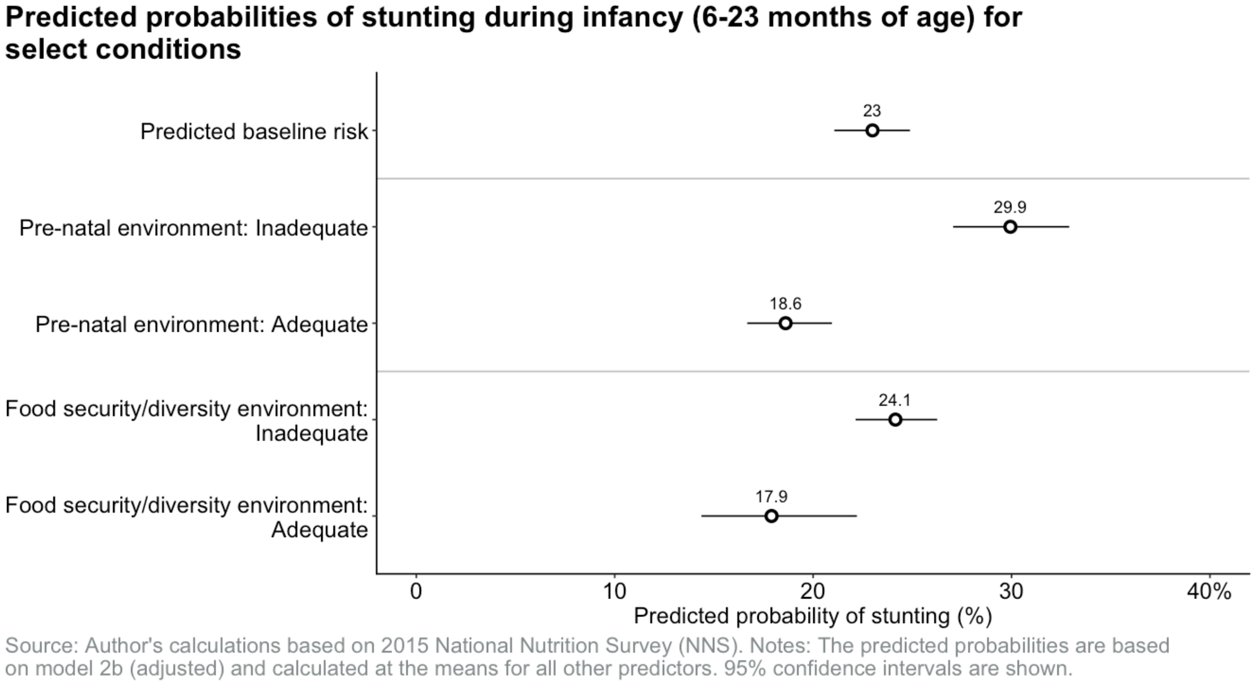


Figure 31. Model 2c, relative risk of stunting (24-60 months of age) by aggregated risk factors and interventions

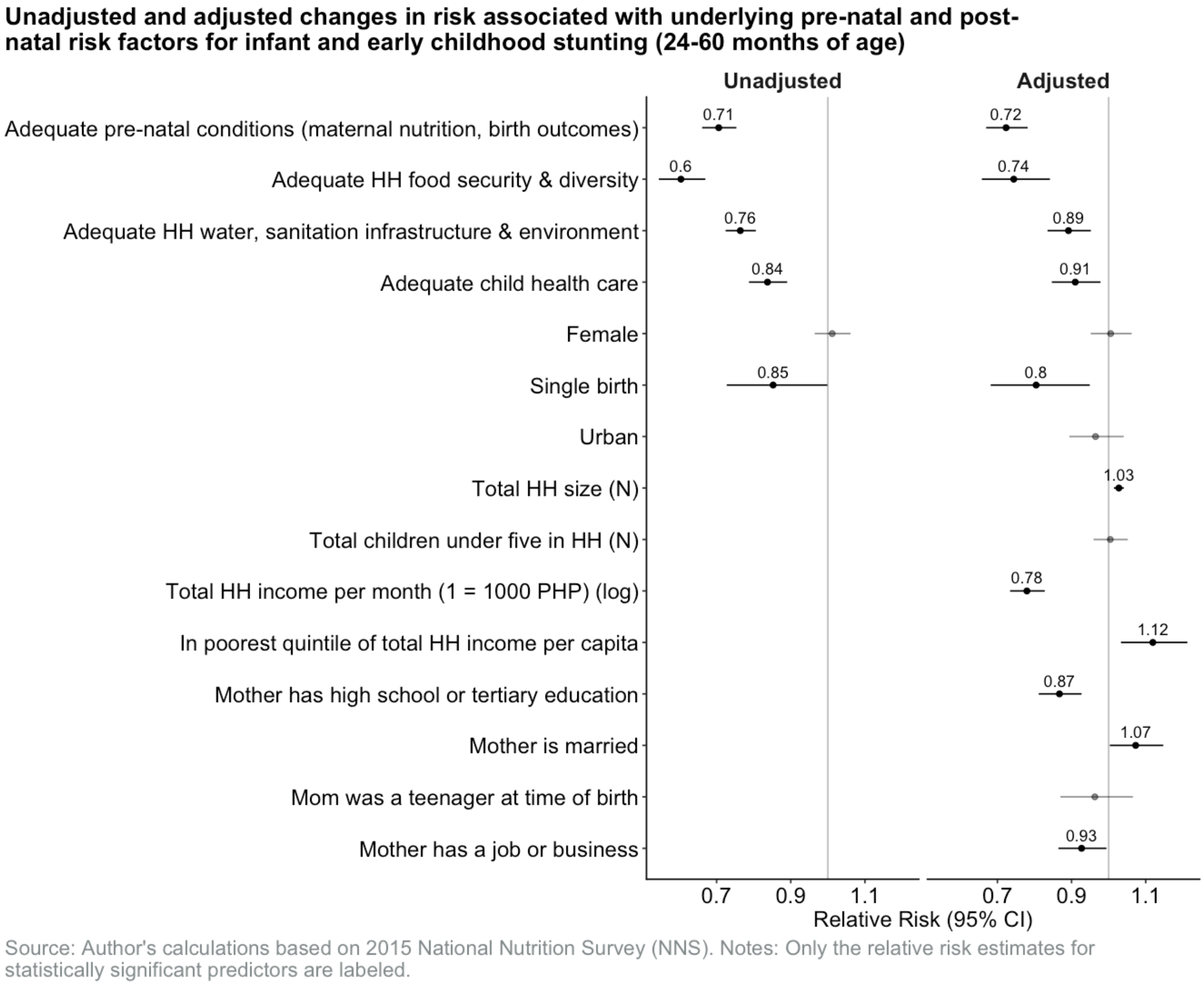
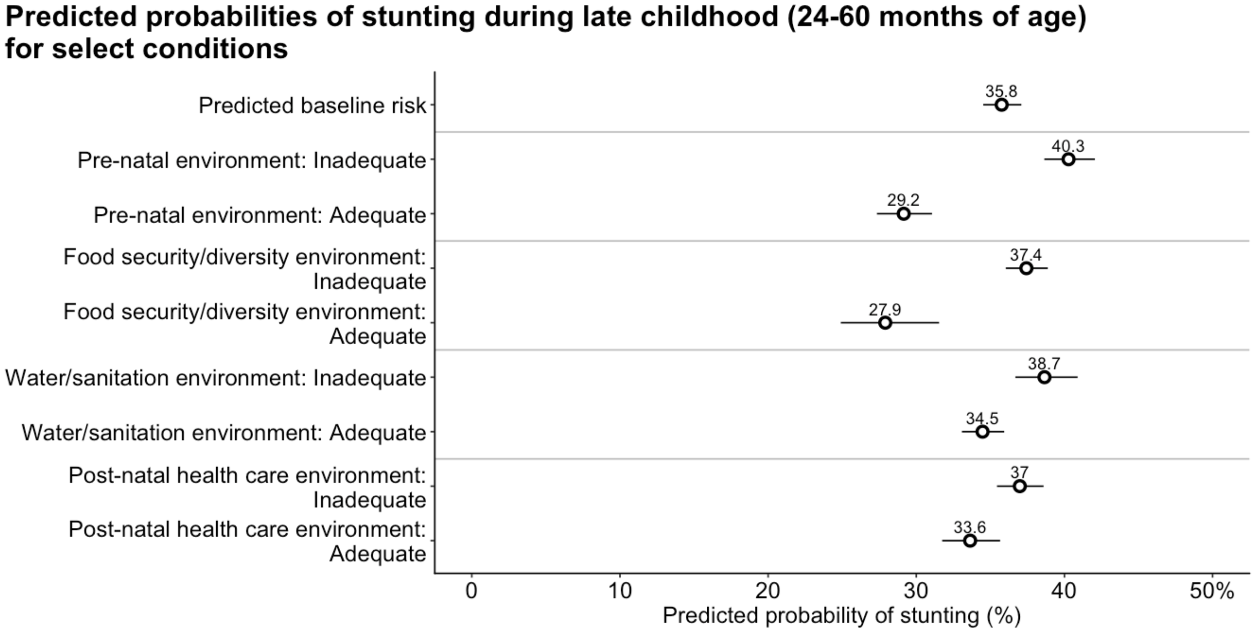


Figure 32. Model 2c, predicted probability of stunting (24-60 months of age) by aggregated risk factors and interventions



Source: Author's calculations based on 2015 National Nutrition Survey (NNS). Notes: The predicted probabilities are based on model 2c (adjusted) and calculated at the means for all other predictors. 95% confidence intervals are shown.

Model 3a investigates the relationship between simultaneous access to one or more of any the five nutrition driver domains and stunting for children under the age of 2 years (N = 2,927), compared to children who do not have adequate access to any (Figures 33 and 34). Large and statistically significant marginal reductions in stunting risk are associated with an increase of adequate access in zero driver categories to any 3 (the PP of stunting declines from 29 to 19 percent, respectively), and an increase in adequate access from any 3 driver domains to any 4 or 5 (the PP of stunting declines from 19 to 13 percent).

Model 3b examines these relationships for children between the ages of 2 and 5 years (N = 6,851). The difference here is that the maximum total number of domains a child can have simultaneous access to is four since caretaking and feeding indicators were not available in the NNS for this age group. Unlike for children under-2, there is a clear dose-response relationship between access to more driver domains and the risk of stunting. The presence of one additional favorable environment reduces the risk of stunting by between 5 and 8 percentage points (Figure 35), so that the cumulative difference in the predicted probability of stunting for children without access to any domain is 46.2 percent while it is 19.7 percent for children with access to all four. This finding lends support to the conceptual framework.

Figure 33. Model 3a, relative risk of stunting for different degrees of simultaneous access to stunting driver domains (0-23 months)

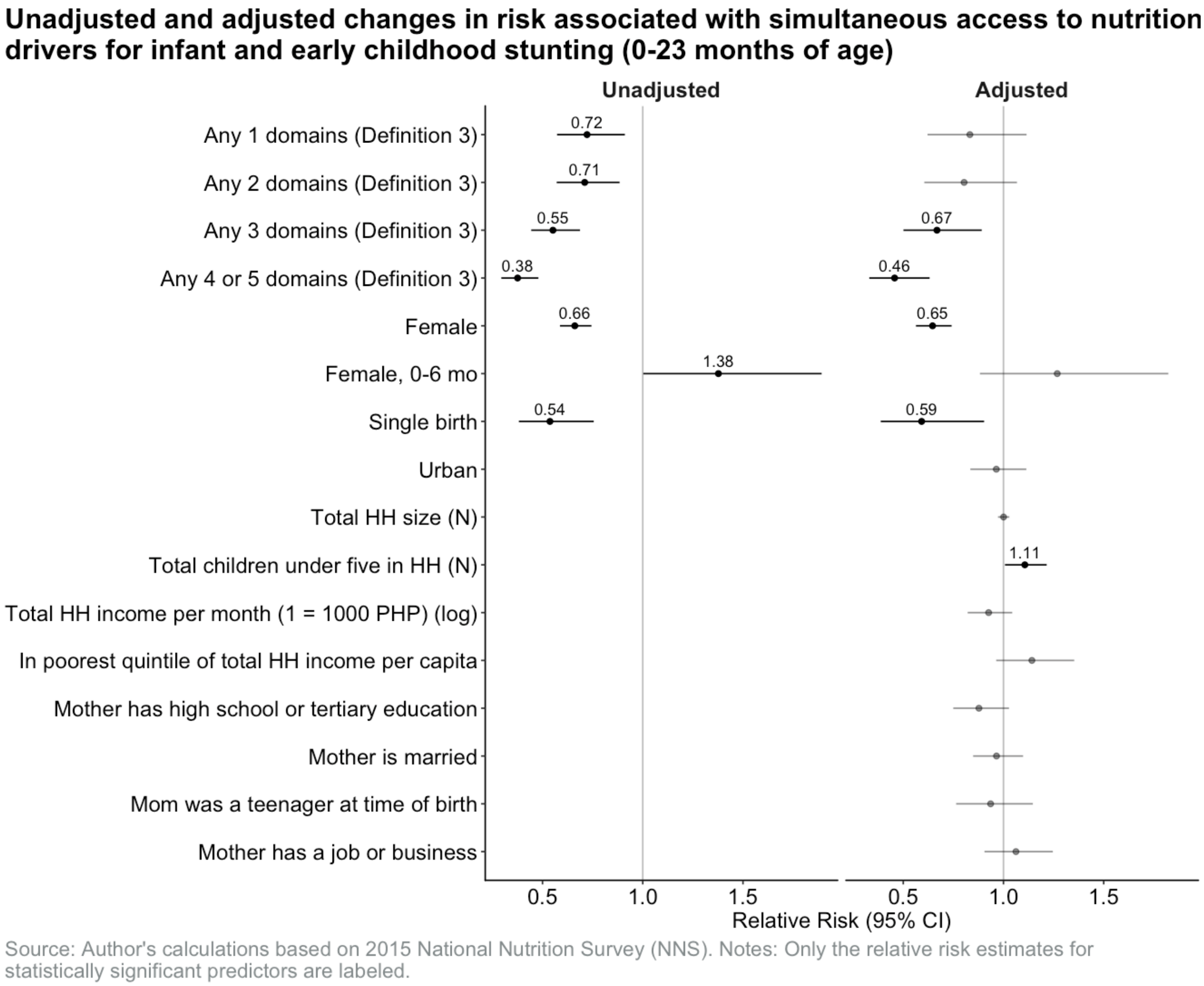
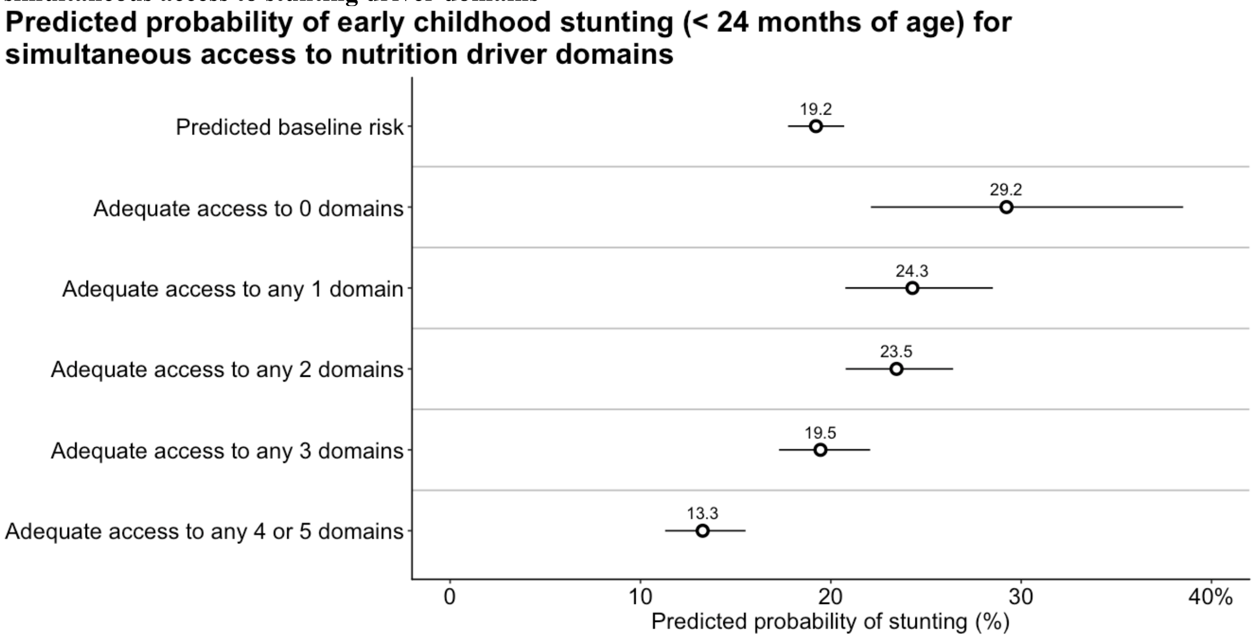
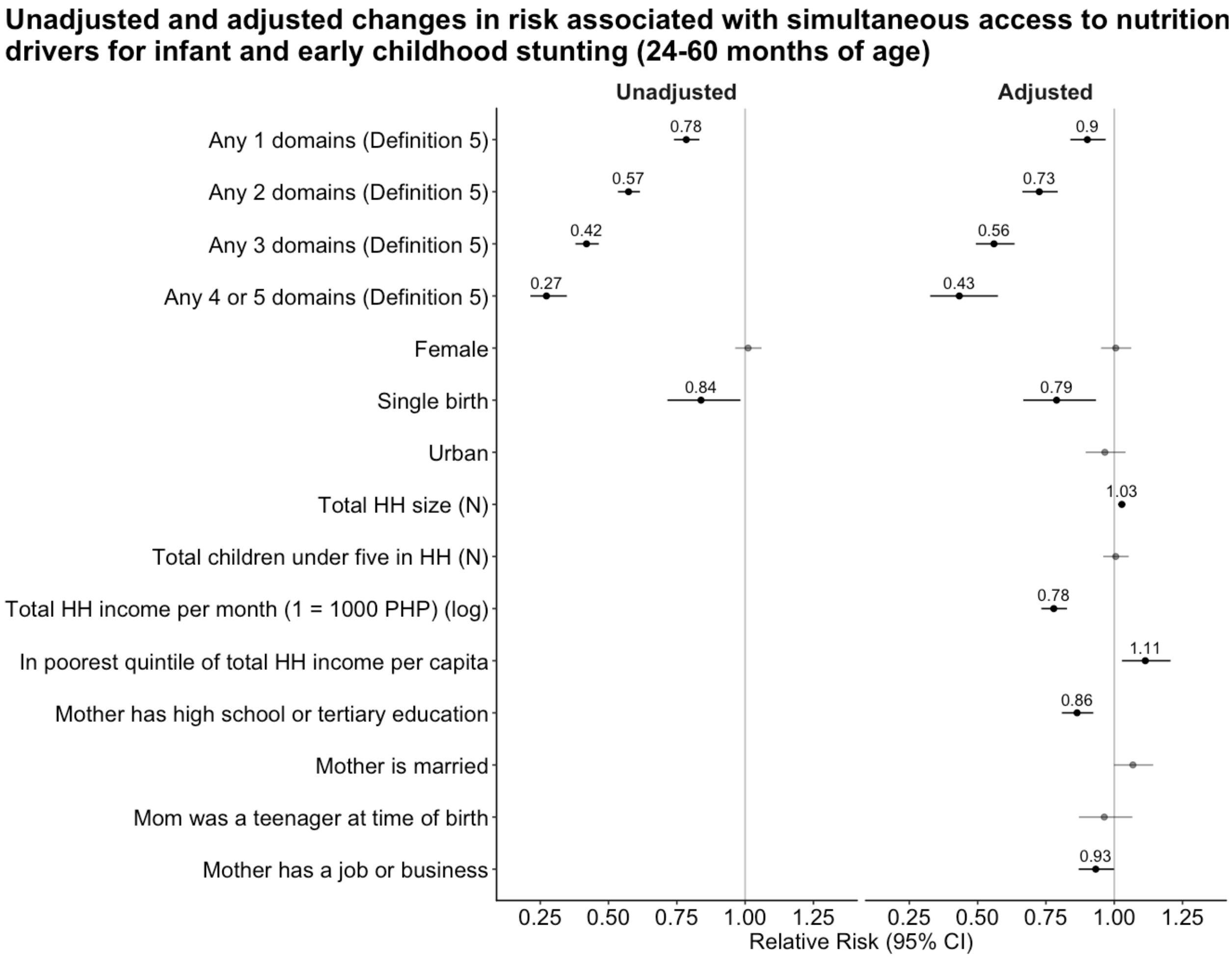


Figure 34. Model 3a, predicted probabilities at sample means (0 - 23 months of age) for different degrees of simultaneous access to stunting driver domains



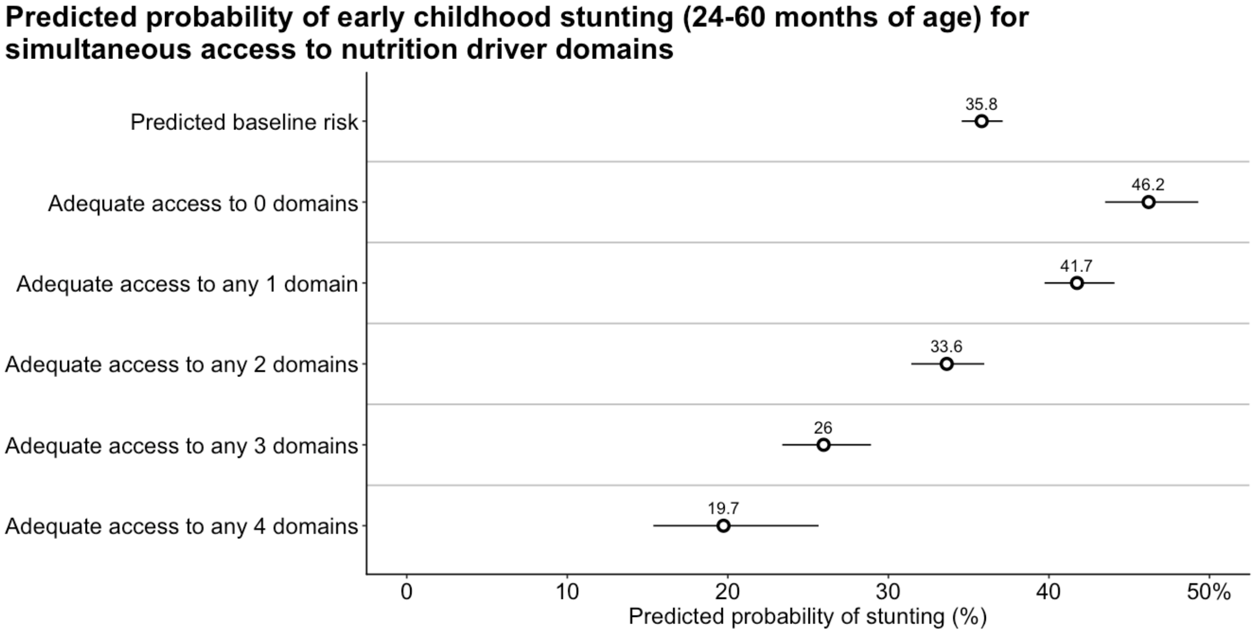
Source: Author's calculations based on 2015 National Nutrition Survey (NNS). Notes: The predicted probabilities are based on model 3a (adjusted) and calculated at the means for all other predictors. 95% confidence intervals are shown.

Figure 35. Model 3b, relative risk of stunting for different degrees of simultaneous access to stunting driver domains (24-60 months)



Source: Author's calculations based on 2015 National Nutrition Survey (NNS). Notes: Only the relative risk estimates for statistically significant predictors are labeled.

Figure 36. Model 3b, predicted probabilities at sample means (24-60 months of age) for different degrees of simultaneous access to stunting driver domains



Source: Author's calculations based on 2015 National Nutrition Survey (NNS). Notes: The predicted probabilities are based on model 3b (adjusted) and calculated at the means for all other predictors. 95% confidence intervals are shown.

7 Discussion

This analysis suggests that a significant fraction of stunting that manifests in infancy and early childhood in the Philippines has its origins in utero. Forty-three percent of children under-2 lack strong evidence of having had an adequate prenatal environment leading up to their birth, measured by having a normal birthweight and a mother with normal BMI and stature (height > 145 cm) as well as access to appropriate antenatal care and support during labor. These children have 1.75 times the risk of stunting compared to under-2s with evidence of a more optimal antenatal environment.[48] An estimated 24 percent of cases of stunting among children under-2 in the Philippines are attributable to exposures in the prenatal environment (Table 9).[49] For children between the ages of 2 and 5 years, sub-optimal prenatal exposures increase the risk of stunting 1.38 times and an estimated 20 percent of cases of stunting among this age group are attributable to exposures in the prenatal environment (Table 10).

Table 9. Sub-optimal environments and stunting, Infancy & early childhood: 0-23 months (2015 Stunting prevalence = 25%)

	Prevalence (% of children exposed)	Relative risk of stunting (adjusted[1])	Predicted increase in absolute probability of stunting[2] associated with sub-optimal conditions in domain (percentage points)	Population attributable fraction[3]
Sub-optimal prenatal environment	43.0%	1.75	10.20	24%
Sub-optimal home care & feeding practices	29.2%	1.02	0	--
Sub-optimal household food security & diversity	84.6%	1.35	6.10	23%
Sub-optimal postnatal maternal & child health care	59.6%	0.93	0	--
Sub-optimal HH water, sanitation infrastructure & environment	26.2%	1.16	1.50	4%

[1]Adjusting for socioeconomic characteristics of the household including household size, number of children household income, mother's education, occupation status, marital status and mother's age. [2]This is calculated as the difference in the predicted probability of stunting in the sub-optimal condition and the predicted probability of stunting in the optimal condition. [3]The population attributable fraction is the proportional reduction in population stunting that would occur if exposure to risk factor were changed to an adequate scenario.

Table 10. Sub-optimal environments and stunting, late childhood: 24-60 months (2015 Stunting prevalence = 37.6%)

	Prevalence (% of children exposed)	Relative risk of stunting (adjusted)	Predicted increase in absolute probability of stunting[2] associated with sub-optimal conditions in domain (percentage points)	Population attributable fraction
Sub-optimal prenatal environment[1]	67.4%	1.38	11.10	20%
Sub-optimal home care & feeding practices			No data	
Sub-optimal household food security & diversity	84.1%	1.34	11.20	22%
Sub-optimal postnatal maternal & child health care[2]	64.8%	1.10	3.80	6%
Sub-optimal HH water, sanitation infrastructure & environment	27.9%	1.12	3.50	3%

[1] Excludes recommended use of at least 4 antenatal care visits (not asked in relation to the pregnancies of children above the age of 2). [2] Excludes access by mother to skilled postnatal check-up (not asked in relation to the pregnancies of children above the age of 2)

Unlike the stunting risk associated with low birth weight and maternal low BMI which diminishes with the child's age, the risk of stunting associated with maternal short stature persists from infancy through childhood. This finding could suggest that different mechanisms link stunting with nutritional shocks faced during pregnancy (that contribute to low birth weight and maternal low BMI) and intergenerational or chronic nutritional shocks (that contribute to the stunted growth of mothers during their own childhood and adolescence). The fact that maternal short stature is associated with child nutrition outcomes independently of an association with low birth weight suggests that adolescent and reproductive health for girls, not just nutrition during pregnancy, is important.

As the stunting risk associated with the nutritional status of the mother and child during pregnancy diminishes for older children, the stunting risk associated with the family's ability to adequately supply nutrition to the child postnatally increases. Children in households that consume eggs, meat and milk or have tools that improve their capability to safely consume them are less likely to be stunted. The presence of a refrigerator and use of improved cooking fuels are both associated with lower stunting risk. Several possibilities might explain this. Both tools protect against illness (by lowering the degree of indoor air pollution and by preventing food spoilage and food borne illness) and facilitate care and feeding at home (a refrigerator enables households to purchase nutrient-rich perishable foods, cookstoves that use cleaner fuel can ease meal preparation and reduce cooking times).

Nearly 85 percent of children under-5 years of age in the Philippines reside in moderately or severely food insecure households that do not regularly consume protein-rich foods (as measured by consumption of ASFs at least once in the past week) (Tables 9 and 10). These children have 1.35 times the risk of stunting compared to children with a more favorable food security and diversity profile, controlling for socio-economic factors and other prenatal and postnatal stunting determinants (Tables 9 and 10). Around 23 percent of cases of stunting among children under-5 are attributable to inadequate household food security and diversity (Tables 9 and 10). Without measures of the actual frequency, quantity and quality of children's diets in the NNS data it is unclear to what degree food security and diversity at the household level translates to child-level food consumption, but it is plausible that this relationship in part reflects the benefits of a higher quality diet enabled by food security and access to ASFs high in protein content. More research would help shed light on both the supply-side (such as the availability and price of ASFs in markets) and demand-side (such as knowledge, traditions and preferences) constraints to diversity in children's diets.

Energy intake from milk - but not breastmilk - by children between 6 and 24 months of age is associated with a reduction in stunting risk even after controlling for income and mother's education (use of breastmilk substitutes is strongly associated with family income and mother's education, reflecting a preference among mothers with more financial resources and education not to breastfeed). More research and data are needed to untangle the behaviors and factors associated with milk feeding that might help explain why it is associated with better nutrition.

There is some evidence that factors associated with children's postnatal health reduce stunting risk. Among infants, access to improved drinking water is associated with a reduction in the risk of stunting. This effect possibly links with the low prevalence of exclusive breastfeeding in the Philippines and the potential prevention of illness among infants whose formula is prepared with clean water. Assistance during birth by a skilled practitioner is negatively associated with stunting for children between the ages of 2 and 5 years. Given that other measures of child health care utilization are not available in the NNS data for children in this age group, this predictor may be capturing the benefits of health seeking behaviors more broadly (for example, mothers who delivered in hospital may be more likely to vaccinate their children or seek professional health care in other situations, such as when their child is ill).

Two socio-economic factors also emerge as important independent drivers of child nutrition in this analysis. Infants under the age of 6 months in single-mother households have an elevated stunting risk relative to children in two-parent households, possibly reflecting the greater burden of caretaking and housework that single mothers face. Children over the age of 2 with university educated mothers have a lower risk of stunting, possibly reflecting the role of formal education in facilitating the acquisition of knowledge - either directly or through expanded social networks - for more effective meal selection and feeding practices.

This analysis also suggests that nutrition drivers across sectors are complementary in their impact on child nutrition. In other words, children's nutrition stands to benefit more if public and private efforts work to create favorable environments for children across multiple domains, not just a single one. But as decision makers move towards defining how limited resources should be used to improve child nutrition, what initiatives should be prioritized?

Empirically, the results explored in this paper suggest that the greatest reduction in stunting prevalence would occur if significant progress was made on two fronts: improving prenatal conditions and improving food security and diversity. Combined, sub-optimal conditions in these two domains account for nearly 50 percent of the cases of stunting in children under the age of 2 years and 42 percent of the cases of stunting in children between the ages of 2 and 5 years. In the former case, this means greater focus on supporting the nutrition and health of expecting mothers and adolescents to improve birth outcomes, including access to contraception to give women greater ability to exercise their fertility preferences. In the latter case, this means supporting efforts to ensure that children are regularly consuming a range of foods that deliver key micronutrients, including protein-dense perishable foods such as meat or eggs and the adoption of technologies that facilitate their consumption (such as refrigeration). This is especially important when children reach the age of 6 months and their dietary intake needs to be significantly supplemented with energy and nutrients from solid or semi-solid foods. In areas where birth outcomes and food security are already generally favorable (e.g. areas with low prevalence of preterm or LBW newborns and diets that incorporate diverse food sources), stakeholders might examine ways to improve the safety and reliability of the drinking water supply and sanitation and wastewater systems. One aspect of the home care environment that is not associated with stunting per this analysis, but nevertheless is important for the cognitive development of children is stimulation through reading and play. Nationally, only 39 percent of children under the age of 2 are both read to and get play time with their caretaker, so more direct interventions to improve learning and schooling outcomes might include encouraging cognitive stimulation for children through outreach, education and investment in early childhood development.

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[48] Thirty percent of children under-5 are either low birth weight, have mothers with a low BMI or have mothers with short stature. Under-5s exposed to any one of these risk factors have 1.6 times the risk of stunting compared to children who are not exposed, controlling for age, sex, socio-economic factors and other postnatal stunting determinants. Children with any two of these risk factors have 1.7 times the risk of stunting, and children with all three of these risk factors have 1.9 times the risk of stunting, controlling for other factors.

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