"THE RELATIONSHIP BETWEEN POVERTY AND SOCIAL DETERMINANTS OF GROWTH IN LOW-INCOME BRAZILIAN CHILDREN"

by

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ABSTRACT OF THE DISSERTATION

"THE RELATIONSHIP BETWEEN POVERTY AND SOCIAL DETERMINANTS OF GROWTH IN LOW-INCOME BRAZILIAN CHILDREN"

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Stunting affects 159 million children under the age of five, while 41 million children are overweight. In general, poorer nutritional and health outcomes are associated with poverty. Poverty has several dimensions and can be defined in several ways, not only as monetary (income) poverty, and sociodemographic characteristics should also be taken into consideration when investigating the influence of poverty on health and nutrition of individuals. The objective of this dissertation was to determine how social and parental characteristics influence nutritional status of children relative to (income) poverty, using longitudinal data from about nutrition education intervention conducted with 500 low-income Brazilian children followed from birth to 7 years. Children living below the poverty line (BPL) had higher prevalence of stunting at 7y compared to children living above the poverty line (APL). Prevalence of overweight did not differ between groups. BPL was associated with increased odds of short exclusive breastfeeding, and participation in a nutritional intervention did not reduce the gap between infants ABL or

BPL, indicating poorer children continue to be more vulnerable. More than income, living conditions of poor families could have been associated with the poorer nutritional outcomes of the BPL. We found that paternal education was associated with lower odds of stunting at 1, 4 and 7y, and infants who lived in extended families grew more from birth to 12 months, but had worst breastfeeding practices. Traditionally, nutritional interventions target lower income individuals, to alleviate nutritional and health gaps between lower and higher income individuals. Indeed, children living under extreme poverty had worse linear growth, noticeable at 7y, and traditional nutritional education interventions might not be enough to reduce the gap between the poorest and the better-off individuals. Nutritional status during infancy was a strong predictor of nutritional status during childhood, suggesting the potential of early interventions to avoid both stunting and overweight during childhood. Finally, more educated fathers had lower odds of having stunted children. Future studies should investigate the effectiveness of nutritional education programs targeting not only mothers, but also fathers.

DEDICATION

I dedicate this dissertation to my parents, siblings, nephews, in-laws and husband, for all the support and patience throughout all these years, for making me laugh and feel loved. I love all of you.

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LIST OF ABBREVIATIONS

AGA: Adequate-for-gestational age

BMIz: Body mass index-for-age *z* score

EBF: Exclusive breastfeeding

GH: Growth hormone

HAZ: Height-for-age *z* score

IGF-1: Insulin-like growth factor 1

LAZ: Length-for-age *z* score

IYCF: Infant and young child feeding

LBW: Low birthweight

PL: Poverty line

SES: Socioeconomic Status

SGA: Small-for-gestational age

CHAPTER 1

Introduction

According to the Food and Agriculture Organization of the United Nations (FAO), about 795 million people in the world were undernourished in 2014-2016[1], and about 40% of the adult world population is overweight and 13% are obese[2]. Malnutrition, either too few or too many calories and nutrients, affects not only adults, but also a large number of children as well, and this can negatively affect their growth.

Undernutrition results from insufficient food intake and/or occurrence of infectious diseases and can be as one of the following conditions: stunting, wasting and underweight. Wasting is defined as weight for height is below -2 standard deviations (SD) for a standard population, such as the gender-specific World Health Organization (WHO) Growth Standards[3,4]. When weight for age is below -2SD, a child is classified as underweight[3]. Both wasting and underweight result from acute undernutrition, which causes weight loss. When a child faces frequent and/or chronic periods of undernutrition, it often results in growth faltering or stunting, defined as length- or height-for-age below -2SD[3]. Stunting is the most prevalent childhood undernutrition problem in the world, affecting 159 million children (25%) under the age of five in 2014, while wasting affected 50 million children under the age of five (7.5%) in the same year[5]. Underweight is seldom reported. Another rising problem is childhood obesity, defined as body mass index for age above 2SD for children under the age of five[3], and above 1 SD for children 5 years and older[4]. In 2014, 41 million of under fives were overweight, 10 million children more than in 1990[5].

As countries develop economically, dietary and living patterns change and there is a shift from health and nutritional problems related to food scarcity and hunger – undernutrition and infectious diseases – towards health and nutritional problems related to excesses – obesity and increasing incidence and prevalence of chronic diseases. Many developing countries now face what has come to be know as the “nutrition transition” including Brazil. Brazil is a upper-middle income country[6] located in South America. Brazil is the fifth largest country in the world, both in area (about 8,5 million squared kilometers, after Russia, Canada, United States and China)[7] and population (with about 208 million inhabitants)[6]. The latest health demographic survey conducted in Brazil estimated 8.4% and 9.4% of boys and girls were stunted at 12 months, while the prevalence of stunting decreased to 4.0% and 6.0%, respectively for boys and girls ages 2 to 4, with lowest prevalence for both genders at 4 years[8]. The south and southeast regions are the most developed regions in Brazil and the urban population in the south of Brazil had the lowest prevalence of stunting among children under the age of five (3.7%)[8]. For children ages 5 to 9 years, the prevalence of stunting was lower in older children (10% among five-year olds and 5.0% among nine-year olds), and lowest for the children living in the south of Brazil (4.7% compared to the national average 7.2%).

While Brazil did not report the prevalence of overweight and obesity among children younger than five years, about 34% of children ages 5 to 9 were overweight (35% of boys, 32% of girls), with similar prevalence across ages, and 14.3% were obese (16.6% of boys, 11.8% of girls)[8], proportions similar to the United States (34% and 17.7% of children ages 6 to 11 years were overweight and obese, respectively, in the United States in 2012[9]). Weight deficits are seldom reported in current national data, and Brazil reported only wasting prevalence among children ages 5 to 9. Among this group, wasting affected 4.1% of children, with slightly higher prevalence among 5 year olds (5.0%) compared to 9 year olds (3.8%)[8].

Generally, undernutrition is associated with poverty and lower socioeconomic status, that is, poorer populations are more likely to be undernourished. In 2015, the world Bank estimated that 700 million people in the world were living in poverty[10]. In Brazil, 22 million people (7.3% of the population) were living under extreme poverty in 2014, defined as monthly income of R$77/*per capita* (approximately US$240/year, per person)[11,12], while poverty is defined as monthly income *per capita* below R$140 (US$440/year) and low-income is defined as half Brazilian Minimum Wage *per capita* (approximately US$4,730/year per person)[13]. Indeed, the prevalence of stunting among Brazilian children under the age of five decreased as the per capita income increased, simply demonstrating that stunting is more prevalent among poorer children[8]. The relationship between income and childhood overweight in Brazil is still unclear, although the latest demographic health data survey showed that prevalence of overweight among children ages 5 to 9 years increased with income. Specifically, in homes with *per capita* income up to 25% of the Brazilian national minimum wage (BMW), less than 27% and 21% of boys and girls, respectively, were overweight, while in households with *per capita* income above 5 BMW 51% and 39% of boys and girls were overweight, respectively[8].

Since the late 1990s, Brazil the prevalence of childhood undernutrition has decreased. In the 1990s and early 2000s, most of Brazilian national public health campaigns related to childhood nutrition focused on reduction of undernutrition, with little focus on obesity. Thus, the Brazilian Ministry of Health developed the “Ten Steps for Healthy Feeding Children from Birth to Two Years of Age”[14], which included ten simple guidelines for healthy breastfeeding and complementary feeding practices, based on the WHO breastfeeding guidelines. A research group in Brazil conducted a nutrition education intervention to evaluate the effectiveness of these guidelines[15]. Briefly, 500 mothers were recruited the day after labor from the only maternity-hospital of the city of Sao Leopoldo, in Rio Grande do Sul, in the south of Brazil. Recruitment in the public wards only of the maternity-hospital guaranteed that only low-income mothers were recruited, although this was not one of the inclusion criteria. Inclusion criteria included singletons, full term, with birth weight at least 2500g. Infants who needed hospitalization or had HIV-positive mothers were excluded from the study. The 500 mother-child pairs were randomly allocated to either the intervention or control groups in a 2:3 ratio. The intervention consisted in 10 home-visits (10 days after birth, monthly from 1 to 6 months, and at 8, 10 and 12 months of the infants), when mothers were counseled in one of more steps from the Ten steps guidelines, based on the age and development of the infant. Participants allocated in the control group did not receive any counseling from the program. Participants from the intervention and control groups were then visited at 6 and 12 months of the child, for collection of anthropometric, health, socioeconomic and dietary data of the infants.

The main goal of the primary study was to increase the proportion of mothers who exclusively breastfed[15]. At the end of the study, infants in the intervention group were more likely to be breastfed for at least 4 months (Relative Risk [RR] = 1.58, 95% Confidence Interval [%CI] = 1.21, 2.06), to be breastfed for at least 12 months (RR = 1.26, 95%CI = 1.05, 1.55) compared to infants in the control group[15]. In addition, infants in the intervention group were less likely to have had diarrhea (RR = 0.68, 95%CI = 0.51, 0.90) and respiratory infection (RR = 0.63, 95%CI = 0.46, 0.85) in the month prior to the interview, compared to infants whose mothers did not receive counseling[15]. However, the authors found no differences in the nutritional status of infants.

Participants of the primary study were from a low-income background. However, the original study did not investigate whether there were differences in the nutritional status or health outcomes of infants living above of below the poverty line. Further, participants of the original study were followed until children were 7 years old. Thus, the objective of this dissertation was to determine whether children who lived above the poverty line and those who lived below the poverty line (that is, the poor and the poorest, respectively), had different nutritional status at three different ages (infancy, pre-school age and mid-childhood), whether living conditions other than income could have influence their nutritional status, whether they had different infant feeding practices and, finally, whether among participants who received the nutritional education intervention, living above or below the poverty line would influence the effectiveness of the intervention.

CHAPTER 2

Background and Literature Review

2.1 Factors that influence child growth

Using data from almost 9,000 breastfed children from five countries (Brazil, Norway, United States, India, Oman and Ghana), the World Health Organization (WHO) published the WHO Growth Standards[3], the current worldwide reference for child growth, according to anthropometric measurements by age and gender. Weight provides information about short-term conditions while height provides more long-term information about health and nutrition. Growth potential is met when other factors do not affect growth and developemnt of the individual. While a child grows quickly after birth, there is a near-plateau at the end of the first year of life until two years of age[16]. A normal child growth pattern is divided into the following overlapping phases[17]: infancy (from birth to two or three years), childhood (preschool age to puberty), and adolescence (begins with puberty)[18,19]. Recently, others have suggested that the prenatal period be included as part of the growth phases[19,20].

The prenatal period is the most rapid human growth phases[20]. During this phase, growth is mainly determined by maternal size, nutrition and health, and birth length has little correlation with adult and parental heights[18,19,21,22]. The following stage, the first post-natal phase of growth, is infancy that extends from birth to 24 to 36 months of age. When growth velocity is at its post-natal peak. Overall, from birth to 36 months, the infant grows quickly, but at a decelerating pace[16]. During infancy, growth is mostly nutritionally driven and related to intrauterine conditions[22]. The second post-natal phase is childhood, which extends from preschool age to puberty when growth continues, but at a more linear rate. In general, girls tend to grow faster than boys until the age of four, when growth rates become similar, 5-6 cm/year until puberty[18,19,21].

During childhood, growth hormone (GH) and insulin-like growth factor 1 (IGF-1) are the main factors driving growth. Sex hormones are the main factors driving the adolescent spurt[22,23]. The final phase of growth is the pubertal growth spurt, when there is a more pronounced increase in height at ages 11 to 16 years, followed by a very small increase until adulthood. Girls usually enter and complete puberty earlier than boys[18,21], but they have a peak growth of nine cm/year, 1-2 cm/year less than boys[21,23]. The later onset of puberty gives boys about two years of extra growth before the onset of puberty which, in combination with the higher growth peak, explains why adult men are generally taller than adult women[19,23].

Nutrition and hormones are among the main biological factors affecting growth[20]. Among the extrinsic factors that might affect growth, socioeconomic status (SES), usually defined by income and/or parental education, is the most studied social determinant of health. While the effects of hormones on growth can be easily isolated through case-studies of hormonal abnormalities, it is difficult to isolate the effects of specifc socioeconomic factors on growth, given that SES might affect several aspects of the life of an individual, including access to adequate nutrition, health care services and sanitation – all conditions that influence health, nutrition and growth.

As discussed above, during intrauterine life, growth is mainly determined by maternal health status. Birthweight is generally used as a proxy for fetal growth and newborns weighing less than 2,500g are considered low birthweight (LBW). While preterm birth is the main cause of LBW in developed countries, LBW is often a result of poor maternal health and nutrition in developing countries[24]. Undernourished women are more likely to give birth to LBW newborns[25–27], as well as women in poor health due to infections, hypertension, physical abuse from a partner during pregnancy, smoking and alcohol abuse[25]. Low birthweight is thought to be the underlying cause of 60 to 80% of neonatal deaths worldwide[25]. When those neonates survive, they have a higher risk of morbidity and mortality during infancy and those who survive infancy are more likely to have growth (linear and developmental) deficits[24]. During adulthood, individuals who experienced poor growth in childhood have greater risks of developing non-communicable diseases such as diabetes, cardiovascular disease and metabolic syndrome, and are more likely to be shorter adults, and shorter women are more likely to give birth to smaller babies[28–30].

While poor fetal growth may be caused by some metabolic conditions, poverty and undernutrition are intrinsincly related. A study conducted in Brazil found an inverse association between family income and LBW for women with normal height (>160cm)[31]. Also, a German study investigating the effects of low to moderate drinking during pregnancy found that while more than 80% of the mothers who drank alcohol during pregancy were from high and middle SES, the prevalence of LBW was higher among mothers from the lower SES (11.1%, for low SES, compared to 5.8% and 8.9% for high and middle SES, respectively, $p < 0.05$)[27]. While confounders such as smoking, maternal height and maternal BMI explained some of the differences in LBW between the lower and higher SES, 40% to 75% of this difference remained unanswered. These data suggest that women from lower SES are not only more likely to give birth to LBW offsprings, but have worse outcomes even when given the same risk factors (smoking, maternal height and BMI). Moreover, relavant socioeconomic factors affecting child growth still remain unaccounted for and there is currently limited data on interactions between biological and social factors and their combined influence on growth after birth.

2.2 Poverty

Despite the recent economic growth of the past few decades, 702 million people were still considered "poor" by the World Bank in 2015[10]. However, the definition of poverty varies between countries due to different social and economic situations and perspectives. In fact, higher income countries tend to have higher poverty lines[32], making it difficult to draw comparisons across nations. In Brazil, "extreme poverty" is defined as monthly income of R$77/*per capita* (approximately US$240/year), a condition affecting 22 million people in 2014 (7.3% of the population)[11,12], while poverty is defined as monthly income *per capita* below R$140 (US$440/year) and low-income is defined as half Brazilian Minimum Wage *per capita* (approximately US$4730/year per person)[13], with no differentiation between member age. In the US, poverty affects 15% of the population (46.7 million people), and it is defined by annual income depending on the number of adults and children in the household[33]. For example, in 2014, the poverty threshold for a couple younger than 65 years with no children was $15,853, while for a couple with two children was $24,008[33]. By contrast, a family of two adults and two children in Brazil that earns US$1,760 per year is considered poor and US$18,920 is considered low-income.

In an attempt to bring attention to the poorest people in the world, independent of nationality, the World Bank proposed the use of a global poverty line[34]. The global poverty line was proposed in 1990 at $1.00 a day, updated in 2005 to $1.25/day *per capita*, and $1.90/day *per capita* in 2012[35]. This international poverty line defines "absolute poverty" consistent with Chen and Ravallion's definition: "An absolute poverty line is intended to have constant real value over time and space"[32]. Thus, according to the global poverty line, individuals living with less than $1.90/day are considered poor, regardless of the nation of residence. Developed countries tend to have higher poverty lines because they usually use "relative poverty" instead of "absolute poverty", since their definition of poverty include social determinants of welfare, which are a more relative than monetary (absolute) definition. "Relative poverty" lines are associated with social deprivation and vary with time and space as socially acceptable living conditions are constantly changing[32].

Independent of the measure of poverty, children are disproportionally affected by poverty. According to the World Bank, while children represent 20% of the non-poor, one-third of the individuals living below the poverty line are children up to 12 years of age. In low-income countries, fifty percent of all children live in poverty[36]. Special attention is given to children because children who grow up in poverty are likely to be poor adults and pass poverty on to their children[37], creating the "vicious cycle" of poverty. Furthermore, poverty has many dimensions as income poverty affects other social aspects, such as access to sanitation, health care and adequate nutrition. In fact, access to safe drinking water and sanitation are some of the underlying causes of undernutrition, and undernutrition is the underlying cause of more than one-third of all deaths of children under the age of five[38]. Thus, poverty and poor nutrition and health are intrinsically related.

2.3 Undernutrition: causes and consequences

The Food and Agriculture Organization of the United Nations (FAO) estimated that 795 million people in the world were undernourished in 2014-2016[1]. Adequate nutrition is essential for adequate linear, neurological and cognitive growth. Undernutrition results from insufficient food intake and/or occurrence of infectious diseases and can be assessed by the following three standards: stunting, wasting and underweight. Both wasting and underweight result from acute undernutrition and weight loss. Wasting is defined as a weight-for-height (WHZ) below -2SD for the reference population[3]. When weight-for-age (WAZ) is below -2SD, it is called underweight[3]. However, when phases of undernutrition are frequent or chronic before adulthood, undernutrition affects the development of bones and other structural components, leading to impaired linear growth, causing a person to become short for age.

Stunting is defined as short stature for age and is is considered the best measure of chronic undernutrition because it results from cumulative phases or chronic undernutrition[27]. Stunting is defined as length- or height-for-age (L/HAZ) below -2SD according to WHO Growth Standards[3]. Fernandes and colleagues emphasized how difficult it is to reverse deficits in stature for children as young as 24 to 45 months[39]. A study in a nutritional recovery center in Brazil found that after three years of treatment, children who initiated treatment for recovery from undernutrition after 24 months of age had 51% lower chances of recovery compared to children who initiated treatment before 12 months[39].

In 2014, approximately 159 million children worldwide under the age of five were stunted, almost 25% of all children under the age of five in the world[5]. Undernutrition during during childhood can have short- and long-term effects on health, including increased susceptibility to infectious diseases, growth faltering and increased risk of chronic diseases in adulthood[38]. Wasting and underweight are less prevalent than stunting, affecting approximately 7.5% and underweight is rarely reported in current documents[5]. However, these data include only moderate and severe forms of undernutrition (below -

2SD). Mild stunting (L/HAZ < -1 SD) is seldom reported in national data and, if it were to be included in worldwide estimates, the number of stunted children would increase to 314 million children[40,41]. Others have suggested that the harmful effects of undernutrition happen across the full undernutrition spectrum[40-42].

Chidhood health is considered one of the basic pillars of social and economic development and, despite declining, childhood undernutrition is still a major public health problem. According to UNICEF, about 6 million children under the age of five died in 2015[43], although an almost 50% decline from 1990, it still implies that 16,000 children die every day before reaching their fifth birthday. Furthermore, most childhood deaths are considered "preventable deaths" since they result from health problems that could be prevented or treated with proven and cost-effective interventions[44]. Undernutrition (in its various forms) is the underlying cause of about half of these deaths[44]. Among the most common causes of childhood mortality are pneumonia, measles and diarrhea, common childhood illness and easily treatable in healthier children[25,38,45]. Progress has been made in childhood mortality, but it is slower in infant mortality and neonatal mortality, and UNICEF estimated about 70% of all under-fives deaths happened within the first year of life[45].

While the direct cause of undernutrition is inadequate dietary intake, its underlying causes are various and involve environmental, economic, and sociopolitical factors[42]. Black and colleagues published a framework for undernutrition based on the conceptual framework of undernutrition from UNICEF, inclusing basic, underlying and immediate causes of maternal and child undernutrition (Figure 2.1).

According to this framework, the basic causes of undernutrition are social, economic, and political context in which a community or family lives. These contexts determine the availability of financial, human, physical, social and natural capital. The lack of one or more of these resources results in the underlying causes of undernutrition, since it will affect the availability of employment, assets, pensions, etc., that determine the presence (or absence) of income poverty. Income poverty influences household food security, childhood care practices, and household environment and health services. Household food insecurity directly affects dietary intake. Inadequate caregiving practices might lead to inadequate dietary intake, as well as occurrence of diseases. Finally, living in an unhealthy household environment and/or lack of health services might lead to occurrence of diseases. Inadequate dietary intake and diseases, the immediate causes of undernutrition, directly and indirectly (by leading to one another) cause maternal and child undernutrition. Immediate causes should be primarily targeted, due to their emergency character, as curative alternative. These are the focus of most nutrition and health interventions. However, preventive, long-term reduction of undernutrition, special attention should be given to underlying causes, which can only be solved when basic causes are heeded.

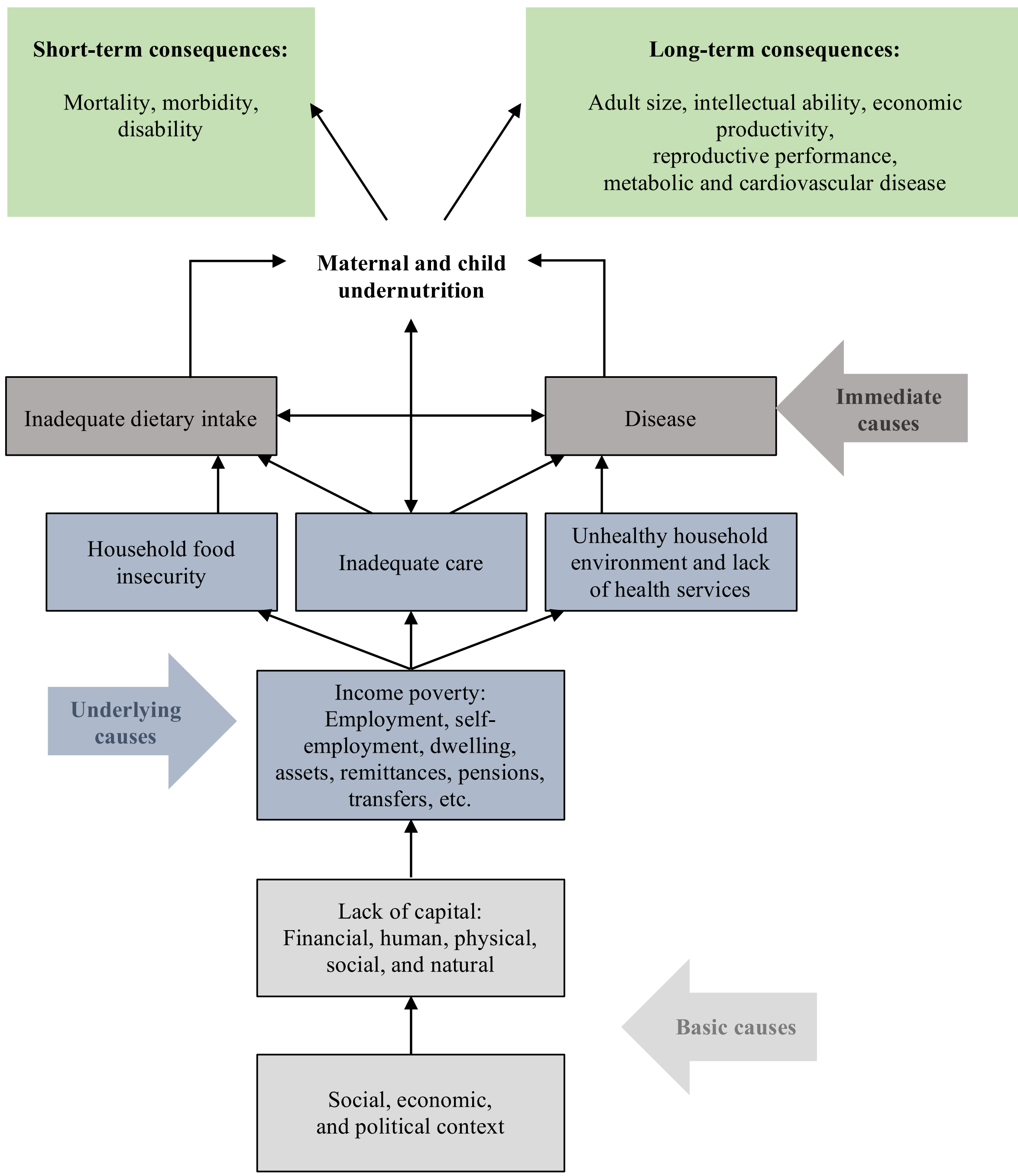

Figure 2.1 – Conceptual framework of undernutrition[42].

One aggravating problem related to stunting is that even under similar conditions, some individuals might be more vulnerable to undernutrition and poverty than others. In a prospective of 6,500 Tanzanian children followed from birth to 18 months, Sania and colleagues found that preterm babies, even if adequate-for-gestational-age (AGA), had twice the risk of being stunted at 18 months (RR = 2.13, 95%CI = 1.93, 2.36) compared to term-AGA children. Being preterm and small-for-gestational-age (SGA) increased the risk to 7.58 (95%CI: 5.41-10.64)[46]. In addition, in low-income settings, stunting might not even be recognized as a problem, since short stature is usually frequent and seen as normal in this environment[47], and thus, parents might not look for health care help to recover the nutritional status of the child.

The association between gender and stunting is controversial and, apparently, dependent on culture. For example in sub-Saharan countries, boys are more likely to be stunted than girls[48–53]. Although these findings might suggest the higher prevalence of stunting among boys is due to a cultural preference for girls, a report from the World Bank highlighted that infant deaths in sub-Saharan Africa are overwhelmingly among girls[54]. The higher prevalence of stunting among boys could be due to advantageous female physiology[53]. In fact, sex-specific differences in fetal growth are known. Under adverse intrauterine circumstances, female fetuses are more sensitive to increased levels of glucocorticoids and adapt to the environment by reducing growth rate[55] and are more likely to be smaller babies, but have higher rates of survival. Male fetuses, on the other hand, tend to adapt to the placental environment by changing gene activation or protein function, which leads to increased risk of IUGR, preterm delivery or stillbirth[55]. These adaptations during intrauterine life might influence the risk of stunting among boys.

A report published by UNICEF, WHO and the World Bank identified an inverse association between the prevalence of stunting and SES[56]. A study conducted with Brazilian children reported that poor sanitation and low SES increased the odds of stunting[57]. Peruvian children from the two lowest quintiles of income also had higher odds of stunting (Odds Ratio (OR) = 3.05, 95%CI = 1.35-6.92 and OR = 4.49, 95% CI = 1.92-10.51) compared to the highest quintile[58]. Finally, a study conducted in Guatemala found a higher prevalence of stunting among children from the lower SES (26.3% vs. 8.5%, low vs. high SES, respectively, for girls; 27.7% vs. 5.8%, low vs. high SES, respectively, for boys)[59]. Therefore, individuals from lower SES have a higher risk of being stunted.

Another way of analyzing SES is through parental education, a variable commonly used as a proxy for SES or when the sample has a similar SES. Maternal education is usually more available than paternal education, explains why it is more commonly found in research. Paternal schooling has also been found to be associated with stunting, but the association loses statistical power when controlling for confounding factors[49,50,58,60]. On the other hand, lower maternal schooling is associated with increased odds of childhood stunting, including countries in Africa[40], South Asia[60–62] and South America[58,63–66]. In the study of Wamani and colleagues, in rural Uganda, maternal schooling up to primary school doubled the odds of stunting compared to children whose mothers had more than primary education (OR = 2.1, 95%CI = 1.2, 3.8)[50]. Using cross-sectional data from more than 3,000 children under 5 years of age in the south of Brazil, Aerts et al. reported that maternal schooling was negatively associated with odds of being stunted[66].

In addition to the high risk of short stature in adulthood, childhood stunting is linked to other short-term and long-term consequences. Stunted children have increased risk of developing infectious diseases and dying[40], even though it is a consequence of the same problems causing stunting (undernutrition), and not a consequence of being stunted. However, stunted children have increased risk of later development of chronic diseases, such as cardiovascular diseases, diabetes, obesity[40]. For example, Sawaya and colleagues investigated anthropometric and dietary differences between stunted (HAZ <-1.4 SD) and non-stunted 7-11 years old girls from Brazilian shantytowns[67]. They found that stunted girls had significantly higher waist-to-hip ratio than non-stunted girls. While there were no differences in energy and macronutrient intake between the two groups, the percentage of fat intake was associated with increased weight-for-height *z* score (WHZ) in stunted girls only.

Short stature for age is also a marker for other underlying causes that affect child's nutrition and health, but are difficult to measure or control. Stunted children have delayed school entry and higher drop out rates[68], and lower school performance[69,70]. Such observations were first reported by the economist Richard Steckel who investigated the relationship between height and income and reported a positive association between height and *per capita* income (correlation (r^2) = 0.90)[71]. Using nationally representative data from the United States, from 1984 to 2005, Rashad reported that for every 10cm (~4 inches) increase in stature, income increased 5.4 to 10.4% for males and 4.2 to 10.7% for females, across different ethnicities[72]. Another study conducted in the US with a sample of more than 400,000 people found that men who did not graduate from high school are 1.27cm (half an inch) shorter than average and 2.54cm (one inch) shorter than the average for those who graduated from college[73]. In combination, these results indicate a possible relationship between height and income, with shorter adults having lower annual salaries[71-73]. Such observations may be due to poorer academic performance and higher drop out rates of stunted children that could be consequences of their economic conditions. In the end, stunted children have higher odds of continuing to live in more impoverished environments, perpetuating a lower SES and higher risk of having stunted offspring.

2.4 Infant and young child feeding practices and child nutritional status

In 2003, WHO and UNICEF developed the Global Strategy for Infant and Young Child Feeding as guidance for world leaders to improve the health of the children in their countries through optimal health[74]. The focus on infants and young child feeding (IYCF) is based on several studies reporting the importance of the timing of interventions to prevent and recover undernutrition and its lasting consequences. This is particularly important as deficits acquired by two years of age are difficult to reverse later[75].

Strategies to improve IYCF have to consider four important aspects: (1) early initiation of breastfeeding, (2) exclusive breastfeeding, (3) continued breastfeeding, and (4) adequate complementary feeding. Evidence for the importance of early initiation of breastfeeding comes from the studies of Edmond and colleagues[77]. Studying almost 11,000 infants, they found that breastfeeding within the first 24 hours after birth was protective against neonatal mortality, but breastfeeding initiated on the second, third or later days increased the odds of neonatal mortality (Adjusted OR (aOR) = 2.52, 95%CI = 1.58, 4.02, aOR = 2.84, 95%CI = 1.59, 5.06, and aOR = 3.64, 95%CI = 1.43, 9.30, respectively), after adjusting for gender, birth size and maternal age[77]. In addition, neonates who were not breastfed within the first day of life had higher odds of mortality by infection (OR = 2.61, 95%CI = 1.68, 4.04), when compared to those breastfed within the first 24 hours[77]. However, there was no association with non-infection-specific mortality[77].

The health benefits of exclusive breastfeeding are numerous and widely accepted in the scientific community. Exclusive breastfeeding (EBF) from birth to six months is protective against mortality from diarrhea, compared to infants who are not being breastfed (RR = 10.5, 95% CI = 2.79, 39.6) or partially breastfed (RR = 4.62, 95% CI = 1.81, 11.76)[78]. At 12 months, infants who received EBF from birth to six months had lower odds of gastrointestinal infections when compared to EBF from birth to three months (OR = 0.61, 95% CI = 0.41, 0.93)[79]. Further, EBF from birth to six months also promotes better motor development. Infants who were exclusively breastfed for six months crawled about one month sooner and were more likely to be walking by 12 months than infants EBF up to four months[80].

The long-term benefits of breastfeeding are many and important. In a meta-analysis of 49 studies, Horta and Victora reported that children younger than five years of age who were breastfed were less likely to have diarrhea, to be hospitalized due to diarrhea, or die from diarrhea, with consistent higher protective effect from younger infants (less than six months)[81]. Regarding upper-respiratory infections, breastfeeding reduced the risk of hospitalization, mortality, and morbidity[81]. By protecting a child against infections, EBF indirectly protects the child against undernutrition, particularly in lower-income settings when in which sanitation may be unsatisfactory.

Kramer et al.[79] studied children who started receiving complementary feeding at three months (but were exclusively breastfed up to then). These children had increased weight and length gain from three to six months, compared to children who were still being EBF (difference: 28g/month and 1.1mm/month, respectively). However, from nine to 12 months, those who received solid foods at three months had reduced gain in length (-0.9mm/month) compared to EBF for six months[79]. The WHO recommends solid foods to be introduced along with breast milk from six to 23 months[75]. It is important to maintain adequate nutrition during this phase and promote optimal growth and development, since growth faltering is most evident during the ages six to 12 months and, after 24 months, recovery from growth faltering is difficult to achieve[75].

Despite WHO and UNICEF recommendations of continued breastfeeding up to 24 months, evidence for the benefits of breastfeeding after 12 months are still scarce in the literature[82]. One such study reported that appetite for complementary foods decreases in sick children (with reduction in 20-30% calories/day), but breast milk was still accepted and consumed in the same frequency and suckling time, promoting recovery from illness[83]. Although this study included only infants up to 12 months of age, it is possible that similar results could be found in older children as well.

Nonetheless, because of these benefits interventions to prevent undernutrition and improve a population health focus on improving a child's health by improving IYCF practices. Even though these programs target lower-income communities, there is little knowledge on how IYCF practices differ between low-income families living below or above the poverty line.

2.5 Nutrition education and IYCF

Adequate nutrition from birth to adulthood promotes a healthier life. However, as discussed previously, undernutrition during early life (fetal and early childhood) has adverse consequences that could last through adulthood. Victora and colleagues analyzed data from 54 countries and reported that growth faltering starts at a young age[84]. Based on these data, weight-for-age and weight-for-height *z* score began to decline at three months of age until 15 to 18 months, when both showed catch-up growth. However, growth faltering for HAZ started at four months of age and continued to decline until 24 months[84]. Thus, special attention should be given to the first 1000 days, from gestation to 24 months, when faltering is being established. The first 1,000 days provide a unique window of opportunity for improving intrauterine and infant growth. Interventions focusing on this period are more likely to be successful in preventing or reversing undernutrition and growth faltering. Using data from 228 children who were treated for undernutrition in Brazil, Fernandes and colleagues found that children who began treatment before the age of 24 months were 51% less likely to recover from undernutrition than those who initiated the treatment before 12 months[39]. These two reports emphasize that (1) growth faltering starts at young age and (2) late interventions are not as successful in recovering from growth faltering.

To prevent childhood undernutrition, large population-based initiatives should be implemented using comprehensive programs. Analyzing results from 34 studies, Britton and colleagues proposed that women who received any type of support (professional or social) were more likely to exclusively breastfeed for up to five months[85]. Also, programs relying on face-to-face guidance were more effective than those relying on contact by telephone. Similar results were found in a meta-analysis of 52 studies in where mothers who received any type of support for breastfeeding were less likely to stop EBF and partial breastfeeding before six months[86]. In a study conducted in Spain, a maternal education program on breastfeeding promotion increased the odds of initiating breastfeeding within the first hour of life in 56%[87]. Similarly, mothers who received counseling about exclusive breastfeeding and adequate infant feeding from birth to 12 months of the child were also more likely exclusively breastfeed up to 6 months compared to mothers who did not receive counseling (RR = 2.34, 95% CI = 1.37, 3.99)[15]. Finally, in a randomized trial conducted with 540 African-American and Latino women, those who received the intervention (focusing on tips on breastfeeding, how to manage pain, and providing social support) were less likely to stop breastfeeding before 6 months[88].

While supplemental programs are effective in improving maternal nutrition during pregnancy and children's nutritional status, educational programs might be more advantageous in the broader scale since they might cost less and mothers retain the knowledge and use it for other pregnancies and/or provide social support. Nonetheless, there is currently no scientific evidence of this possible advantage. Even though there is evidence that nutrition education programs improve IYCF practices across different populations, there is no evidence that such programs are efficacious, when they reach individuals living below the poverty line. More important, nutrition education programs in developing countries, such as Brazil, have focused on reducing the burden of undernutrition, but little attention has been given to the rise of childhood overweight and obesity.

2.6 The dual burden of undernutrition and overweight

Developing countries, such as Brazil, have been experiencing nutrition transition, facing challenges related to undernutrition, as well as overnutrition, such as adult and childhood obesity. The nutrition transition is a collective change in industrialization and modernization that lead to changes in physical activity and dietary patterns. Individuals in developing nations are transitioning from traditional diets, rich in fiber and vegetables, to the "Western diet", high in ultra-processed foods, saturated fat, and refined sugar and low in dietary fiber. The nutrition transition is also associated with higher food availability (and receding of hunger) and an increased prevalence of obesity[89], defined as “abnormal or excessive fat accumulation that may impair health”[2].

During the nutrition transition, interventions have focused on reducing the burden of undernutrition, programs that might not address or even worsen overnutrition problems. Indeed, the prevalence of stunting among Brazilian children younger than 5 years decreased from 13.4% in 1996 to 6.7% in 2006[90], while the prevalence of excess weight (overweight or obesity) remained stable at 7.3%[90]. Worldwide, the prevalence of overweight among children under the age of five increased from 4.8% in 1990 to 6.1% in 2014, currently affecting 41 million children, 15.5 million of those, living in developing countries[5]. With the exception of overweight, poorer children have worse nutritional and health outcomes compared to better-off children[91].

In summary, the immediate cause of stunting is chronic undernutrition due to inadequate food intake and diseases[92], although the underlying causes include social determinants such as poverty, poor access to clean water and sanitation, poor parental education and maternal depression[93]. Improvements in the nutritional status of Brazilian children have been partially attributed to increases in *per capita* income and female education[94]. Still, the association between poverty and obesity is still unclear, varying with countries economic development. For example, lower SES is protective against obesity in low-income countries, but is a risk factor for obesity in upper-middle income countries[95], while others found no association between income and childhood obesity[96]. Nevertheless, most studies include data with a broad age, socioeconomic status (SES) or income range[8,91,95,97,98], and little is known about the association between poverty level and the nutritional status of children from a low-income environment.

CHAPTER 3

Rationale

3.1 Statement of the Problem

Developing countries, such as Brazil, are undergoing the nutrition transition where the prevalence of hunger and undernutrition is decreasing and the prevalence of overweight and obesity are increasing[94]. Food scarcity and caloric excesses coexist in the population as well as at the community, household or individual level. While undernutrition is generally a problem of the poor, the relationship between obesity and income seems to be influenced by the economic development of the country. In high-income countries, such as the US and Germany, individuals from lower socioeconomic status have higher risk of being overweight or obese[99,100], while in low-income countries, obesity is more prevalent among people from higher socioeconomic status[101]. In middle-income countries, this relationship can go either way: in richer middle-income nations the relationship income-obesity is similar to the high-income nations, while in poorer-middle income countries, it reflects low-income countries relationship[95,102]. Associations between income and obesity in developing countries, however, still focus more in obesity among adults or adolescent, and relationship between income and childhood obesity in developing countries is still conflicting. Further, studies examining the relationship between extreme poverty and malnutrition (undernutrition and overweight) in low-income children from developing countries are scarce. It is important to improve our understanding as to how nutritional status changes with growth and development, relative to poverty level and past health. Therefore, the focus of this research project is to determinant specific determinants of nutritional status in children born in low-income communities in the south of Brazil.

3.2 Significance of the Research

Children from lower socioeconomic status have a higher risk of poor health and studies tend to focus on the association between income and nutritional status of children. In general, research on income and nutrition do not differentiate between poor and families living in extreme poverty. Thus, there is a great need to better understand how living under extreme poverty affects the nutritional status of children. The public health importance of such work will allow for identification of the most vulnerable individuals, thereby improving targeting of nutrition programs. Thus, this focus of this project is to characterize factors influencing the health of children from low-socioeconomic status in transitioning countries, such as Brazil.

3.3 Objectives and Specific Aims of the Research

The objective of this dissertation is to determine how social and parental characteristics influence nutritional status of children relative to poverty accordingly to the conceptual framework in Figure 3.1. The main hypothesis of this project is that children living under extreme poverty will have lower height-for-age *z* score (HAZ) and higher body mass index-for-age *z* score (BMIz) compared to those living above the poverty line, from 1 to 7 years of age, as well as poor overall health. This objective will be achieved through the following aims:

1. To determine how living above or below the poverty line influences growth and weight outcomes of children at three time points: infancy (1y), preschool age (4y), and mid-childhood (7y).

2. To determine how social factors influence the nutritional status of children at the three time points: infancy (1y), preschool age (4y), and mid-childhood (7y).
3. To determine infant feeding styles (exclusive breastfeeding, breastfeeding duration and early introduction of food) during the first year of life of low-income infants.
4. To determine the nutritional status and health outcomes at 1y of extremely poor and better-off infants who participate in the intervention during the first year of life.

This study will test the following hypotheses:

1. Extremely poor children have lower growth and weight outcomes at infancy, preschool age and mid-childhood compared to better-off children.
2. The association between the nutritional status of children and income will be influenced by other social determinants.
3. Extremely poor infants have worse infant feeding styles compared to better-off infants.
4. After participating in a nutrition education intervention about infant feeding practices, infants from extremely poor and better-off mothers have similar feeding, growth and health outcomes.

3.4 Importance of the Research

The results of this study will allow for the improved understanding of factors that influence growth and weight status of low-income children. There is great potential to expand this work with additional data collection of those participants, currently 13 to 14 years of age. Data derived from the current study will provide findings for the development of a grant proposal to be submitted to the National Counsel of Technological and Scientific Development (CNPq) in Brazil to further investigate the long-term associations between relative poverty and socioeconomic conditions and health and nutrition of children, including cognitive and psychosocial aspects. Moreover, this work has potential to better guide the development of intervention tools to promote infant care practices to alleviate childhood malnutrition, and, therefore, to influence major changes in current public health programs, which mostly target stunting and undernutrition independently of overweight and obesity status.

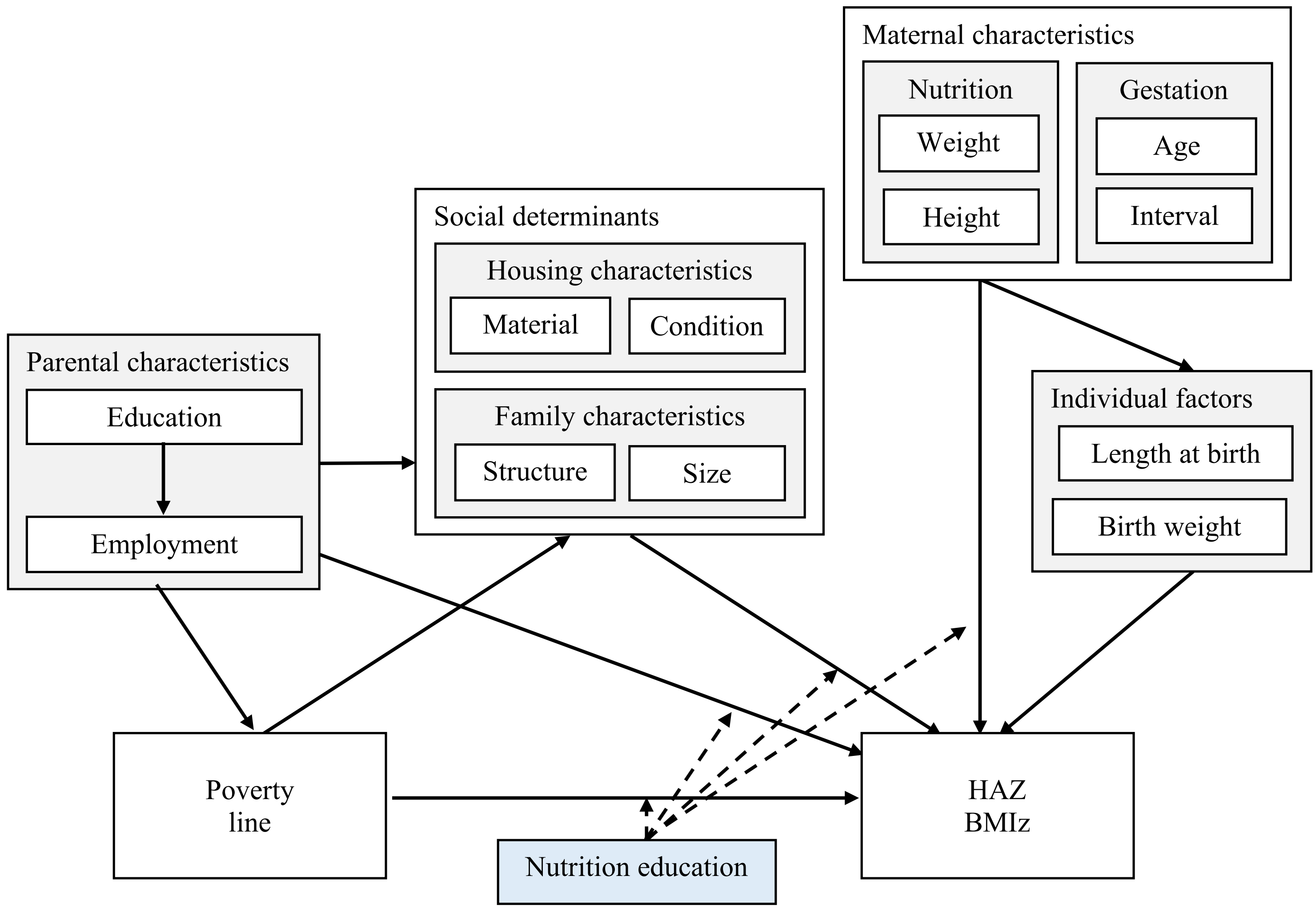

Figure 3.1 – Framework of main objective

CHAPTER 4

Poorer children have lower BMIz at 4y and lower HAZ at 7y

4.1 Abstract

Childhood stunting and overweight are public health problems in Brazil, where prevalence of overweight and stunting are similar, at 7% for children under the age of five. While the association between stunting and poverty is more stablished, the relationship between childhood overweight and family poverty status is not well stablished in developing countries. The aim of this study was to compare prevalence of mild stunting (L/HAZ < -1 SD) and overweight (BMIz > 2 SD for children <5y and >1 SD for children >5y) between low-income children living above or below the poverty line at three growth periods. Participants were followed since birth, and follow-up waves were conducted when children were 6 months-, 12 months-, 4 years- and 7 years-old (n=112 with complete follow-up waves). Stunting affected 22, 13 and 9% of children at ages 1, 4 and 7y. Overweight affected 10, 7 and 28% of children at ages 1, 4, and 7y. Children living below the poverty line were shorter (HAZ = -.38 ± 1.02 v. .61 ± 1.21, $p < .05$), grew less from 4 to 7y (height increments = 22.2 ± 4.87 cm v. 24.2 ± 4.83, $p < .05$) and had higher prevalence of stunting (33.3% v. 4.3%, $p < .05$) at age 7 compared to children living above the poverty line. Income was not associated with linear growth outcomes. On the other hand, prevalence of overweight did not differ between groups at any age, but increments of USD100/person in annual family income was associated with higher BMIz at 4y (b = .048, 95%CI = .001, .095). Thus, among low-income Brazilian children, children living below the poverty line have worse linear growth outcomes at 7y, while income is positively associated with BMIz at 4y.

4.2 Introduction

Undernutrition during childhood is a serious public health concern given that it increases the risk of death due to a variety of causes, including common diseases from which healthier children could recover, such as acute respiratory infections and diarrhea[103]. When episodes of undernutrition are frequent or chronic during periods of growth, the development of bones and other structural components is impaired, leading to poor linear growth and stunting (HAZ below -2 SD)[3]. In 2014, approximately 159 million children under the age of five were stunted[5]. Undernutrition has severe consequences through childhood, adolescence and adulthood, such as increased risk of morbidity and mortality[28], delayed school entry[68], lower academic performance[69,70], and increased risk of chronic diseases[105-108]. Although the immediate causes of stunting are chronic undernutrition due to inadequate food intake and diseases[92], underlying causes of undernutrition include social determinants such as poverty, poor access to clean water and sanitation, poor parental education and maternal depression[93].

Since the 1990s, Brazil has been in a nutrition transition, facing challenges related to undernutrition as well as challenges related to overnutrition, such as adult and childhood obesity. During the nutrition transition, interventions have focused on reducing the burden of undernutrition, programs that might not address or even worsen overnutrition problems. The prevalence of stunting among children younger than 5 years decreased from 13.4% in 1996 to 6.7% in 2006[90]. In the same period, the prevalence of excess weight (overweight or obesity) remained stable at 7.3% [83]. Twenty-three percent of children under the age of five years among the richest 20% in the world are stunted, while 51% of children in the poorest 20% are stunted[104]. With the exception of overweight, poorer children have worse nutritional and health outcomes compared to better-off children[91]. Conde and Monteiro attributed the improvements in nutritional status of Brazilian children in part to the increase of per capita income and female education[94].

From 1990 to 2014, prevalence of overweight among children under the age of five increased from 4.8 to 6.1% and affected 41 million children in 2014, 15.5 million in developing countries only[5]. The association between poverty and obesity is still conflicting, varying with countries economic development. Lower SES is protective against obesity in low-income countries, but it is a risk factor for obesity risk in upper-middle income countries[95], while others found no association between income and childhood obesity[96]. However, most data include data with a broad age, socioeconomic status (SES) or income range[8,91,95,97,98], and little is know about the association between poverty level and the nutritional status of children from a low-income environment.

To address these issues, the objective of this study was to investigate whether children living in extreme poverty at three growth phases (infancy, pre-school age and mid-childhood) have different nutritional status from low-income children living above this threshold. We hypothesize that children living below the poverty line will have lower HAZ and higher BMIz at the three time-periods.

4.3 Methodology

Study population, inclusion criteria and study group

The study sample consisted of 300 low-income Brazilian mother-child pairs allocated in the control group of the study "Implementation and Evaluation of the Impact of the Program of Promoting Healthy Feeding for Children Younger than Two Years" (*Implementação e Avaliação do Impacto do Programa de Promoção para a Alimentação*

Saudável para Crianças Menores de Dois Anos), that is, only participants who did not receive the educational program. Details of the previous study can be found elsewhere[15]. Inclusion criteria included delivery in the maternity wards attended by the Brazilian public healthcare system (*Sistema Único de Saúde, SUS*) of the only maternity-hospital in the city of Sao Leopoldo, RS/Brazil, full-term (≥ 37 weeks) singleton and birth weight ≥ 2500g. Newborns who suffered from any impediment to breastfeeding, needed intensive care, had congenital malformation or were diagnosed with HIV/AIDS were excluded from the study. Although income was not inclusion criteria, delivery at the SUS wards of the hospital indicates a woman is from a lower socioeconomic class. The study protocol was approved by the Ethics Committee of the *Universidade Federal de Ciencias da Saude de Porto Alegre* and informed consent of the mother was obtained at study entry.

Data collection

Mother-newborn dyads were invited to participate in the study the day after giving birth. At this time, only contact information was collected. Mothers were then visited four times: when infants were 6-months, 12-months, 4-years and 7-years old. From the 300 mother-child pairs allocated to the control group of the original study, 161 (53.7%) completed the first follow-up (at 6 months), 224 (74.7%) completed the second follow-up (when infants were 12 months old), 199 (66.3%) completed the third follow-up (when children were 3 to 4 years old) and 178 (59.3%) completed the fourth follow-up (when children were 7 years old). Baseline data (birth weight, length at birth and gestational age) were collected from hospital records. Trained research assistants collected anthropometric and socioeconomic data during the follow-ups. Infants' length was measured using a portable infant stadiometer (Serwital Inc., Brazil) and weight was measured using a portable scale (Techline, Brazil), with the infants wearing no clothes and no shoes. Maternal pre-pregnancy weight was self-reported, but maternal height and weight were measured at the 6-months follow-up. Height and weight of the children and mothers were assessed using portable digital scale (Techline, Brazil) and statiometer (SECA, Germany), when the subject wearing light clothing and no shoes. Length and height were measured to the nearest 1cm and weight was measured to the nearest 100g.

Relative poverty was set as the global poverty line, defined as US$1/day *per capita* for infants and US$1.25/day *per capita* when children were 4 years old, according to the World Bank relative poverty line for that year[34]. Since nutritional outcomes result from chronic conditions, financial data collected in the previous follow-up was used (for infants, income at 6 months; for children at 4 years, income at 12 months; and, for children at 7 years, income at 4 years).

Study outcomes

Nutritional status of infants was determined using the WHO growth standards[3]. Outcomes of interest were length- or height-for-age (L/HAZ) and body mass index-for-age *z* score (BMIz). L/HAZ below -1, -2 and -3 SD were used as thresholds for mild, moderate and severe stunting, respectively, and stunting was defined as L/HAZ < -1 SD for all ages, to include the entire spectrum of stunting. Overweight was defined as BMIz above 2 SD for children younger than five, and 1 SD for children older than five[3,4]. Linear growth was calculated as height/length differences from 0 to 1, 1 to 4 and 4 to 7 years.

Statistical analyses

Descriptive statistics of the sample are presented as mean and standard deviation (SD) or frequency for continuous or categorical variables, respectively. Outcomes (L/HAZ, BMIz, stunting, overweight and linear growth) mean and proportion differences between the two poverty status were assessed by student's *t* test (for continuous variables) or chi-squared test (for categorical variables). Spearman's rank-order correlation and linear regression were used to determine the association between annual *per capita* income and nutritional status of children at the different ages. Normality was defined by Kolmogorov-Smirnov test. Statistical significance was determined at the $p < 0.05$ level. All analyses were conducted in SPSS for Mac, version 23[109].

4.4 Results

General characteristics of the study sample are summarized in Tables 4.1 and 4.2. Final sample included 112 (37.3%) participants with complete data for all four follow-ups (at six months, and 1, 4 and 7 years of the child), and 26.8, 32.1 and 16.1% lived below the poverty line at the 6-months, 12-months and 4-years interviews, respectively. Almost 60% of participants were boys (n=67), less than 5% had moderate/severe stunting at 12 months (LAZ < -2 SD) and moderate/severe stunting was not found in older children. Prevalence of overweight when participants were 1 year-old was 10%, decreased to 7% at preschool age and increased back to 28% when children were 7 years-old. About 8% of families lived below the poverty line at all times and about 63% lived above this threshold at all times. Infants and children living above or below the poverty line did not differ in baseline characteristics, except for parental schooling (Table 4.2).

Nutritional status did not differ between infants (12 months old) who lived above or below the poverty line (Table 4.3). Differences in nutritional status between preschoolers living above or below the poverty line were not statistically significant. However, children who lived below the poverty line at age 4 had HAZ 1 SD lower (below

PL – above PL = -0.99 SD, p = .001), grew ~2cm less from 4 to 7 years (below PL – above PL = -1.95cm, p = .041) and were more likely have mild stunting (RR = 5.10, 95%CI = 2.45, 10.62) (Table 4.3). Income was not correlated with nutritional status when children were 1 and 7 years old (data not shown), but there was a weak positive correlation with HAZ at 4 years (p = .011, rho = .238). Income was not associated with BMIz at any age group (data not shown). In linear regression analyses, increments in annual family income of $100.00/person was associated with a 0.05 increase in BMIz at 4 years (p = .045). Annual income per capita was not associated with L/HAZ, linear growth and BMIz for the other time-points.

4.5 Discussion

According to UNICEF, stunting and overweight affect 159 and 41 million children under the age of five, respectively[5], and both problems are commonly associated with poverty[8,95,104]. Studies have shown an inverse association between income and risk of stunting[38,110]. The aim of this study was to compare the nutritional status of low-income children living below or above the poverty line. There were no differences in the nutritional status between children who lived above or below the poverty line during infancy. However, children who lived below the poverty line at 4 years grew less, were shorter and had higher risk of being stunted compared to the better-off children. Although BMIz of children living above or below the poverty line did not differ at any age, BMIz at 4 years was positively associated with family annual income.

Mild stunting (HAZ < -1 SD) is seldom reported in national data and if it were to be included in worldwide estimates, the number of stunted children would be 314 million children[40,41]. In agreement with such estimates, less than 2% of our sample had LAZ below

-2 SD at 12 months while 22.3% had LAZ below -1 SD. Moderate or severe stunting was not found when children were older. Prevalence of mild stunting decreased with age, consistent with other studies that found stunting to be more prevalent in younger children[42,111].

Previous studies have reported an association between linear growth and income. However, many studies include samples from different social strata. In our study, the nutritional status of children during infancy and preschool age was similar for those who lived above or below the poverty line. While poorer families may have less financial resources to buy healthy foods in adequate quantity to their children, it is possible that families in our sample had similar limited access to food, despite some being poorer. For low-income families, food acquisition is not solely dependent on buying food as it can be acquired from government programs, school lunch programs, assistance from friends and relatives, home-grown, or donations[112-114]. In Brazil, many low-income women work as cleaning ladies in upper- or middle-upper class homes and it is a common behavior from the employer to provide food and/or clothing, in addition to the salary[115]. Thus, although families could earn less and be classified as living below the poverty line, some could have important financial assistance and have more access to food than families living above the poverty line without such outside support. This might have led to the similar HAZ and BMIz of children during infancy and preschool age.

Growth faltering starts immediately after birth, often due to intrauterine growth restriction[84,116], but it is possible that milder growth retardation takes longer to become apparent and might be very small, making it difficult for parents and health care practitioners to identify children who are slowing but steadily showing signs of growth retardation from those who are short but healthy children (the healthy children from the reference populations of the growth charts). In our study, when children were 7 years old, those who lived below the poverty line had lower HAZ and grew less from 4 to 7 years, and those living above the poverty line had lower risk of stunting. Aid programs traditionally target children younger than five years and it is possible that participants could have received aid when the children were younger and, at 7 years, were less likely to receive help of friends and family, which could have results in the higher risk of stunting for poorer children. An alternative or additional hypothesis could be the birth of a younger sibling, which could cause the mothers to give more attention to the younger child and/or to prioritize the younger child diet. However, literature on intra-familial food distribution specifically among children is scarce. Taken together, these results suggest that the disadvantages of living under extreme poverty might start after weaning, but the gap between poorest and the slightly better-off children became statistically significant only later in childhood.

The opposite association between income and risk of childhood obesity in developing and developed countries has been previously reported: in developing countries, children from higher socioeconomic status have higher risk of obesity while in developed countries, children from lower socioeconomic status have increased risk of obesity[95,117]. In our study, income was positively associated with BMIz at 4y. Our findings agree with other studies[97,118,119]. Even among low-income families, those lightly better-off might have higher purchasing power and, thus, might be more likely to buy industrialized and empty-calorie food items[97,118]. The lack of association between poverty and overweight during infancy and mid-childhood was not surprising. Previous studies have reported the incidence of picky eaters is highest during early infancy, very low at age 6, and in most cases, lasts about 2 years[120]. It is possible that prevalence of picky eaters in our study was highest during preschool age and declined during mid-childhood. With that, higher-income mothers in our study could have been more likely to offer industrialized and energy-dense food to their picky eaters at age 4, in order to feed them with their preferred snacks, resulting in overweight at that age. However, we have no data about the prevalence of picky eaters in our sample. Also, further studies need to be conducted to assess how income influences the diet of picky eaters.

This study had limitations that need to be discussed. First, low-birth-weight (LBW) and premature newborns were not included in the study, reducing the sample size and limiting the association between income and the nutritional status of children beginning even before conception. However, premature and LBW babies might have different growth patterns due to possible intra-uterine growth restriction (LBW) and incomplete fetal development (premature births), which could have had shifted the results of our study. Second, our study had a relatively small sample. Yet, availability of data from the same cohort at three different time-points mitigates this limitation. Strengths of this study are the fact that all participants were from low-income families (maximum household income less than $9,000/year) and data used in the analyses are from the same group of children.

In conclusion, children living under extreme poverty were shorter and had lower HAZ at age 7. There were no differences in BMIz and prevalence of overweight between the children living above or below the poverty line at any age. However, income was positively associated with BMIz at age 4. Thus, although poverty is commonly associated with stunting in developing countries, in Brazil, we found that prevalence of overweight was higher than prevalence of stunting among low-income children, and aid programs and interventions should address this growing double-burden problem.

Table 4.1 – General characteristics of study population

Variable	**n (%)**	**Mean (SD)**	**Median**	**Range**
Boys	67 (59.8)	-	-	-
Birth weight (g)	-	3384 (466.1)	3335	2500 – 4840
Length at birth (cm)	-	48.9 (2.18)	49.0	45.0 – 55.0
Gestational age (w)	-	39.4 (1.24)	40.0	37 – 42
Maternal age (y)	-	26.2 (6.75)	26.0	16 – 45
Maternal height (cm)	-	158.8 (6.43)	159.1	140.8 – 174.0
Pre-gestational BMI overweight/obese	41 (37.6)	-	-	-
Maternal schooling (y)		7.13 (2.71)	7.00	1 - 11
1-4 y	18 (16.1)	-	-	-
5-8 y	59 (52.7)	-	-	-
9-11 y	35 (31.3)	-	-	-
Paternal schooling (y)		7.56 (2.68)	7.00	2 – 11
1-4 y	15 (14.3)	-	-	-
5-8 y	50 (47.6)	-	-	-
9-11 y	40 (38.1)	-	-	-
Age at the 12m follow-up (m)	-	12.1 (0.909)	12.00	11 - 15
Age at the 4 years follow-up (y)	-	3.50 (0.50)	3.50	3 – 4
Age at the 7 years follow-up (y)	-	7.25 (0.43)	7.00	7 – 8
LAZ at 1y	-	-0.10 (1.10)	-.26	-2.94 – 2.13
LAZ ≤ -2 SD	2 (1.8)	-	-	-
LAZ ≤ -1 SD	25 (22.3)	-	-	-
HAZ at 4y	-	0.20 (1.03)	.18	-1.93 – 2.85
HAZ ≤ -1 SD	15 (13.4)	-	-	-
HAZ at 7y	-	0.45 (1.23)	.34	-1.90 – 4.30
HAZ ≤ -1 SD	10 (8.9)	-	-	-

Table 4.1 – General characteristics of study population (cont.)

Variable	n (%)	Mean (SD)	Median	Range
BMIz at 1y	-	0.54 (1.08)	.61	-2.26 – 3.35
BMIz > 2 SD	11 (9.8)	-	-	-
BMIz at 4y	-	0.33 (1.10)	.28	-2.04 – 4.15
BMIz > 2 SD	8 (7.1)	-	-	-
BMIz at 7y	-	0.32 (1.36)	.19	-3.58 – 3.77
BMIz > 1 SD	31 (27.7)	-	-	-
Baseline yearly income (US$)	-	2769 (1819)	2101	698.8 – 8468
Baseline yearly income *per capita* (US$)	-	639.0 (445.4)	527.8	127.1 – 2823
Income *per capita* ≤US$1/day at 6m (≤PL)	30 (26.8)	-	-	-
Income *per capita* ≤US$1/day at 1y (≤PL)	36 (32.1)	-	-	-
Income *per capita* ≤US$1.25/day at 4y (≤PL)	18 (16.1)	-	-	-
≤PL at all times	9 (8.1)	-	-	-
≤Pl during infancy (0-12m)	17 (15.3)	-	-	-
>PL at all times	71 (63.4)	-	-	-

Table 4.2 – Characteristics of the sample according to poverty status.

Follow-up wave	6 months		12 months		4 years	
Variable	≤ PL (n=30)	> PL (n=82)	≤ PL (n=36)	> PL (n=76)	≤ PL (n=18)	> PL (n=94)
Boys[a]	21 (70%)	46 (56.1)	24 (66.7)	43 (56.6)	11 (61.1)	56 (59.6)
Birth weight (g)[b]	3449 ± 476.4	3360 ± 462.9	3451 ± 502.1	3352 ± 447.9	3349 ± 451.0	3371 ± 470.2
Length at birth (cm)[c]	49.2 ± 2.12	48.8 ± 2.20	49.2 ± 2.29	48.8 ± 2.13	49.2 ± 2.55	48.9 ± 2.11
Maternal age (y)[c]	26.1 ± 7.18	26.2 ± 6.63	27.3 ± 7.89	25.7 ± 6.12	29.7 ± 6.92*	25.5 ± 6.54
Maternal height (Q)[a]						
1st quartile (≤154cm)	9 (30.0)	21 (25.6)	10 (27.8)	20 (26.3)	5 (27.8)	25 (26.6)
4th quartile (>163cm)	5 (16.7)	24 (29.3)	7 (19.4)	22 (28.9)	3 (16.7)	26 (27.7)
Pre-gestational overweight/obese[a]	12 (40.0)	29 (36.7)	15 (42.9)	26 (35.1)	6 (35.3)	35 (38.0)
Weight gain during gestation (kg)[b]	13.0 ± 5.43	13.2 ± 6.12	14.0 ± 6.05	12.8 ± 5.85	13.5 ± 4.94	13.1 ± 6.10
Maternal schooling[a]						
Less than middle school	23 (76.7)**	36 (43.9)	26 (72.2)**	33 (43.4)	13 (72.2)	46 (48.9)
Paternal schooling[a]						
Less than middle school	20 (66.7)*	35 (42.7)	22 (61.1)	33 (43.4)	13 (72.2)*	42 (44.7)

Different from >PL: * $p < .05$ ** $p < .001$ [a] n(%), analyses performed in Chi-squared.
[b] mean±SD, analyses performed in *t* test. [c] mean±SD, analyses performed in Mann-Whitney test

Table 4.3 – Means and proportions of nutritional status indicators by poverty line

Nutritional status	Infants – 1 year			Preschooler – 4 years			Children – 7 years		
	<PL (n=30)	**>PL (n=82)**	**p**	**<PL (n=36)**	**>PL (n=76)**	**p**	**< PL (n=18)**	**> PL (n=94)**	**p**
Infants									
LAZ 1y[a]	-.17 (.949)	-.07 (1.16)	.696						
BMIz 1y[a]	.51 (1.23)	.55 (1.03)	.867						
Length increment 0-1y (cm)[a]	26.4 (2.19)	26.5 (2.92)	.810						
LAZ < -1 SD[b]	3 (10.0)	22 (26.8)	.058						
BMIz > 2 SD[b]	4 (13.3)	7 (8.5)	.481						
Preschoolers									
HAZ 4y[a]				-.06 (1.10)	.32 (.986)	.071			
BMIz 4y[a]				.31 (.977)	.34 (1.16)	.891			
Height increment 1-4y (cm)[a]				35.8 (3.36)	36.9 (4.30)	.180			
HAZ < -1 SD[b]				7 (19.4)	8 (10.5)	.238			
BMIz > 2 SD[b]				3 (8.3)	5 (6.6)	.710			
Children 7 y									
HAZ 7y[a]							-.38 (1.02)	.61 (1.21)	.001
BMIz 7y[a]							.06 (1.48)	.37 (1.34)	.372
Height increment 4-7y (cm)[c]							22.2 (4.87)	24.2 (4.83)	.041
HAZ < -1 SD[b]							6 (33.3)	4 (4.3)	.001
BMIz > 1 SD[b]							4 (22.2)	27 (28.7)	.775

[a] Analyses performed by student's *t* test. [b] Analyses performed by chi-squared test.
[c] Analyses performed by Mann-Whitney test.

CHAPTER 5

Paternal education and early nutritional status are associated with stunting and overweight in low-income 4 and 7 years old children

5.1 Abstract

Stunting and overweight affect 159 and 41 million children under the age of five worldwide. Both nutrition conditions are currently affecting developing countries and can be found in low-income communities. Identifying social determinants associated with nutritional status of children has becoming increasingly important in an attempt to identify the most vulnerable populations and target those individuals to alleviate or even prevent undesirable nutritional outcomes. The objective of this study was to identify social determinants of stunting, overweight, catch-up growth and linear growth in a cohort of low-income Brazilian children followed since birth, using a hierarchical approach. Stunting affected 26, 13 and 9% of participants at 1, 4 and 7y, and overweight affected 18, 13 and 18% of children, respectively. Living in extended families was associated with linear growth from birth to 12 months 2.5cm. Maternal height and paternal education were protectors against stunting at all times. LAZ at 1y was protective of stunting at 4 and 7y. BMIz at 1y was positively associated with childhood overweight. In conclusion, paternal education is a protector against stunting and nutritional status during infancy is a significant predictor of nutritional status later in childhood. Further, nutritional status during infancy is a strong predictor of nutritional status later in childhood, for both stunting and overweight, and thus, interventions to prevent malnutrition should indeed start in early infancy.

5.2 Introduction

From 1990 to 2014, prevalence of stunting (height-for-age *z* score below minus 2 standard deviations)[29] decreased from 255 to 159 million children[5]. Since the 1990s, nutrition programs in developing nations targeted reducing the burden of undernutrition, with several programs focusing on food supplementation and nutrition education, for instance. While the prevalence of undernutrition is decreasing worldwide, the nutritional problem shifted to the increasing rates of obesity, even among children and in developing nations. During the same period, overweight among children under the age of five increased from 4.8 to 6.1%, affecting 41 million children in 2014, 40% of those in developing countries alone[5]. It is generally accepted that poorest children have worse health and nutritional outcomes[91]. However, the association between SES and childhood obesity is controversial[97,121]. Further, associations between the nutritional status of children and social determinants such as household and family characteristics are not often explored and there is no consistency among the factors between the different studies, leading to conflicting results. Therefore, the aim of this study is to investigate the association between social determinant and the nutritional status of poor children living above or below the poverty line.

The World Bank estimated that 702 million people in the world were living in poverty in 2012, mostly in developing countries, defined as *per capita* income less than $1.90/day[35]. The relationship between familial income and the nutritional status of children is complex because income is not the only social aspect that influences health of children. Factors such maternal nutritional status, maternal health knowledge, access to safe drinking water and sanitation, for instance, are associated with the mortality of children under five years[121]. Despite the fact that the poverty line identifies the most vulnerable individuals, there is scarce literature on the association between living under extreme poverty (the most economically vulnerable group) and health and nutrition of children (the most vulnerable age group) in developing countries (the most vulnerable nations).

The prevalence of stunting is higher among the poorest children[122]. Other income-related variables also influence the nutritional status and overall health of children, such as maternal factors (maternal education, age, nutritional status, parity, etc.) and housing factors (housing conditions, material, access to toilet, etc.)[43]. For instance, recurrent diarrhea and intestinal infections, associated with water and hygiene conditions, can increase nutritional requirements of children and decrease appetite and nutrient absorption, increasing the odds of stunting[122]. Further, shorter women are more likely to give birth to smaller babies, which are more likely to be stunted later in childhood[123]. Nonetheless, while income is an important predictor of stunting, other social factors also play important roles in shaping health and growth of a child.

The relationship between SES and childhood obesity is still unclear and seems to differ according to the nations socioeconomic development. In Brazil, the co-existence of undernutrition and obesity is more prevalent among adults in the poorest sectors, where adults are shorter (indicative of chronic undernutrition during childhood) and are becoming obese[94]. However, national data shows the prevalence of overweight is lower among children from poorer regions in Brazil[124]. Regional studies have conflicting results, with some finding higher prevalence of overweight among children from lower SES[97,125] while others found no association[126,127]. Thus, the objective of this study is to identify social determinants of growth and nutritional status of children at three different age groups (infancy, preschool age and mid-childhood) using a hierarchical approach, adjusting for income and social characteristics.

5.3 Methodology

Study population, inclusion criteria and study group

The study sample consisted of 300 low-income Brazilian mother-child pairs allocated in the control group of the study "Implementation and Evaluation of the Impact of the Program of Promoting Healthy Feeding for Children Younger than Two Years" (*Implementação e Avaliação do Impacto do Programa de Promoção para a Alimentação Saudável para Crianças Menores de Dois Anos*), that is, only participants who did not receive the educational program. Details of the previous study can be found elsewhere[15]. Inclusion criteria included delivery in the maternity wards attended by the Brazilian public healthcare system (*Sistema Único de Saúde, SUS*) of the only maternity-hospital in the city of Sao Leopoldo, RS/Brazil, full-term (≥ 37 weeks) singleton and birth weight ≥ 2500g. Newborns who suffered from any impediment to breastfeeding, needed intensive care, had congenital malformation or were diagnosed with HIV/AIDS were excluded from the study. Although income was not inclusion criteria, delivery at the SUS wards of the hospital indicates a woman is from a lower socioeconomic class. The study protocol was approved by the Ethics Committee of the *Universidade Federal de Ciencias da Saude de Porto Alegre* and informed consent of the mother was obtained at study entry.

Data collection

Mother-newborn dyads were invited to participate in the study the day after giving birth. At this time, only contact information was collected. Mothers were then visited four times: when infants were 6-months, 12-months, 4-years and 7-years old. From the 300 mother-child pairs allocated to the control group of the original study, 161 (53.7%) completed the first follow-up (at 6 months), 224 (74.7%) completed the second follow-up (when infants were 12 months old), 199 (66.3%) completed the third follow-up (when children were 3 to 4 years old) and 178 (59.3%) completed the fourth follow-up (when children were 7 years old). Baseline data (birth weight, length at birth and gestational age) were collected from hospital records. Trained research assistants collected anthropometric and socioeconomic data during the follow-ups. Infants' length was measured using a portable infant stadiometer (Serwital Inc., Brazil) and weight was measured using a portable scale (Techline, Brazil), with the infants wearing no clothes and no shoes. Maternal pre-pregnancy weight was self-reported, but maternal height and weight were measured at the 6-months follow-up. Height and weight of the children and mothers were assessed using portable digital scale (Techline, Brazil) and statiometer (SECA, Germany), when the subject wearing light clothing and no shoes. Length and height were measured to the nearest 1cm and weight was measured to the nearest 100g.

Relative poverty was set as the global poverty line, defined as US$1/day *per capita* for infants and US$1.25/day *per capita* when children were 4 years old, according to the World Bank relative poverty line for that year[34]. Since nutritional outcomes result from chronic conditions, financial data collected in the previous follow-up was used (for infants, income at 6 months; for children at 4 years, income at 12 months; and, for children at 7 years, income at 4 years).

Study outcomes

Nutritional status of infants was determined using the WHO growth standards[3]. Outcomes of interest were length- or height-for-age (L/HAZ) and body mass index-for-age *z* score (BMIz). L/HAZ below -1, -2 and -3 SD were used as thresholds for mild, moderate and severe stunting, respectively, and stunting was defined as L/HAZ < -1 SD for all ages, to include the entire spectrum of stunting. Overweight was defined as BMIz above 2 SD for children younger than five, and 1 SD for children older than five[3,4]. Linear growth was calculated as height/length differences from 0 to 1, 1 to 4 and 4 to 7 years. Catch-up growth was considered if L/HAZ change was above 0.67 SD between the age groups[128].

Hierarchical model

Social poverty was assessed using an adapted version of the framework proposed by Aerts and colleagues[66]. Social determinants were grouped into 5 blocks: (1) socioeconomic status: poverty line status (≤ or > poverty line) and parental schooling (in years) and employment status (employed vs. unemployed); (2) housing factors: housing material (brick v. else) and conditions (poor/unsatisfactory, fair, satisfactory); (3) family factors: family structure (nuclear v. extended), single mother, family size (≤ v. >4 people); (4) maternal factors: maternal age, height (cm), pre-gestational and 6-months post-partum overweight, birth order (only/oldest v. else), interval from previous birth and following birth (≤ 24 months v. > 24 months); and (5) individual factors: weight and length at birth, gender, LAZ and BMIz at 1 year. The housing conditions index was created so presence of adequate (safe) drinking water, toilet facility and sanitation were coded as 1 and if these factors were absent or inadequate, they were coded 0. Results were added and final score of 3 was classified as good/satisfactory, 2 was classified as fair, and 1 or 0 were classified as poor/unsatisfactory[66]. As for family structure, both parents and children formed nuclear families and any other configuration was considered "extended families" (single mothers were not included in this variable). Relative poverty was set as the global poverty line, defined as US$1/day *per capita* for infants and US$1.25/day *per capita* when children were 4 years old, according to the World Bank relative poverty line for the respective year[34].

Statistical analyses

Descriptive statistics of the sample are presented as mean and standard deviation (SD) or frequency for continuous or categorical variables, respectively, and normality was assessed using the Kolmogorov-Smirnov test. Linear and logistic regression analyses were used to determine the association between dependent variables (linear regression: linear growth; logistic regression: mild stunting (1=yes), overweight (1=yes) and catch-up growth (1=yes)) and independent variables. Independent variables included in the analyses are based on the hierarchical model explained above, based on the framework proposed by Aerts, Drachler and Giuglini[66] (Figure 5.1). Variables included in the model varied slightly according to the age of the child and outcome of interest. Regression analyses were conducted using the following 5 steps: (1) association between variables in the SES block and outcomes of interest were analyzed separately in bivariate analyses. Variables associated with the outcome were selected to be included in the following steps; (2) all variables in the housing and family block were added to the model simultaneously, adjusting for any significant variable from step (1). Significant variables from this block were selected to be included in the following steps; (3) all variables from the maternal block were included in the model, adjusting for all significant variables from the previous steps; (4) variables from the individual block were included in the model, adjusting for significant variables from the previous steps; (5) non-significant variables from the individual block were removed from the model. The final model included all significant variables from steps 1, 2, 3 and 4. Significance for inclusion in the models was set as p <

0.20 and was defined as the p value from when the variable was first included in the model (that is, within its respective block/step). Statistical significance was determined at the $p < 0.05$ level. All analyses were conducted in SPSS for Mac, version 23[109].

5.4 Results

General characteristics of the sample

The general characteristics of the study sample are summarized in Table 5.1. Our final sample included 112 children who had complete data from all four follow-up waves (6 months and 1, 4 and 7y), of which 26.8, 32.1 and 16.1% lived below the poverty line at 6 months, 12 months and 4 years, respectively. About 60% of participants were boys (n=67), and average age at the follow-up interview were 12 months (1y follow-up), 3.5y (4y follow-up) and 7.2y (7y follow-up). Only 2 participants had moderate/severe stunting at 12 months (LAZ < -2 SD) and moderate/severe stunting was not found in older children. About 10% of participants lived with single mothers, 27% lived in extended families, and 71% of homes had satisfactory sanitary conditions (Table 5.1).

Growth Outcomes

Catch-up during the first 12 months of life was observed in 18% of participants, while 34% of participants showed catch-up growth from 1 to 4 years. Catch-up growth from 4 to 7 years was observed in 19% of participants. Stunting affected 22.3%, 13.4% and 8.9% of participants at ages 1, 4 and 7 years (Table 5.1).

Social determinants of growth varied with age and outcome. Factors in the socioeconomic block were not associated with growth outcomes during infancy. During childhood, paternal education was associated with lower odds of stunting at 1y, 4y and 7y. Previous growth (length at birth and LAZ at 1y) and maternal height were consistently associated growth outcomes at the three periods. Maternal height was associated with lower odds of stunting at 1y (aOR = .881, 95%CI = .788, .984), 4y (aOR = .818, 95%CI = .675, .991) and 7y (aOR = .817, 95%CI = .662, 1.01) (Tables 5.2, 5.4 and 5.6, respectively). Length at birth was associated with lower odds of stunting at 1y, but was not associated with catch-up growth or linear growth at 12 months (Tables 5.2 and 5.3, respectively). LAZ at 1y was associated with lower odds of stunting at 4y and 7y (Tables 5.4 and 5.6, respectively), and lower odds of catch-up growth at 4y (Table 5.4). Paternal education was associated with lower odds of stunting at 1, 4 and 7y (aOR = .769, 95%CI = .595, .994; aOR = .581, 95%CI = .355, .951; and OR = .673, 95%CI = .490, .923, respectively), although the association lost significance in fully adjusted model at age 7 (Table 5.6).

Overweight outcomes

The prevalence of overweight was 9.5%, 7.1% and 27.7% of participants when they were 1, 4 and 7 years old, respectively. Factors in the socioeconomic block were not associated with overweight during infancy (1y) and childhood (7y). Paternal education reduced the odds of overweight at 4y, but association lost significance in the fully adjusted model (Table 5.8). Being the second or later child lowered the odds of overweight at 1y, and birth interval up to 24 months from the previous sibling and birth weight were associated with higher odds of overweight during infancy (Table 5.8). BMIz at 1y was the only significant predictor of overweight at ages 4 (aOR = 6.04, 95%CI = 1.18, 31.0) and 7 (aOR = 1.79, 95%CI = 1.13, 2.85). BMIz at 1y was the only significant predictor of overweight at 4y and 7y (Table 5.8).

5.5 Discussion

UNICEF estimates that 159 million children under the age of five (under-fives) are stunted[129], while overweight and obesity affect 41 million children[5]. Developing countries, such as Brazil, are undergoing a nutrition transition and experiencing the dual burden of undernutrition and overweight. The association between risk of stunting and SES has been reported in several studies. However, most reports include data from children ages 0-59 months, high- or middle- and low-income participants, and include limited social determinants, mostly maternal education and feeding styles[60,130,131]. The association between SES and childhood obesity is controversial[97,121]. In this study, we investigated whether social determinants would be better predictors of nutritional status of low-income children at different ages, using a hierarchical approach. Briefly, predictors of growth differ depending on the age group and outcome of interest. Maternal height and paternal education were associated with lower odds of stunting at the three time points (1, 4 and 7y). LAZ at 1y was associated with lower odds of stunting at 4 and 7y, while BMIz was associated with higher odds of overweight at 4 and 7y.

Our finding that the prevalence of stunting decreased with age differ with some reports[132,133], but are in agreement with findings for the Brazilian population[90,134]. Data from a nationally representative sample in Brazil found that prevalence of stunting almost doubles from the first to the second year of life, but decreases at older ages[90]. The decreasing trend in stunting indicates early nutritional recovery. Indeed, in the study of Fernandes et al.[39] the likelihood of nutritional recovery after 5 years of treatment was higher when treatment began when infants were 0 to 11 months of life compared to initiating the treatment with 2 year-old children. Further, catch-up growth was more prevalent from 12 to 48 months compared to the other age groups. Indeed, growth during infancy is driven mainly by nutrition[22], and thus, improvements on diet and health can lead to nutritional recovery, while growth during childhood and adolescence are driven mostly by hormones, even though nutrition also plays an important role.

The prevalence of stunting in our sample was higher than national estimates (4.9% among infants, 6.3% among 3 to 4 year-olds, and 7.2% for 7 year-olds[8,90]. Prevalence of overweight when children were 1 and 4 years old was higher in our sample than in Brazilian national data[90], while overweight at 7 years was slightly lower in our sample compared to the 34% reported for 7-years old Brazilian children[8]. As the harmful effects of undernutrition happen across the full undernutrition spectrum[41,42], differences in the prevalence of overweight and stunting may also be explained by the fact that national data include all strata of the population. Our results highlight that the gap between the poor and the rich goes beyond financial differences, but also include health and nutritional aspects. It has been previously reported the 20% poorest children are more likely to have worse health outcomes when compared to the 20% richest[43]. Indeed, prevalence of stunting and overweight among under-fives participating in the cash-transfer program *Bolsa Familia* was 14.5% and 16.4%, respectively[135]. Motta and Silva also found prevalence of stunting (HAZ < -1 SD) among low income infants, children at preschool age and children at school age of almost 20% for each age group, while overweight affected approximately 15% of children at the three age groups[136], more similar to our findings.

With regard to social determinants, we found that infants living in extended families grew about 2.5cm more (~1 inch) from birth to 12 months than infants living in nuclear families, results that differ from previous studies. Aerts and colleagues[66] found no association between family structure and odds of stunting, however, they used data from children 0 to 5y. One explanation may be that living in extended families may be associated with linear growth due to the help provided by grandmother during the first year of life of the child. For example, Aubel[137] reported that in many cultures, grandmothers (or other older women) often play roles of both advisors and caregivers by "training" or "teaching" the new mothers[137-139]. The presence of a grandmother-like figure in this sample could not be confirmed, though, since data collection did not specify family members living in the home. However, we found that children who were cared for by someone other than the mothers had higher odds of catch-up growth and grew 2.4cm more from 1 to 4y compared to those cared for by their mothers, indicating the importance of a grandmother-like presence in the early years of the child's life. Still, other aspects of family structure, including the presence of a caring father, may be responsible for these findings.

In our study, paternal education was consistently associated with lower odds of stunting at 1, 4 and 7y, while we saw no association between maternal education and growth outcomes. Others have suggested that, with respect to child care, men are *advisees* and not *advisors,* and the involvement of men in child care is very limited in most societies[137,139]. Contrasted with previous studies, fathers may become more present during childhood and help with caregiving, either for feeling more confident in caring for a child or for necessity in helping the mother. Most studies have reported an association between maternal education and childhood nutritional status, but few studies have collected data on paternal education[140,141]. The framework proposed by Frost and colleagues for the association between maternal education and the nutritional status of children[143] could provide a hypothesis for the inverse association between paternal education and risk of stunting, so fathers with higher education have: (1) higher SES[142]; (2) higher health knowledge; (3) better attitudes towards health; and (4) autonomy (in child care). In addition, better educated fathers could feel more confident helping the mothers and caring for the child. Taken together, these results might indicate that while maternal education is an important factor for childhood nutrition, in urban communities in developing countries with fair access to information and medical services, other determinants might be better predictors of child health and paternal education might become more relevant.

We found that taller newborns were less likely to be stunted at 12 months and LAZ at 1 year was associated with lower odds of stunting 4 and 7 years, while BMIz at 1 year was associated with BMIz at 4 and 7 years. Taken together, these findings are in agreement with the current global strategy to alleviate and prevent childhood undernutrition by focusing on the first 1,000 days of life. Public health interventions aiming to reduce or alleviate growth retardation should focus on improving pregnancy health status and, thus, reducing the number of preventable LBW and premature babies. Such interventions should also focus on improving nutritional status of infants. In addition, interestingly, social factors were not associated with BMIz at 1, 4 and 7 years. The results for childhood overweight emphasize that the focus on the first 1,000 days should include pre-conception nutrition and special attention to infant feeding practices, and efforts should be made not only to prevent undernutrition, but also to prevent childhood obesity.

This study had some limitations that need to be discussed. First, low-birth-weight (LBW) and premature newborns were not included in the study, reducing the sample size and limiting the association between income and the nutritional status of children beginning even before conception. However, premature and LBW babies might have different growth patterns due to possible intra-uterine growth restriction (LBW) and incomplete fetal development (premature births), which could have had shifted the results of our study. Second, our study had a relatively small sample. Yet, availability of data from the same cohort at three different time-points mitigates this limitation. Third, we could not differentiate the family members in the home, so we could not test the hypothesis of the presence of a grandmother-like figure helping caring for the infant. In future analyses, we could investigate the role of grandmothers in caring for infants and influencing their nutritional status, comparing children cared by grandmothers, grandmothers and mothers, and mothers. Strengths of this study are the fact that all participants were from low-income families (maximum household income less than $9,000/year) and data used in the analyses are from the same group of children.

In conclusion, while maternal education is often cited as an important predictor of the nutritional status of children, in our study, maternal education was not associated with growth and nutritional status during infancy or childhood. We found that predictors of growth and nutritional status differ with age and that maternal height and paternal education are consistently associated with lower odds of stunting during childhood (1, 4 and 7y), and living in extended families was associated with better linear growth during infancy and early childhood. These findings highlight the importance of educating not only mothers regarding infant care, but also other family members that are involved in caring for the child or providing maternal emotional and social support, such as grandmothers and fathers/partners. In historically patriarchal societies, women usually have experience with caring for younger siblings or other children and often are taught by their mothers and grandmothers, while men are not involved in child care until they become fathers. Thus, fathers should receive attention from nutritional interventions, so they can feel more confident in their caregiving skills and even feel more compelled to help their partners caring for the child's health. In addition, our findings also highlight the significance of early interventions, since, nutritional status at 1 year was a significant predictor of nutritional status later in childhood, in agreement with the current scientific recommendation of interventions focusing on health during pregnancy and infant feeding practices. Thus, to reduce and eradicate childhood malnutrition, children should have a fair start in life.

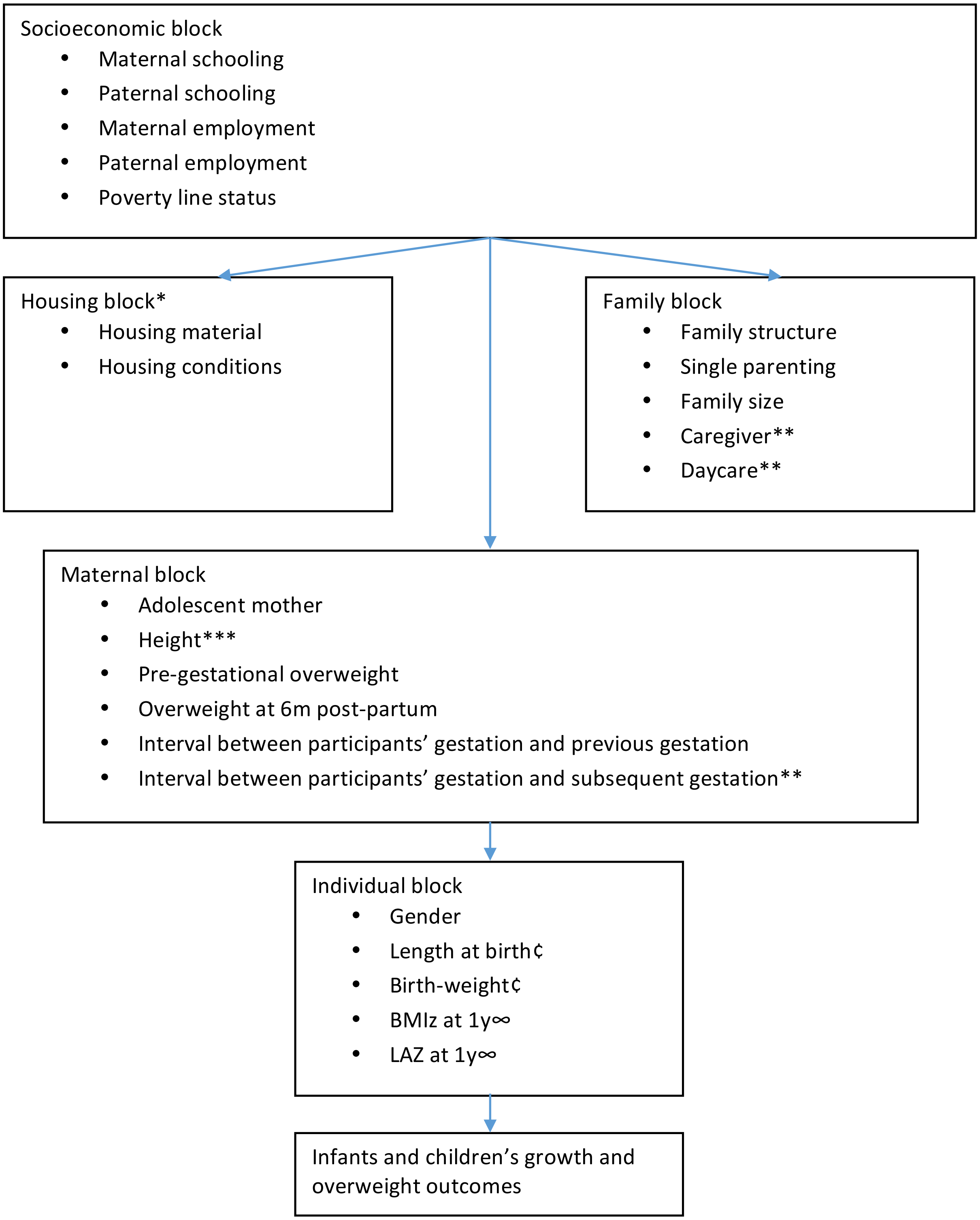

Figure 5.1 – Conceptual framework of hierarchical regression approach. Based on Aerts et al[66].

* Not used for the 8y outcomes (data not collected at 4y)

** Not used for outcomes during infancy

*** Not used for overweight outcomes

¢ Used only for infants' outcomes

∞ Used only for children's outcomes

Table 5.1 – General characteristics of study population

Variable		n (%)	Mean (SD)	Median	Range
Boys		67 (59.8)	-	-	-
Birth weight (g)		-	3384 (466.1)	3335	2500 – 4840
Length at birth (cm)		-	48.9 (2.18)	49.0	45.0 – 55.0
Gestational age (w)		-	39.4 (1.24)	40.0	37 – 42
Maternal age (y)		-	26.2 (6.75)	26.0	16 – 45
	Adolescent mothers	23 (20.5)	-	-	-
Maternal height (cm)		-	158.8 (6.43)	159.1	140.8 – 174.0
Pre-gestational BMI overweight/obese		41 (37.6)	-	-	-
Maternal schooling (y)			7.13 (2.71)	7.00	1 - 11
	1-4 y	18 (16.1)	-	-	-
	5-8 y	59 (52.7)	-	-	-
	9-11 y	35 (31.3)	-	-	-
Paternal schooling (y)			7.56 (2.68)	7.00	2 – 11
	1-4 y	15 (14.3)	-	-	-
	5-8 y	50 (47.6)	-	-	-
	9-11 y	40 (38.1)	-	-	-
Single mothers		12 (10.7)	-	-	-
Nuclear families		79 (73.1)	-	-	-
Housing conditions					
	Poor	4 (4.3)	-	-	-
	Fair	23 (25.0)	-	-	-
	Satisfactory	65 (70.7)	-	-	-
Oldest or only child		42 (37.5)	-	-	-
Age at the 12m follow-up (m)		-	12.1 (0.91)	12.00	11 - 15
Age at the 4 years follow-up (y)		-	3.50 (0.50)	3.50	3 – 4

Table 5.1 – General characteristics of study population (cont.)

Variable	n (%)	Mean (SD)	Median	Range
Age at the 7 years follow-up (y)	-	7.25 (0.43)	7.00	7 – 8
LAZ at 1y	-	-0.10 (1.10)	-.26	-2.94 – 2.13
LAZ ≤ -2 SD	2 (1.8)	-	-	-
LAZ ≤ -1 SD	25 (22.3)	-	-	-
HAZ at 4y	-	0.20 (1.03)	.18	-1.93 – 2.85
HAZ ≤ -1 SD	15 (13.4)	-	-	-
HAZ at 7y	-	0.45 (1.23)	.34	-1.90 – 4.30
HAZ ≤ -1 SD	10 (8.9)	-	-	-
BMIz at 1y	-	0.54 (1.08)	.61	-2.26 – 3.35
BMIz > 2 SD	11 (9.5)	-	-	-
BMIz at 4y	-	0.33 (1.10)	.28	-2.04 – 4.15
BMIz > 2 SD	8 (7.1)	-	-	-
BMIz at 7y	-	0.32 (1.36)	.19	-3.58 – 3.77
BMIz > 1 SD	31 (27.7)	-	-	-
Baseline yearly income (US$)	-	2769 (1819)	2101	698.8 – 8468
Baseline yearly income *per capita* (US$)	-	639.0 (445.4)	527.8	127.1 – 2823
Income *per capita* ≤US$1/day at 6m (≤PL)	30 (26.8)	-	-	-
Income *per capita* ≤US$1/day at 1y (≤PL)	36 (32.1)	-	-	-
Income *per capita* ≤US$1.25/day at 4y (≤PL)	18 (16.1)	-	-	-
≤PL at all times	9 (8.1)	-	-	-

Table 5.2 – Associations between social determinants at 6 months and stunting and catch-up growth at 1y.

Variables	Unadjusted OR	95%CI	Adjusted OR*	95%CI	p
Model for Stunting at 1y					
Step 1: SES block					
Maternal schooling (y)	.990	.840, 1.17			.910
Paternal schooling (y)	.881	.738, 1.05			.164
Unemployed mother (ref: employed)	.836	.319, 2.19			.716
Unemployed father (ref: employed)	.670	.074, 6.02			.720
≤ PL at 6 months (ref: >PL)	.303	.084, 1.10			.069
Step 5: Final model					
Paternal schooling (y)			.769	.595, .994	.045
≤ PL at 6 months (ref: >PL)			.151	.026, .869	.034
Housing conditions: poor/fair (ref: good)			.566	.156, 2.05	.386
Household size: 5+ (ref: ≤4 people)			.497	.104, 2.37	.380
Maternal height (cm)			.881	.788, .984	.025
Birth interval (previous): ≤ 24m (Ref: only child or >24m)			14.24	1.64, 123.3	.016
Length at birth (cm)			.385	.204, .727	.003
Birth weight (100g)			1.20	.915, 1.58	.186
Gender: girls (ref: boys)			.216	.051, .905	.036

* Adjusted for all variables in the block.

Table 5.2 – Associations between social determinants at 6 months and stunting and catch-up growth at 1y (cont.).

Variables	Unadjusted OR	95%CI	Adjusted OR*	95%CI	p
Model for Catch-up Growth at 1y					
Step 1: SES block					
Maternal schooling (y)	.881	.732, 1.06			.183
Paternal schooling (y)	.971	.803, 1.17			.763
Unemployed mother (ref: employed)	1.81	.553, 5.90			.327
Unemployed father (ref: employed)	.000	.000			.999
≤ PL at 6 months (ref: >PL)	.893	.294, 2.71			.842
Step 5: Final model					
Maternal schooling (y)			.834	.681, 1.02	.079
Adolescent mother (ref: ≥20y)			.357	.074, 1.72	.199
Maternal height (cm)			1.11	1.01, 1.20	.022

* Adjusted for all variables in the block.

Table 5.3 – Associations between social determinants at 6 months and linear growth from birth to 1y.

Variables	Unadjusted B	95%CI	Adjusted B*	95%CI	p
Step 1: SES block					
Maternal schooling (y)	.111	-.079, .301			.249
Paternal schooling (y)	.060	-.138, .259			.547
Unemployed mother (ref: employed)	.352	-.796, 1.50			.545
Unemployed father (ref: employed)	-2.00	-4.25, .245			.080
≤ PL at 6 months (ref: >PL)	-.142	-1.30, 1.02			.810
Step 5: Final model					
Unemployed father (ref: employed)			-2.15	-4.20, -.102	.040
Type of family: extended (ref: nuclear)			2.51	1.32, 3.69	<.001
Household size: 5+ (ref: ≤4 people)			-.960	-1.98, .063	.066
Adolescent mother (ref: ≥20y)			-.855	-2.06, .350	.162
Maternal height (cm)			.069	-.006, .142	.066
Gender: girls (ref: boys)			-.274	-1.24, .690	.574

* Adjusted for all variables in the block.

Table 5.4 – Associations between social determinants at 1 year and stunting and catch-up growth at 4y.

Variables	Unadjusted OR	95%CI	Adjusted OR*	95%CI	p
Model for Stunting at 4y					
Step 1: SES block					
Maternal schooling (y)	.827	.665, 1.03			.087
Paternal schooling (y)	.662	.501, .874			.004
Unemployed mother (ref: employed)	.872	.269, 2.82			.819
Unemployed father (ref: employed)	.934	.106, 8.22			.951
≤ PL at 1 year (ref: >PL)	2.05	.681, 6.19			.202
Step 5: Final model					
Maternal schooling (y)			1.03	.667, 1.59	.890
Paternal schooling (y)			.581	.355, .951	.031
Adolescent mothers (ref: ≥20y)			3.64	.503, 26.3	.201
Maternal height (cm)			.818	.675, .991	.040
LAZ at 1y			.073	.013, .402	.003
Gender: girls (ref: boys)			9.95	1.08, 92.0	.043

* Adjusted for all variables in the block.

Table 5.4 – Associations between social determinants at 1 year and stunting and catch-up growth at 4y (cont.).

Variables	Unadjusted OR	95%CI	Adjusted OR*	95%CI	P
Model for Catch-up Growth at 4y					
Step 1: SES block					
Maternal schooling (y)	1.13	.974, 1.31			.107
Paternal schooling (y)	1.13	.967, 1.31			.125
Unemployed mother (ref: employed)	1.87	.767, 4.54			.169
Unemployed father (ref: employed)	.627	.120, 3.28			.581
≤ PL at 1 year (ref: > PL)	.540	.223, 1.31			.173
Step 5: Final model					
Maternal schooling (y)			1.16	.885, 1.52	.279
Paternal schooling (y)			1.23	.946, 1.60	.123
Unemployed mother (ref: employed)			4.52	1.11, 18.5	.036
≤ PL at 1 year (ref: > PL)			.435	.119, 1.58	.206
Single mother (ref: with partner)			7.96	.934, 67.8	.058
Extended family (ref: nuclear)			.403	.075, 2.16	.288
Family size: 5+ (ref: ≤4 people)			2.88	.813, 10.2	.101
Caregiver: else (ref: mother)			7.46	1.67, 33.3	.009
Pre-gestational overweight (ref: not)			.584	.190, 1.80	.350
LAZ at 1y			.410	.236, .715	.002

* Adjusted for all variables in the block.

Table 5.5 – Associations between social determinants at 1y and linear growth from 1 to 4y.

Variables	Unadjusted B	95%CI	Adjusted B*	95%CI	p
Step 1: SES block					
Maternal schooling (y)	.116	-.166, .397			.416
Paternal schooling (y)	.117	-.178, .411			.433
Unemployed mother (ref: employed)	1.08	-.516, 2.67			.183
Unemployed father (ref: employed)	-.445	-3.40, 2.51			.766
≤ PL at 1 year (ref: > PL)	-1.10	-2.72, .515			.180
Step 5: Final model					
Unemployed mother (ref: employed)			2.33	.829, 3.82	.003
≤ PL at 1 year (ref: > PL)			-1.01	-2.42, .402	.159
Caregiver: else (ref: mother)			2.39	.701, 4.09	.006
Maternal height (cm)			.108	-.002, .219	.054
Birth interval (previous): ≤24m (ref: only or >24m)			-1.36	-3.67, .941	.066

* Adjusted for all variables in the block.

Table 5.6 – Associations between social determinants at 4 years and stunting and catch-up growth at 7y.

Variables	Unadjusted OR	95%CI	Adjusted OR*	95%CI	p
Model for Stunting at 7y					
Step 1: SES block					
Maternal schooling (y)	.776	.591, 1.02			.069
Paternal schooling (y)	.673	.490, .923			.014
Unemployed mother (ref: employed)	.412	.101, 1.68			.217
Unemployed father (ref: employed)	3.25	1.25, 5.61			<.001
≤ PL at 4 years (ref: > PL)	11.25	2.77, 45.7			.001
Step 5: Final model					
Maternal schooling (y)			1.12	.609, 2.06	.713
Paternal schooling (y)			.819	.459, 1.46	.498
Unemployed father (ref: employed)			3.54	1.66, 7.55	.022
≤ PL at 4 years (ref: > PL)			2.03	.953, 4.32	.054
Maternal height (cm)			.817	.662, 1.01	.059
LAZ at 1y			.052	.004, .626	.020

* Adjusted for all variables in the block.

Table 5.6 – Associations between social determinants at 4 years and stunting and catch-up growth at 7y (cont.).

Variables	**Unadjusted OR**	**95%CI**	**Adjusted OR***	**95%CI**	**p**
Model for Catch-up Growth at 7y					
Step 1: SES block					
Maternal schooling (y)	.974	.817, 1.16			.773
Paternal schooling (y)	.999	.829, 1.20			.989
Unemployed mother (ref: employed)	1.46	.559, 3.81			.440
Unemployed father (ref: employed)	.556	.116, 2.66			.463
≤ PL at 4 years (ref: > PL)	.487	.103, 2.30			.364
Step 5: Final model					
Extender family (ref: nuclear)			.370	.115, 1.19	.095

* Adjusted for all variables in the block.

Table 5.7 – Associations between social determinants at 4y and linear growth from 4 to 7y.

Variables	Unadjusted B	95%CI	Adjusted B*	95%CI	p
Step 1: SES block					
Maternal schooling (y)	-.175	-.520, .170			.316
Paternal schooling (y)	.092	-.253, .436			.599
Unemployed mother (ref: employed)	-.165	-2.04, 1.71			.862
Unemployed father (ref: employed)	-2.15	-4.77, .461			.105
≤ PL at 4 years (ref: > PL)	-1.95	-4.42, .520			.120
Step 5: Final model					
Unemployed father (ref: employed)			-1.10	-3.76, 1.56	.415
≤ PL at 4 years (ref: > PL)			-1.44	-4.10, 1.21	.284
LAZ at 1y			1.08	.255, 1.92	.011

* Adjusted for all variables in the block.

Table 5.8 – Associations between social determinants and overweight outcomes during infancy, and early- and mid-childhood.

Variables	**Unadjusted OR***	**95%CI**	**Adjusted OR****	**95%CI**	**p**
Model for Overweight at 1y					
Step 1: SES block					
Maternal schooling (y)	1.02	.811, 1.29			.857
Paternal schooling (y)	.942	.745, 1.19			.619
Unemployed mother (ref: employed)	.450	.127, 1.60			.217
Unemployed father (ref: employed)	.000	-			.999
≤PL at 6 months (ref: > PL)	1.65	.446, 6.09			.454
Step 5: Final model					
Birth order: 2nd or more (ref: 1st/only)			.207	.043, .989	.048
Birth interval (previous): ≤ 24m (Ref: only child or >24m)			10.12	1.18, 86.9	.035
Birth weight (100g)			1.20	1.05, 1.37	.007

* Adjusted for all variables in the block.

Table 5.8 – Associations between social determinants and overweight outcomes during infancy, and early- and mid-childhood (cont.).

Variables	**Unadjusted OR***	**95%CI**	**Adjusted OR****	**95%CI**	**p**
Model for Overweight at 4y					
Step 1: SES block					
Maternal schooling (y)	.999	.765, 1.30			.992
Paternal schooling (y)	.617	.397, .959			.032
Unemployed mother (ref: employed)	.809	.182, 3.59			.780
Unemployed father (ref: employed)	1.86	.199, 17.30			.587
≤PL at 1 year (ref: > PL)	1.29	.291, 5.73			.737
Step 4: Final model					
Paternal schooling (y)			.608	.303, 1.22	.161
Caregiver: other (ref: mother)			400.2	.043, 37544	.199
Adolescent mother (ref: >19y)			175.8	.021, 14600	.262
BMIz at 1y			6.04	1.18, 31.0	.031

* Adjusted for all variables in the block.

Table 5.8 – Associations between social determinants and overweight outcomes during infancy, and early- and mid-childhood (cont.).

Variables	Unadjusted OR*	95%CI	Adjusted OR**	95%CI	p
Model for Overweight at 7y					
Step 1: SES block					
Maternal schooling (y)	1.00	.862, 1.17			.947
Paternal schooling (y)	.972	.828, 1.14			.726
Unemployed mother (ref: employed)	1.26	.545, 2.93			.586
Unemployed father (ref: employed)	.149	.019, 1.18			.072
≤PL at 4 years (ref: > PL)	.764	.228, 2.55			.661
Step 5: Final model					
Unemployed father (ref: employed)			.172	.021, 1.40	.100
Maternal height (cm)			1.04	.969, 1.12	.275
BMIz at 1 y (SD)			1.79	1.13, 2.85	.013

* Adjusted for all variables in the block.

CHAPTER 6

Poorer and less educated mothers have worse infant feeding practices during the first year of life of the infant

6.1 Abstract

The WHO recommends children to be breastfed within the first hour after birth and exclusive breastfeeding should continue until the infant completes 6 months of age, when semi-solid foods should be gradually introduced, while still maintaining free-demand breastfeeding until the child is 24 or more months. However, less than 40% of world infants are breastfed. Previous studies have suggested women from lower income and less educated mothers are less likely to exclusive breastfeed, with conflicting findings regarding breastfeeding duration. Nonetheless, studies rarely discuss infant feeding practices among women living above or below the poverty line. Thus, in this study we compared breastfeeding and complementary feeding practices among 151 Brazilian low-income mother-child pairs living above or below the poverty line. Living below the poverty line was a significant predictor of short exclusive breastfeeding duration (SEBF) (OR = 3.64, $p = .037$), while previous breastfeeding experience for at least 4 months was associated with lower odds of breastfeeding for less than 12 months (OR = .237, $p = .003$). Maternal education was associated with reduced odds of offering soft drinks before the infant completed 10 months of life (OR = .782, $p = .033$). Thus, nutrition interventions should focus on first-time mothers and low-income mothers in general, but special attention should be given to the poorest women, and interventions for these mothers should target exclusive breastfeeding practices. Qualitative studies are needed to understand why the poorest women cease exclusive breastfeeding before 6 months.

6.2 Introduction

The World Health Organization (WHO) recommends children to be breastfed within the first hour after birth and exclusive breastfeeding should continue until the infant completes 6 months of age, when semi-solid foods should be gradually introduced, while still maintaining free-demand breastfeeding until the child is 24 or more months[144]. Exclusive breastfeeding for 6 months is associated with lower risk of diarrhea and respiratory infections morbidity and mortality[78,81,145]. However, less than 40% of infants are exclusively breastfed for 6 months worldwide[43]. Further, there is still little comprehension about which factors influence the decisions of the mothers regarding breastfeeding type and duration. For example, early initiation of breastfeeding is less prevalent among poor mothers in sub-Saharan Africa, while in Latin America, the highest prevalence of early initiation of breastfeeding is seen among lower income families[43]. In order to develop interventions targeting the most vulnerable populations, there is an urgent need for identifying factors associated with breastfeeding and complementary feeding practices among low-income families.

Breastfeeding has short- and long-term benefits for both the mother and the infant. For the mothers, longer exclusive breastfeeding is associated with greater weight reduction after birth compared to non-exclusive breastfeeding or early breastfeeding cessation[146,147]. Exclusively breastfeeding for 6 months is associated with lower likelihood of illnesses, such as diarrhea and respiratory infections[78,81,145,148]. Longer breastfeeding duration is associated with slower pace of growth (which is associated with lower odds of obesity later in life)[149], lower risk of obesity during infancy[150], longer ulnar length [151], lower risk of early onset of puberty[152], and higher IQ scores and higher income at age 30[153]. However, longer breastfeeding duration, without adequate complementary feeding is associated with increased risk of undernutrition[132].

Income and maternal education are among the most commonly reported factors related to the feeding practices of infants. In general, better educated mothers have better overall feeding practices. More educated mothers are more likely to exclusively breastfeed their infants and less likely to offer complementary feeding before 4 months of the child compared to less educated women in some[154-157], but not all studies[158]. The association between infants feeding practices and income are also complex. Some have reported that low-income women are less likely to breastfeed[159–162], and others reported low-income women breastfeed for a longer period[160,163], while others found poorer women breastfed for shorter periods[164].

On the other hand, mothers from higher socioeconomic status (SES) were more likely to introduce complementary feeding at the appropriate time[165]. Such associations might differ due to different definitions of breastfeeding or to interactions between maternal education and familial income and other socioeconomic variables, many times not included in the studies. Thus, the purpose of this study is to investigate whether, among low-income women, those living under extreme poverty have different infant feeding styles compared to those poor, but living above the extreme poverty line. We hypothesize that poorer mothers will have worse overall feeding practices compared to better-off mothers.

6.3 Methodology

Study population, inclusion criteria and study group

The study sample consisted of 300 low-income Brazilian mother-child pairs allocated in the control group of the study "Implementation and Evaluation of the Impact of the Program of Promoting Healthy Feeding for Children Younger than Two Years" (*Implementação e Avaliação do Impacto do Programa de Promoção para a Alimentação Saudável para Crianças Menores de Dois Anos*), that is, only participants who did not receive the educational program. Details of the previous study can be found elsewhere[15]. Inclusion criteria included delivery in the maternity wards attended by the Brazilian public healthcare system (*Sistema Único de Saúde, SUS*) of the only maternity-hospital in the city of Sao Leopoldo, RS/Brazil, full-term (≥ 37 weeks) singleton and birth weight ≥ 2500g. Newborns who suffered from any impediment to breastfeeding, needed intensive care, had congenital malformation or were diagnosed with HIV/AIDS were excluded from the study. Although income was not inclusion criteria, delivery at the SUS wards of the hospital indicates a woman is from a lower socioeconomic class. The study protocol was approved by the Ethics Committee of the *Universidade Federal de Ciencias da Saude de Porto Alegre* and informed consent of the mother was obtained at study entry.

Data collection

Mother-newborn dyads were invited to participate in the study the day after giving birth. At this time, only contact information was collected. Mothers were then visited when infants were 6-months old, to avoid recall bias, and at 12-months old. From the 300 mother-child pairs who agreed in participating in this study, 161 (53.7%) completed the first follow-up and 224 (74.7%) completed the second follow-up, with 151 (50.3%) mothers completing both follow-ups. Baseline data (birth weight, length at birth and gestational age) were collected from hospital records. Trained research assistants collected anthropometric, socioeconomic and infant feeding data during the follow-ups. Infants' length was measured using a portable infant stadiometer (Serwital Inc., Brazil) and weight was measured using a portable scale (Techline, Brazil), with the infants wearing no clothes and no shoes. Maternal pre-pregnancy weight was self-reported, but maternal height and weight were measured at the 6-months follow-up. Height and weight of the mothers were assessed using portable digital scale (Techline, Brazil) and statiometer (SECA, Germany), with the subject wearing light clothing and no shoes. Length and height were measured to the nearest 1cm and weight was measured to the nearest 100g.

During the interviews, mothers were asked about families' income, structure (household size, family structure, single parenting), parental occupation and education, housing characteristics (water, sanitation, housing material) and children's health information (hospitalization, medication, respiratory infections, diarrhea episodes during the past 6 months). In addition, mothers were asked if the infant was being exclusively breastfed at the time. If the answer was yes, mothers were prompted about the intake of water, tea, and other liquids by the infant. If answer was no, mothers were asked when (in which month) infants were offered specific food items. Infants were considered exclusively breastfed if only breast milk was being offered. Food items were selected from a previous published list of items commonly introduced in infants feeding[166].

Study outcomes

The outcomes of interest were exclusive breastfeeding less than 4 months (short exclusive breastfeeding – SEBF)[156], breastfeeding for less than 12 months, early introduction of water, other milks, fruits, porridge, sugar and soft drinks, as well as consumption of sugar- and lipid-dense foods. Exclusive breastfeeding was considered if nothing but breast milk was being offered to the infant, while breastfeeding was considered if breast milk and other food items were consumed. A "healthy diet" index was created.

An infant was considered to have a healthy diet if s/he was exclusively breastfed for 4 or more months, breastfed for 12 or more months and consumed sugar- and lipid-dense foods only after 12 months of age. The consumption of lipid- and sugar-dense food was assessed by asking the mothers whether infants had consumed sugar, honey, candy and soft drink (sugar-dense) and sandwich-cookies, chocolate and cheese-puffs (lipid-dense foods). Consumption of sugar- or lipid-dense foods was considered if the infant consumed all items within the category during the previous month.

Hierarchical model

Social poverty was assessed using a hierarchical approach[66,167]. Social determinants were grouped into 5 blocks: (1) socioeconomic status: poverty line status (≤ or > poverty line) and parental schooling (in years) and employment status (employed vs. unemployed); (2) housing factors: housing material (brick v. else) and conditions (poor/unsatisfactory, fair, satisfactory); (3) family factors: family structure (nuclear v. extended), single mother, family size (≤ v. >4 people); (4) maternal factors: maternal age, pre-gestational and 6-months post-partum overweight, interval from previous birth (≤ 24 months v. > 24 months), mother breastfed older siblings; and (5) individual factors: weight and length at birth and gender (Figure 6.1).

The housing conditions index was created so presence of adequate (safe) drinking water, toilet facility and sanitation were coded as 1 and if these factors were absent or inadequate, they were coded 0. Results were added and final score of 3 was classified as good/satisfactory, 2 was classified as fair, and 1 or 0 were classified as poor/unsatisfactory[56]. As for family structure, both parents and children formed nuclear families and any other configuration was considered "extended families" (single mothers were not included in this variable). Poverty line status was defined as US$1/day *per capita*[34]. Sociodemographic data collected at the 6-months follow-up was considered the baseline SES.

Statistical analyses

Descriptive statistics of the sample are presented as mean and standard deviation (SD) or frequency for continuous or categorical variables, respectively, and normality was assessed using the Kolmogorov-Smirnov test. Differences between participants living above or below the poverty line were tested using student's *t* or Mann-Whitney tests and Chi-squared test for continuous and categorical variables, respectively.

Logistic regression analyses were conducted using a hierarchical approach. Outcome variables were coded 1 (if outcome was present) or 0 (if outcome was not present). Breastfeeding predictors were selected based on factors associated with breastfeeding in previous studies[154,163,168-173]. Poverty line was included as the income variable. Many studies have reported the association between breastfeeding practices and family support[154,174]. Family variables were included in the analyses to investigate whether family characteristics could be used to predict breastfeeding practices in this group. In addition, housing conditions were included in the model since income is not the only dimension of poverty, and access to basic living-conditions can also influence children's nutrition and health[43].

Regression analyses were conducted using the following 5 steps: (1) association between variables in the SES block and outcomes of interest were analyzed separately in bivariate analyses. Variables associated with the outcome were selected to be included in the following steps; (2) all variables in the housing and family block were added to the model simultaneously, adjusting for any significant variable from step (1). Significant variables from this block were selected to be included in the following steps; (3) all variables from the maternal block were included in the model, adjusting for all significant variables from the previous steps; (4) variables from the individual block were included in the model, adjusting for significant variables from the previous steps; (5) non-significant variables from the individual block were removed from the model. The final model included all significant variables from steps 1, 2, 3 and 4. Significance for inclusion in the models was set as $p < 0.20$ and was defined as the p value from when the variable was first included in the model (that is, within its respective block/step). Statistical significance was determined at the $p < 0.05$ level. All analyses were conducted in SPSS for Mac, version 23[109].

6.4 Results

General characteristics of the study sample are summarized in Tables 6.1 and 6.2. Fifty-seven percent of infants were boys (n=86), average birth weight was 3360g, and 45% of mothers were overweight or obese 6 months after delivery. Only about one-third of the parents had completed middle school education and 30% of participants were living below the poverty line (Table 6.1). Participants living below or above the poverty line had similar baseline characteristics, except for income and parental education (Table 6.2).

Overall, families living above or below the poverty line did not show different infant feeding style, except for exclusive breastfeeding (Table 6.3). Extremely poor mothers were less likely to exclusively breastfeed for at least four moths compared to mothers living above the poverty line ($p = .021$). In the logistic regression, maternal education and poverty line were associated with early weaning (exclusive breastfeeding for less than 4 months), but only poverty line remained a significant predictor after model adjustments (Table 6.4). In the fully adjusted model, prior breastfeeding for 4 or more months was a significant predictor of breastfeeding duration (breastfeeding for less than 12 months) (Table 6.5). The association between maternal schooling and early introduction of soft drinks remained significant after controlling for other factors in the model ($p = .033$) (Table 6.6). The proposed model did not predict the other outcomes (data not shown).

6.5 Discussion

Adequate breastfeeding and complementary feeding practices are associated with lower risk of diarrhea and respiratory infections morbidity and mortality[78,81,145,148], lower odds of obesity[149,150] and higher IQ[153]. Despite these benefits, less than 40% of infants are exclusively breastfed in the world, and poorer infant feeding styles are often seen among women with lower education[154-157] and/or lower SES [159–162,164]. However, little is known about the infant feeding habits of mothers living under extreme poverty. In our sample, about 30% of infants were exclusively breastfed for four or more months, and 60% and 40% were breastfed for 6 and 12 or more months, respectively. Lower maternal education and living below the poverty line were associated with lower exclusive breastfeeding duration.

Other studies have reported that women from lower SES are less likely to breastfeed. In our study, however, there were no significant differences in exclusive breastfeeding and breastfeeding duration between low-income women living above or below the poverty line. A study conducted in Ethiopia found that mothers from lower SES were less likely to exclusively breastfeeding[161]. However, exclusive breastfeeding was considered if the infant was reported to have consumed only breast milk the day before the interview and sample included infants 0 to 6 months. Nonetheless, we found that short exclusive breastfeeding (SEBF) was more prevalent among mothers living below the poverty line compared to mothers living above this threshold. Better maternal education was also associated with lower odds of SEBF. However, after adjusting for confounders, association between SEBF and maternal education lost significance, while strengthening the association with poverty line, indicating the association between poverty status and SEBS is independent of maternal education. These findings differ from some[155], but are in agreement with other Brazilian studies[162]. In the study conducted in the US, EBF for 4 or more months was associated with maternal education and not income[155], conflicting with our findings. However, their study included participants from all socioeconomic levels and lowest education level varied from high school to college graduate, while none of our participants had complete high school education.

There are at least three possible hypotheses for the increased odds of SEBF among the poorest women. First, although most mothers believe breast milk is an economical and practical option and it is the best option for the infant[175–177], they might believe their breast milk is not strong enough to nurture their infant. Studies have reported mothers might compare the color of their breast milk to the color of cow's milk (considered strong), or because they do not consider their own food intake adequate, they are not strong, and thus their own milk will not be strong[175,178]. Second, mothers might think weaker infants (smaller or sick infants) need stronger milk, that is, non-human milk or formula[162,177]. And third, in low-income settings, heavier children tend to be seen as healthier, and since breastfed babies grow at a slower pace, mothers who believe "bigger is better" might be more likely to introduce gruels and other foods earlier, so the infant grows more, what is seen as “successful parenting and feeding”[179]. Indeed, poorer mothers were more have shorter exclusive breastfeeding duration, but about 60% of all mothers breastfed for at least 12 months, with no differences between the poor and the poorest participants.

Mothers with prior breastfeeding experience might have more knowledge about breastfeeding benefits and thus, be more likely to exclusively breastfeed. Indeed, we found that mothers who had breastfed their older children for more than 4 months (any type of breastfeeding) had higher odds of breastfeeding for at least 12 months. Fegan and colleagues[180] reported that Canadian mothers who had previously breastfed were more likely to breastfeed the infant participating in the study for at least 6 months. In their study, however, authors considered any type of breastfeeding. Our findings that prior breastfeeding experience increases the odds of exclusive breastfeeding for at least 4 months adds to the current body of literature. In our study, maternal education was not associated with breastfeeding for 12 months.

The Brazilian infant feeding recommendations advise mothers to avoid introduction of sugary drinks before the infant completes 24 months[14]. In our sample, almost 60% of mothers offered soft drinks to the infant before they completed 10 months of age. However, we found that more educated mothers were less likely to introduce soft drinks before the infants completed 10 months of age. Canada’s Food Guide advise mothers to avoid introduction of sugary drinks before the 12 months of the child and in the study of Fegan et al.[180], 95% of mothers followed this recommendation. On the other hand, using data from developing countries in Asia and Africa, Huffman et al.[181] found that 25% of infants 6-23 months old consumed soft-drinks about 2 times a week. A study conducted in South Africa found that almost 40% of infants 6-12 months consumed soft drinks at least once a week[182]. Thus, our findings that almost 60% of infants consumed soft drinks are higher than rates previously reported in other developing countries. Nevertheless, in our study we considered only consumption within the previous month, while these other studies considered frequency of consumption and, thus, had lower prevalence. More educated mothers might be more likely to avoid soft drinks during early infancy because they may be more aware of the actual infant feeding guidelines or they can better understand the harmful effects of early introductions of industrialized food items in the diet of young children, despite their similar financial limitations.

Our study had a few limitations that need to be addressed. First, our sample did not include low-birth weight (LBW) newborns (<2500g), which limited the sample size and the association between social determinants and breastfeeding practices. It has been previously reported that predictors of breastfeeding practices differ between LBW and infants with birth weight above 2500g[162]. A second limitation of our study is the fact we relied on the memory of the mothers about the age of introduction of the food items, which could lead to recall bias. However, the addition of a follow-up at 6 months could have mitigated this problem. Strengths of our study include the fact that trained nutrition undergraduate students conducted the interviews, the inclusion of several socioeconomic factors in the models, and the hierarchical approach to the regression analyses.

In conclusion, we found that SEBF was more common among poorer women and that association remained strong after adjusting for other confounders in the model. While previous experience with breastfeeding was positively associated with breastfeeding duration, more educated mothers were less likely to offer soft drinks before the child completed 10 months of life. Thus, first-time and poorer mothers should receive special attention in programs targeting infant feeding practices. First-mothers might need more intensive programs, and, even if interventions do not increase exclusive breastfeeding duration, mothers with prior breastfeeding experience will be more likely to exclusively breastfeed a subsequent child. In general, low-income women need to be educated regarding the adequacy of exclusive breastfeeding for their infants and should be taught in how to properly introduce complementary feeding. However, interventions should focus not only on teaching mothers about the importance of breastfeeding but also on the adequacy of their own breast milk to their infants. More studies are needed in order to understand why poorer women stop exclusive breastfeeding earlier and interventions should target these causes.

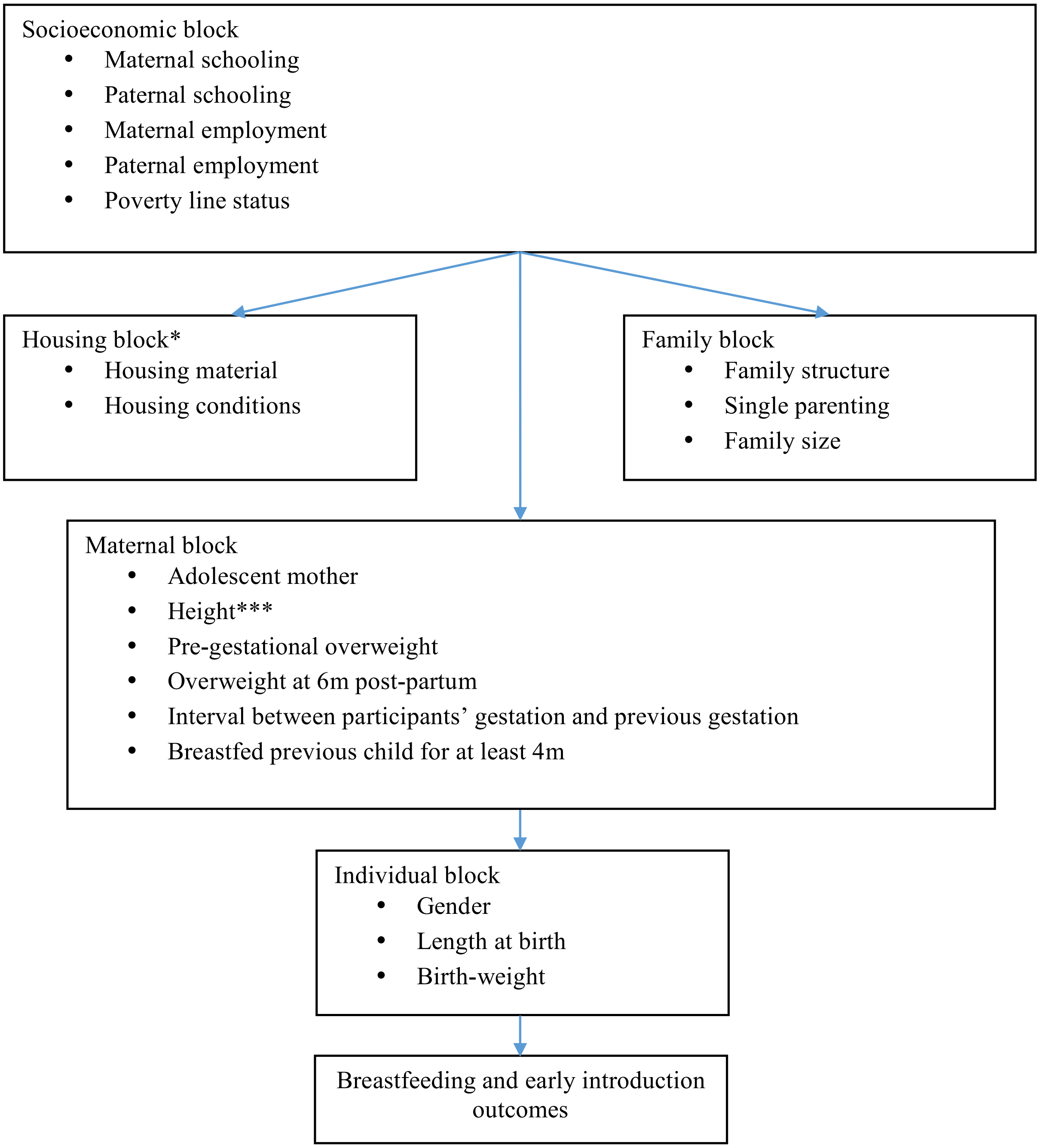

Figure 6.1 – Conceptual framework of hierarchical regression approach (based on Aerts and colleagues framework[66])

Table 6.1 – General characteristics of the sample.

Characteristic		n (%)	Mean (SD)	Range
Boys		86 (57.0)	-	-
Birth weight (g)		-	3360 (482.1)	2500 – 4840
Length at birth (cm)		-	48.9 (2.22)	44.0 – 55.0
Gestational age (w)		-	39.4 (1.20)	37 – 42
Maternal age (y)		-	25.8 (6.59)	15 – 45
	≤19y	31 (20.5)	-	-
	20-35y	106 (70.2)	-	-
	>35y	14 (9.3)	-	-
Pre-gestational maternal BMI				
	Adolescent mother[a]	-	.35 (0.721)	-1.44 – 1.85
	Adult mothers[b]	-	24.7 (4.45)	14.3 – 40.7
	Maternal overweight[c]	52 (35.9)	-	-
Weight gain during gestation (kg)				
	Adolescent mothers	-	13.1 (6.06)	4.00 – 27.0
	Adult mothers	-	13.6 (6.10)	0 – 30.0
Maternal height (cm)				
	Adolescent mother	-	158.8 (7.21)	146.6 – 179.0
	Adult mothers	-	158.5 (6.17)	140.8 – 174.0
	Stunted mothers[d]	35 (23.2)	-	-
Maternal BMI 6-months post-partum				
	Adolescent mother[a]	-	.36 (.953)	-1.37 – 2.41
	Adult mothers[b]	-	26.4 (5.07)	18.4 – 39.3
	Maternal overweight[c]	67 (44.7)	-	-
Maternal schooling (y)			6.96 (2.72)	1 - 11
	1-4 y	30 (19.9)	-	-
	5-8 y	76 (50.3)	-	-
	9-11 y	45 (29.8)	-	-
Paternal schooling (y)			7.42 (2.68)	2 - 11
	1-4 y	19 (13.6)	-	-
	5-8 y	72 (51.4)	-	-
	9-11 y	49 (35.0)	-	-
LAZ at 1y		-	-.23 (1.13)	-3.15 – 2.13
	LAZ ≤ -2 SD	8 (5.3)	-	-
	LAZ ≤ -1 SD	40 (26.5)		

[a] Adolescent mothers pre-gestational BMI: BMI-for-age (BMIz).
[b] Adult mothers pre-gestational BMI: kg/m^2.
[c] Pre-gestational overweight: adult mothers with BMI ≥ $25kg/m^2$ and adolescent mothers with BMIz > 1SD.
[d] Stunted mothers: adult mothers with height < 155cm or adolescent mothers with HAZ < -2SD.

Table 6.1 – General characteristics of the sample (cont.).

Characteristic	n (%)	Mean (SD)	Range
BMIz at 1y	-	.56 (1.11)	-2.26 – 3.35
BMIz ≥ 2 SD	16 (10.6)	-	-
Exclusive breastfeeding (m)	-	2.44 (1.70)	1 – 6
Breastfeeding (m)	-	7.54 (4.42)	1 – 12
Baseline yearly income (US$)	-	2619 (1867)	368.9 – 11338
Baseline yearly income *per capita* (US$)	-	610.3 (432.4)	66.3 – 2823
Income *per capita* ≤US$1/day at 6m (≤PL)	46 (30.5)	-	-

[a] Adolescent mothers pre-gestational BMI: BMI-for-age (BMIz).
[b] Adult mothers pre-gestational BMI: kg/m^2.
[c] Pre-gestational overweight: adult mothers with BMI ≥ 25kg/m^2 and adolescent mothers with BMIz > 1SD.
[d] Stunted mothers: adult mothers with height < 155cm or adolescent mothers with HAZ < -2SD.

Table 6.2 – Characteristics of the sample according to poverty status.

Characteristic	Poverty line ≤ PL (n = 46)	Poverty line > PL (n = 105)
Boys	30 (65.2)	56 (53.3)
Birth weight (g)	3389 (499.8)	3347 (476.1)
Length at birth (cm)	49.2 (2.28)	48.8 (2.20)
Maternal age (y)	26.2 (6.25)	25.7 (6.76)
≤19y	6 (13.0)*	25 (23.8)
20-35y	38 (82.6)	68 (64.8)
>35y	2 (4.3)	12 (11.4)
Pre-gestational maternal BMI		
Adolescent mother[a]	.36 (.950)	.35 (.844)
Adult mothers[b]	24.8 (4.09)	24.6 (4.64)
Maternal overweight[c]	17 (38.6)	35 (34.7)
Weight gain during gestation (kg)		
Adolescent mothers	10.8 (4.71)	13.7 (6.31)
Adult mothers	13.7 (6.40)	13.5 (5.99)
Maternal height (cm)		
Adolescent mother	154.3 (6.73)	159.9 (7.02)
Adult mothers	157.8 (6.12)	158.9 (6.21)
Stunted mothers[d]	13 (28.3)	22 (21.0)
Maternal BMI 6-months post-partum		
Adolescent mother[a]	.21 (1.15)	.39 (.925)
Adult mothers[b]	27.0 (5.00)	26.2 (5.12)
Maternal overweight[c]	24 (52.2)	43 (41.3)
Maternal schooling (y)	5.35 (2.39)***	7.67 (2.56)
1-4 y	20 (43.5)***	10 (9.5)
5-8 y	21 (45.7)	55 (52.4)
9-11 y	5 (10.9)***	40 (38.1)
Paternal schooling (y)	5.93 (2.41)***	8.04 (2.54)
1-4 y	12 (29.3)***	7 (7.1)
5-8 y	22 (53.7)	50 (50.5)
9-11 y	7 (17.1)***	42 (42.4)

* $p < .05$ *** $p \leq .001$

[a] Adolescent mothers pre-gestational BMI: BMI-for-age (BMIz).

[b] Adult mothers pre-gestational BMI: kg/m^2.

[c] Pre-gestational overweight: adult mothers with BMI ≥ $25kg/m^2$ and adolescent mothers with BMIz > 1SD.

[d] Stunted mothers: adult mothers with height < 155cm or adolescent mothers with HAZ < -2SD.

Table 6.2 – Characteristics of the sample according to poverty status (cont.).

Characteristic		Poverty line ≤ PL (n = 46)	Poverty line > PL (n = 105)
LAZ at 1y		-.30 (1.10)	-.20 (1.14)
	LAZ ≤ -2 SD	3 (6.5)	5 (4.8)
	LAZ ≤ -1 SD	10 (21.7)	20 (28.6)
BMIz at 1y		.48 (1.29)	.60 (1.03)
	BMIz ≥ 2 SD	6 (13.0)	10 (9.5)
Exclusive breastfeeding (m)		2.11 (1.43)	2.59 (1.79)
Breastfeeding (m)		6.91 (4.20)	7.82 (4.50)
Baseline yearly income (US$)		1275 (448.5)***	3208 (1947)
Baseline yearly income *per capita* (US$)		240.6 (75.2)***	772.2 (424.7)

* $p < .05$ *** $p \leq .001$

[a] Adolescent mothers pre-gestational BMI: BMI-for-age (BMIz).

[b] Adult mothers pre-gestational BMI: kg/m^2.

[c] Pre-gestational overweight: adult mothers with BMI ≥ $25kg/m^2$ and adolescent mothers with BMIz > 1SD.

[d] Stunted mothers: adult mothers with height < 155cm or adolescent mothers with HAZ < -2SD.

Table 6.3 – Differences in infant feeding practices between families living above or below the poverty line.

Variables	Poverty line status [a] <PL (n=46)	 >PL (n=105)	p
Infant feeding practices			
Exclusive breastfeeding < 4m	38 (82.6)	67 (63.8)	.021
Breastfeeding < 12m	30 (65.2)	59 (56.2)	.299
Early introduction			
Water/tea < 4m	25 (54.3)	47 (44.8)	.278
Non-human milk/formula	21 (45.7)	40 (38.1)	.384
Fruits (including juice)	9 (19.6)	18 (17.1)	.721
Porridge/pureed	8 (17.4)	10 (9.5)	.170
Sugar < 4m	22 (47.8)	55 (52.4)	.606
Soft drinks < 10m	28 (62.2)	59 (56.7)	.532
Food intake			
Lipid dense food 1^{st} year	24 (53.3)	61 (58.1)	.590
Sugar dense food 1^{st} year	16 (35.6)	39 (37.1)	.853
Unhealthy diet cluster	3 (8.3)	11 (11.2)	.759

[a] Analyses performed by chi-squared test.

Table 6.4 – Associations between SEBF and social determinants.

Variables	Exclusive breastfeeding < 4m *				
	Unadjusted OR	**95%CI**	**Adjusted OR****	**95%CI**	***p***
Step 1: SES block					
Maternal schooling (y)	.856	.750, .977			.021
Paternal schooling (y)	.947	.827, 1.08			.435
Unemployed mother (ref: employed)	1.02	.477, 2.16			.967
Unemployed father (ref: employed)	1.78	.363, 8.76			.477
Poverty line status: ≤ PL (ref: >PL)	2.69	1.14, 6.37			.024
Step 5: Final model					
Maternal schooling (y)			.866	.702, 1.07	.178
Poverty line status: ≤ PL (ref: >PL)			3.64	1.08, 12.56	.037
Extended family (ref: nuclear)			4.84	.755, 31.0	.096
Maternal pre-gestational overweight (ref: not overweight)			.635	.224, 1.80	.393
Birth interval (previous): ≤ 24m (Ref: only child or >24m)			.366	.087, 1.54	.171
Breastfed previous child ≥4m (ref: <4m)			.419	.139, 1.26	.122

* Logistic regression

** Adjusted for all variables in the model

Table 6.5 – Associations between breastfeeding for less than 12 months and social determinants.

Variables	Breastfeeding < 12m * Unadjusted OR	95%CI	Adjusted OR**	95%CI	p
Step 1: SES block					
Maternal schooling (y)	1.06	.936, 1.19			.375
Paternal schooling (y)	.967	.852, 1.10			.607
Unemployed mother (ref: employed)	1.12	.553, 2.26			.757
Unemployed father (ref: employed)	3.19	.652, 15.6			.152
Poverty line status at 6m (ref: >PL)	1.46	.712, 3.00			.301
Step 5: Final model					
Housing conditions: poor/fair (ref: good)			.371	.147, .937	.036
Breastfed previous child ≥4m (ref: <4m)			.237	.092, .612	.003
Length at birth (cm)			1.38	.956, 2.01	.085
Birth weight (100g)			.872	.736, 1.03	.114

* Logistic regression

** Adjusted for all variables in the model

Table 6.6 – Associations between early introduction of soft drinks and social determinants.

Variables	Soft drinks < 10m * Unadjusted OR	95%CI	Adjusted OR**	95%CI	p
Step 1: SES block					
Maternal schooling (y)	.827	.729, .939			.003
Paternal schooling (y)	.895	.787, 1.02			.091
Unemployed mother (ref: employed)	1.00	.493, 2.04			.994
Unemployed father (ref: employed)	.747	.206, 2.70			.656
Poverty line status at 6m (ref: >PL)	1.26	.614, 2.57			.533
Step 5: Final model					
Maternal schooling (y)			.782	.623, .981	.033
Paternal schooling (y)			1.08	.855, 1.35	.533
Housing material: other (ref: brick)			.607	.178, 2.07	.425
Maternal pre-gestational overweight (ref: not overweight)			2.57	.056, 1.72 .576, 4.89	.181 .343
Maternal pre-gestational overweight (ref: not overweight)			1.30	.539, 3.13	.560

* Logistic regression
** Adjusted for all variables in the model

CHAPTER 7

Extreme poverty is associated with higher risk of respiratory infections among infants

7.1 Abstract

Nearly 70% of the 6 million annual deaths of under fives affect infants. Programs targeting infant mortality focus mostly on breastfeeding, although less than 40% of infants are exclusively breastfed for 6 months worldwide. There is still little comprehension about the effect of poverty on breastfeeding practices. The objective of this study was to investigate whether poverty status would act as a modifier in a nutrition education intervention and participants living above and below the poverty line would have different results. A nutritional intervention was conducted with 200 low-income mother-child pairs in Sao Leopoldo, Brazil. The intervention was conducted during infants' first year of life, and focused on infants feeding. Overall, infants living above (APL) of below the poverty line (BPL) did not show different feeding styles, however, infants BPL had higher risk of developing respiratory infections (Relative Risk (RR) = 1.90, 95% Confidence Interval (95%CI) = 1.29, 2.81), while infants APL had higher risk of WHZ >2 SD (RR = 1.41, 95%CI = 1.11, 1.79). Living in extended families was associated with higher odds early cessation of breastfeeding (adjusted odds ratio (AOR) = 2.54, p = .027, for exclusive breastfeeding (EBF) < 1 month; AOR = 3.26, p = .009, for EBF < 4 months; AOR = 3.60, p = .053 for EBF < 6 months; and AOR = 3.16, p = .007, for breastfeeding < 12 months). Taken together, these data suggest that, even after receiving nutritional education, poorer infants are still at disadvantage compared to better-off infants, and thus, nutritional interventions should better target extremely poor families. Further, interventions should include not only mothers, but also other family member that might influence mothers' decisions regarding infant feeding practices, such as partners and, possibly, grandmothers.

7.2 Introduction

According to UNICEF, about 16,000 children die every day before reaching their fifth birthday, about 6 million children in 2015[43]. Further, most of these deaths are considered "preventable deaths", since they result from health problems that could be prevented of treated with proven and cost-effective interventions[44]. Progress has been made in childhood mortality, but progress is slower in infant mortality and neonatal mortality, and UNICEF estimated about 70% of all under-fives deaths happened within the first year of life[45]. Programs targeting infant mortality focus mostly on adequate breastfeeding and complementary feeding practices[183]. Adequate breastfeeding practices include timely initiation of breastfeeding (within 1 hour after birth), and exclusive breastfeeding until the infant completes 6 months of age, when semi-solid foods should be gradually introduced, while still maintaining free-demand breastfeeding until the child is 24 or more months[144]. However, less than 40% of infants are exclusively breastfed for 6 months worldwide[43], and interventions promoting breastfeeding are still needed. Nonetheless, there is currently little comprehension about which factors influence the decisions of the mothers regarding breastfeeding type and duration and little comprehension about the effect of poverty on breastfeeding practices.

Breastfeeding has short- and long-term benefits for both the mother and the infant, and these benefits have been extensively reviewed elsewhere[81,145,184]. For the mothers, exclusive breastfeeding is associated with greater weight reduction after birth compared to non-exclusive breastfeeding or early breastfeeding cessation[146,147]. Exclusively breastfeeding for 6 months is associated with lower likelihood of diarrhea and respiratory infections during infancy[78,81,145,148]. Longer breastfeeding duration is associated with slower pace of growth (which is associated with lower odds of obesity later in life)[149], lower risk of obesity during infancy[150], longer ulnar length[151], lower risk of early onset of puberty[152], and higher IQ scores and higher income at age 30[153]. However, longer breastfeeding duration, without adequate complementary feeding is associated with increased risk of undernutrition[132], highlighting the importance of adequate maternal education regarding breastfeeding and infant feeding.

Income and maternal education are among the most commonly reported factors related to the feeding practices of infants, but these associations are complex. Some studies found that more educated mothers were more likely to exclusively breastfeed and to offer complementary feeding after 4 months of the child[155-157], while some studies found the opposite[158]. Further, it has been previously reported that low-income women are less likely to breastfeed[159–161], while others reported low-income women breastfeed for a longer period[160,163], but not all[164]. Thus, there is a clear need for better comprehension abut factors influencing breastfeeding practices specially among the most vulnerable groups.

Intervention programs targeting child nutrition, in general target low-income communities, considered the most vulnerable individuals. It is believed that women from different socioeconomic (SES) background respond differently to educational programs. However, there is little investigation about how low-income women, living above or below the poverty line, respond to the same nutrition education program. Further, we need to understand if women from different poverty statuses respond differently to educational programs targeting infant feeding practices, so programs can be better targeted and have greater impact. Thus, the objective of this study was to investigate whether poverty status would act as a modifier in a nutrition education intervention and participants living above and below the poverty line would have different results. We hypothesize that mothers living below the poverty line (extreme poverty) will have worse outcomes than mothers living above this threshold (but are still poor).

7.3 Methodology

Study population, inclusion criteria and study group

The study sample consisted of 200 low-income Brazilian mother-child pairs allocated in the intervention group of the study "Implementation and Evaluation of the Impact of the Program of Promoting Healthy Feeding for Children Younger than Two Years" (*Implementação e Avaliação do Impacto do Programa de Promoção para a Alimentação Saudável para Crianças Menores de Dois Anos*), that is, only participants who did not receive the educational program. Details of the previous study can be found elsewhere[15]. Inclusion criteria included delivery in the maternity wards attended by the Brazilian public healthcare system (*Sistema Único de Saúde, SUS*) of the only maternity-hospital in the city of Sao Leopoldo, RS/Brazil, full-term (≥ 37 weeks) singleton and birth weight ≥ 2500g. Newborns who suffered from any impediment to breastfeeding, needed intensive care, had congenital malformation or were diagnosed with HIV/AIDS were excluded from the study. Although income was not inclusion criteria, delivery at the SUS wards of the hospital indicates a woman is from a lower socioeconomic class. The study protocol was approved by the Ethics Committee of the *Universidade Federal de Ciencias da Saude de Porto Alegre* and informed consent of the mother was obtained at study entry.

Intervention

From the 200 mother-child pairs who agreed to participate in this study and were allocated to the control group, 167 (83.5%) completed the first follow-up (at six months of the child) and 166 (83.5%) completed the second follow-up (when infants were about 12 months old). One hundred and fifty-seven mother-child pairs completed both follow-ups (78.5% of the original sample) and were included in this study. Trained research assistants, in pairs, conducted the intervention, which consisted in 10 home-visits, being one visit within the first 10 days after birth (visit 1), then monthly from 1 to 6 months (visits 2 to 7) and bimonthly from 8 to 12 months (visits 8 to 10). During those visits, accordingly to infants age and development, mothers were appropriately counseled on the Ten steps to healthy feeding manual[14], which is based on the WHO breastfeeding guidelines.

Data collection

Other group of research assistants collected anthropometric and income data during the follow-up visits, which did not coincide with intervention visits. In addition to the follow-up visit at the end of the intervention, when infants were 12 months old, research assistants also visited participants at 6 months of the child, to reduce the risk of memory bias for information regarding age at introduction of specific food items, breastfeeding practices and health of the infant. At the 6-months interview, mothers were asked if the infant was being exclusively breastfed. If answer was yes, mothers were prompted about the intake of water, tea and other liquids by the infant. Infants were considered exclusively breastfed if only breast-milk was being offered. If answer was no, mothers were asked when (in which month) infants were offered specific food items. Food items were selected from a previous published list of items commonly introduced in infants feeding[166].

Anthropometric and morbidity data of infants were collected at both 6- and 12-months follow-ups. Mothers were asked whether the infant had had up fever that required fever-reducing medication, diarrhea for more than three days, respiratory problems (cough, runny nose, difficult breathing) or required hospital admission currently or during the past 30 days. Mothers were referred to the neighborhood health clinic, where blood analyses could be conducted. Length of the infants was measured using a portable infant stadiometer (Serwital Inc., Brazil) and weight was measured using a portable scale (Techline, Brazil), with the infants wearing no clothes and no shoes (the diaper weight was collected from a table with average table weight and subtracted from the weight of the infant). Length was measured to the nearest 1cm and weight was measured to the nearest 100g. Maternal pre-pregnancy weight was self-reported, but maternal height and weight were measured at the 6-months follow-up, using a portable digital scale (Techline, Brazil) and a portable stadiometer (SECA, Germany), respectively, with participant wearing light clothing and no shoes. Height was measured to the nearest 1cm and weight was measured to the nearest 100g.

Study outcomes

The outcomes of interest were the same as published in the original study[15]: exclusive breastfeeding duration less than 1, 4 and 6 months, breastfeeding during less than 6 and 12 months, consumption of lipid-dense and sugar-dense food items, occurrence of morbidities (diarrhea, fever, respiratory infections, hospitalization and anemia) and LAZ below -2 SD (stunting) and WHZ above +2 SD (overweight). Nutritional status of infants was assessed according to the WHO growth standards[3]. Although BMI-for-age *z* score (BMIZ) is usually used for overweight and obesity screening[185], weight-for-height *z* score (WHZ) was chosen so the results could be compared to the results of the original study[15]. Further, BMIZ and WHZ are highly correlated[186]. The consumption of lipid-dense (LDF) and sugar-dense foods (SDF) was assessed by asking the mothers whether infants had consumed sugar, honey, candy and soft drink (SDF) and sandwich-cookies, chocolate and cheese-puffs (LDF). Consumption of SDF or LDF was considered only if the infant consumed all items within the category during the previous month. Anemia was defined as hemoglobin below 11g/dL[187]. We further investigated linear growth from birth to 6 months, 6 to 12 months and birth to 12 months, calculated as length difference between the ages.

Statistical analyses

Participants were grouped according to their daily *per capita* income in above or below the poverty line, defined as US$1/day *per capita*, according to the World Bank relative poverty line for that year[34]. Since nutritional outcomes result from continuous conditions, we used the financial data collected at the 6-months follow-up as the baseline socioeconomic status (SES).

Descriptive statistics of the sample are presented as mean and standard deviation (SD) or frequency for continuous or categorical variables, respectively, and normality was assessed using the Kolmogorov-Smirnov test. Differences between participants living above or below the poverty line were tested using Chi-squared test and student's *t* or Mann-Whitney tests, for categorical and continuous variables, respectively. Logistic regression was used to determine the association between the outcome of interest (coded 1 if outcome was present or 0 if outcome was not present) and poverty line. Poverty line status was the independent variable of interest and the model was adjusted for maternal age (adolescent mothers = 1), maternal education and family structure (extended families = 1).

$$\text{outcome} = b_0 + b_1 \text{ x poverty level} + b_2 \text{ x maternal age} + b_3 \text{ x maternal education} + b_4 \text{ x family structure}$$

Statistical significance was determined as $p < 0.05$. All analyses were conducted in SPSS for Mac, version 23[109].

7.4 Results

Results of the original study from Vitolo et al., are presented in Table 7.1 (translation from Portuguese, from the original publication, to English). General characteristics of the study sample are summarized in Tables 7.2 and 7.3. Fifty-six percent of infants were boys (n=93), average birth weight was 3381g, and 53% of mothers were overweight or obese 6 months after delivery. Only about one-fourth of the parents had completed middle school education and 36% of participants were living below the poverty line (Table 7.2). Participants living below or above the poverty line had similar baseline characteristics, except for income and maternal education (Table 7.3).

Overall, intervention outcomes did not differ between participants living below or above the poverty line, expect for occurrence of respiratory infection and WHZ (Table 7.4). Infants living below the poverty live were almost twice as likely to have had respiratory infections during the first year of life, compared to infants living above the poverty line (RR = 1.90, 95%CI = 1.29, 2.81) and had lower average WHZ (difference below poverty line – above poverty line (d) = -0.48, SE = .172). Infants living above the poverty line had higher risk of WHZ above +2 SD (RR = 1.41, 95%CI = 1.11, 1.79).

In logistic regression analyses, extreme poverty was associated with higher odds of respiratory infections during the first year of live, and association remained significant after adjusting for maternal education, civil status and employment (Table 7.5). Poverty line and the other confounding variables were not statistically significant associated with exclusive breastfeeding practices, however, living in extended families was associated with increased odds of SBFD (aOR= 2.54, p = .027, for exclusive breastfeeding less than 1 month; aOR = 3.26, p = .009, for exclusive breastfeeding for less than 4 months; and aOR = 3.60, p = .053 for exclusive breastfeeding for 6 months). Living in extended families was also associated with increased odds of breastfeeding for less than 12 months (aOR = 3.16, p = .007) and LDF consumption (aOR = 2.43, p = .036), while infants from adolescent mothers had higher odds of needing hospitalization (aOR = 5.88, p = .032) and being anemic (aOR = 2.97, p = .048) during the first 12 months of life. In adjusted model, infants living under extreme poverty had higher odds of respiratory infections during the first year of life and lower odds of being overweight at 1 year (Table 7.5).

7.5 Discussion

About 6 million children younger than five years die yearly[43], mostly from preventable causes[44]. Seventy percent of those deaths happen within the first year[45], and efforts to reduce infant mortality focus mostly on adequate breastfeeding and complementary feeding practices[183]. However, less than 40% of infants are exclusively breastfed for 6 months worldwide[43], and interventions promoting breastfeeding are still needed, although there is currently little comprehension about the effect of poverty on breastfeeding practices. In this study, there were no significant differences in infant feeding practices between mothers living above or below the poverty line and participated in a nutrition education program. However, living in extended families was associated with general worse breastfeeding practices.

In our sample, about 6% of infants were stunted and 10% were overweight at 1 year. These results are in agreement with previous studies conducted with under-fives in a similar Brazilian sample[57,189] and American infants[9]. While the prevalence of stunting was similar for infants living above or below the poverty line, better-off infants were about 40% more likely to be considered overweight than infants from poorer families. These findings are in agreement with previously published studies for developing countries[91,102,119,190-193]. In a cross-section study conducted with about 4,000 children 1 to 59 months, Vitolo and colleagues found that children from higher socioeconomic status had about 50% higher odds of being overweight (WHZ > 2 SD) than lower income children[57]. While childhood overweight is inversely associated with income in high-income nations[100,194], higher socioeconomic status is associated with increased risk of overweight in developing nations. Independent of nation's economic development, reduced physical activity due to increased television time and to unsafe neighborhood for playing outside are usually regarded as reasons for the increased risk of childhood obesity[192]. However, our sample is comprised on 12-months old infants, which do not usually play outdoors. For this age group, increased risk of overweight might be related to increased consumption of highly energy-dense and ultra-processed food items by the better-off families, although we did not see statistical differences in SDF and LDF consumption.

Overall, infants living above or below the poverty line did not differ in the intervention outcomes related to feeding habits and overall health of the infants. In the original study, infants allocated to the intervention group were less likely to have had diarrhea or respiratory problems up to one month prior to the interview compared to those in the control group[15]. While poverty line was not associated with diarrhea, those living under extreme poverty were more likely to have had respiratory problems than the better-off infants. These findings highlight the fact that not all low-income families are the same and that the poorest of the poor have worse outcomes, even after participating in an intervention. Those families are in disadvantage and, although interventions should not exclude slightly better-off poor individuals, interventions should improve targeting and adequate the strategies so the poorest and most vulnerable individuals in the society also get benefited.

In addition to the socioeconomic environment, the social network or family environment also influence the decisions of the mothers regarding infant feeding. In this context, the role of grandmothers goes beyond direct infant care. They are not only caregivers of the infants, but also caregivers of the mother and the family, and advisers, influencing the mothers feeding practices decisions[137,195]. Indeed, we found that living in extended families was associated with worse breastfeeding and feeding practices, as well as worse health outcomes. Infants who lived in extended families had higher odds of breastfeeding cessation at all studied time-points (exclusive breastfeeding at 1, 4 and 6 months and breastfeeding at 12 months), LDF consumption during infancy, and being hospitalized or anemic at 12 months. Family structure is not directly associated with family income, but living with relatives might be an indicator of poorer socioeconomic status among low-income individuals, despite income *per capita*. The poverty line and income *per capita* do not differentiate between family members age, but living costs of adults are different from living costs of children, and family size and living costs do not increase at the same rate[196]. Another possible explanation for the worse outcomes could be due to the complex family interactions that happen in bigger families, specially when grandmothers or other relatives are involved. Others have found that while introduction of complementary feeding is done mostly by the mothers, in 17% of infants, grandmothers are the one to first introduce solid food. In the same study, authors found that in 20% of the cases, mothers did not follow the infant feeding guidelines of the pediatricians due to interference of the grandmothers[65]. These results are in agreement with Susin and colleagues study, which also found that non-daily contact with grandmothers was associated with lower odds of early exclusive breastfeeding cessation[197].

Our study had a few limitations that need to be addressed. First, our sample did not include low-birth weight (LBW) newborns (<2500g), which limited the sample size and the association between social determinants and breastfeeding practices. However, it has been previously reported that predictors of breastfeeding practices differ between LBW and infants with birth weight above 2500g[162], and by excluding LBW infants, we might have avoided biased results. A second limitation of our study is the fact we relied on the memory of the mothers about the age of introduction of the food items, which could lead to recall bias. Nonetheless, the addition of a follow-up at 6 months could have mitigated this problem. Finally, we were not able to isolate the grandmother presence in the household, to confirm our hypothesis of grandmother interference. Strengths of our study include the fact that trained nutrition undergraduate students conducted the interviews, the inclusion of several socioeconomic factors in the models, and the hierarchical approach to the regression analyses.

In conclusion, we found that participants living above or below the poverty line had similar infant feeding practices after participating in a nutrition education program, but showed different intervention-related outcomes. Despite the overall improvements in occurrence of respiratory infections among intervention participants compared to control, those living below the poverty line had about 3 times the risk of having respiratory problems compared to those living above the poverty line. On the other hand, compared to extremely poor infants, those better-off had higher risk of being overweight at 12 months. Thus, interventions to improve the overall health of infants and infants feeding practices should focus on low-income individuals, but should better target the intervention so it reaches all poverty levels. Further, interventions to reduce undernutrition should be revised in order to not predispose infants to overweight. Finally, our study highlights the importance of family structure on the feeding practices of infants. We found that those living in extended families had worse feeding outcomes, and thus, interventions should include not only mothers, but other family members that might be involved in the caretaking or might be advise mothers regarding infant feeding practices, such as grandmothers.

Table 7.1 – Results from the primary study of Vitolo et al.[15].: Simple frequencies and percentiles, relative risk (RR) and 95% confidence interval (95%CI) of outcomes accordingly to intervention or control groups*

Variable	Intervention n (%)	Control n (%)	RR	95%CI	p
Feeding practices					
Exclusive breastfeeding					
Less than 1 month	54 (33.3)	111 (48.0)	.69	.54, .90	.004
4 or more months	73 (45.1)	66 (28.6)	1.58	1.21, 2.06	.001
6 months	31 (19.1)	19 (8.2)	2.34	1.37, 3.99	.001
Breastfeeding					
At 6 months	114 (66.3)	134 (55.6)	1.19	1.02, 1.39	.037
At 12 months	86 (52.8)	98 (41.9)	1.26	1.02, 1.55	.040
Morbidity outcomes					
Diarrhea	46 (28.4)	98 (42.0)	.68	.51, .90	.006
Fever	77 (47.5)	115 (49.3)	.96	.78, 1.19	.721
Respiratory infections	42 (25.8)	96 (41.0)	.63	.46, .85	.002
Medication	19 (11.7)	49 (20.9)	.56	.34, .91	.017
Hospitalization	9 (5.5)	15 (6.4)	.86	.38, 1.91	.715
Hemoglobin < 11g/dL	104 (66.2)	131 (61.8)	1.07	.92, 1.25	.380
Nutritional status					
LAZ ≤ -2 SD	9 (5.5)	13 (5.6)	.98	.43, 2.24	.980
WHZ ≥ 2 SD	9 (5.5)	13 (5.6)	.98	.43, 2.24	.980

* Translation of Table 2 from original publication: Vitolo et al., 2005[15].

Table 7.2 – General characteristics of the sample.

	n (%)	Mean (SD)	Range
Boys	88 (56.1)	-	-
Birth weight (g)	-	3393 (452.6)	2540 – 5200
Length at birth (cm)	-	48.8 (1.87)	44.0 – 54.0
Gestational age (w)	-	39.3 (1.32)	37 – 43
Maternal age (y)	-	25.9 (6.71)	15 – 43
≤19y	29 (18.5)	-	-
20-35y	112 (71.3)	-	-
>35y	16 (10.2)	-	-
Maternal BMI	-	-	-
Adolescent mothers[@]	-	.74 (1.03)	-1.22 – 2.24
Adult mothers[$]	-	26.8 (5.78)	15.62 – 45.80
Maternal overweight[%]	80 (53.3)	-	-
Maternal height (cm)	-	157.5 (6.34)	141 – 177.5
Stunted mothers[&]	40 (25.5)	-	-
Weight gain during gestation (kg)	-	12.49 (6.03)	2.0 – 36.0
Adolescent mothers	-	14.80 (7.99)	3.0 – 36.0
Adult mothers	-	11.94 (5.35)	2.0 – 31.5
Maternal schooling (y)		6.66 (2.74)	1 - 12
1-4 y	41 (26.3)	-	-
5-8 y	72 (46.2)	-	-
9-11 y	42 (26.9)	-	-
≥ 12 y	1 (0.6)	-	-
Paternal schooling (y)		6.83 (2.88)	1 - 19
1-4 y	31 (21.7)	-	-
5-8 y	78 (54.5)	-	-
9-11 y	33 (23.1)	-	-
≥ 12y	1 (0.7)	-	-
LAZ at 1y	-	-.28 (1.01)	-3.24 – 2.27
LAZ ≤ -2 SD	9 (5.7)	-	-
WHZ at 1y	-	.66 (1.06)	-1.88 – 3.90
WHZ ≥ 2 SD	15 (9.6)	-	-
Baseline yearly income (US$)	-	2274 (1635)	319 – 12,631
Baseline yearly income *per capita* (US$)	-	527.1 (419.7)	64 – 3197
Income *per capita* ≤US$1/day at 6m (≤PL)	57 (36.3)	-	-

[@] Adolescent mothers: ≤ 19y, [#] Adult mothers: ≥20y at birth of the child.
[%] Overweight: BMI 6m post-partum ≥25kg/m^2 for adult mothers or BMIz > 1 for adolescent mothers.
[&] Stunted mothers: adult mothers with height < 155cm or adolescent mothers with HAZ < -2SD.

Table 7.3 – Characteristics of the sample according to poverty status.

Characteristic		< PL (n=57)[1]	> PL (n=100)
Boys (%)		30 (52.6)	58 (58.0)
Birth weight (g)			
	Mean	3339	3425
	SD	477.6	437.1
Length at birth (cm)			
	Mean	48.8	48.8
	SD	1.97	1.82
Gestational age (w)			
	Mean	39.2	39.3
	SD	1.24	1.37
Maternal age (y)		25.6 (6.94)	26.0 (6.62)
	≤19y	12 (21.1)	17 (17.0)
	20-35y	37 (64.9)	75 (75.0)
	>35y	8 (14.0)	8 (8.0)
Maternal BMI			-
	Adolescent mothers[@]	.95 (1.18)	.58 (.92)
	Adult mothers[$]	27.5 (4.88)	26.3 (6.21)
	Maternal overweight[%]	36 (65.5)*	44 (46.3)
Maternal height (cm)		-	157.5 (6.34)
	Stunted mothers[&]	40 (25.5)	-
Weight gain during gestation (kg)		11.94 (5.86)	12.80 (6.13)
	Adolescent mothers	13.68 (8.27)	15.59 (7.95)
	Adult mothers	11.44 (4.96)	12.20 (5.55)
Maternal schooling (y)		5.84 (2.42)**	7.13 (2.82)
	1-4 y	21 (36.8)*	20 (20.2)
	5-8 y	28 (49.1)	44 (44.4)
	9-11 y	8 (14.0)*	34 (34.3)
	≥ 12 y	0 (0.0)	1 (1.0)
Paternal schooling (y)		5.74 (2.35)***	7.42 (2.98)
	1-4 y	15 (30.0)	16 (17.2)
	5-8 y	30 (60.0)	48 (51.6)
	9-11 y	5 (10.0)*	28 (30.1)
	≥ 12y	0 (0.0)	1 (1.1)
Baseline yearly income (US$)			
	Mean	1207***	2882
	SD	450.9	1751
Baseline yearly income *per capita* (US$)			
	Mean	238.2***	691.7
	SD	70.59	446.5

[1] Different from above the poverty line: * $p < .05$ ** $p < .01$ *** $p \leq .001$

[%] Maternal overweight: BMI ≥25kg/m^2 for adult mothers or BMIz > 1 for adolescent mothers.

[&] Stunted mothers: adult mothers with height < 155cm or adolescent mothers with HAZ < -2SD.

Table 7.4 – Effect of dietary counseling of mothers during the first year of life of the infants on feeding practices and health outcomes

Variables	Poverty line status <PL (n=57)	>PL (n=100)	p
Infant feeding practices			
Exclusive breastfeeding[¢]			
Less than 1 month	15 (26.3)	35 (35.4)	.244
Less than 4 months	28 (49.1)	57 (57.0)	.341
Less than 6 months	44 (77.2)	82 (82.0)	.467
Breastfeeding[¢]			
Less than 6 months	12 (21.1)	32 (32.0)	.142
Less than 12 months	22 (38.6)	46 (46.0)	.368
Food intake[¢]			
Lipid dense food 1st year	21 (36.8)	30 (31.6)	.506
Sugar dense food 1st year	6 (10.5)	19 (20.0)	.127
Infants health outcomes[¢]			
Diarrhea	14 (24.6)	31 (31.0)	.391
Fever	27 (47.4)	43 (43.4)	.634
Respiratory infection	22 (38.6)	17 (17.0)	.003
Hospitalization	3 (5.3)	5 (5.0)	1.00
Anemia	40 (70.2)	60 (60.0)	.202
Infants nutritional status			
WHZ ≥ 2 SD[¢]	2 (3.5)	13 (13.0)	.052
WHZ[$]	.35 (.907)	.83 (1.11)	.007
LAZ ≤ -2 SD[¢]	4 (7.0)	5 (5.0)	.724
LAZ[$]	-.41 (1.00)	-.21 (1.01)	.221
Infant growth[%]			
Linear growth 0-6m (cm)	17.6 (2.52)	18.3 (1.82)	.117
Linear growth 6-12m (cm)	8.18 (2.00)	8.20 (2.02)	.839
Linear growth 0-12m (cm)	25.8 (2.47)	26.5 (2.41)	.120

[¢] Analyses performed by chi-squared test.
[$] Analyses performed by Student's *t* test.
[%] Analyses performed by Mann-Whitney test..

Table 7.5 – Association between outcomes with poverty line and social variables

Variable	Unadjusted[@] OR	Unadjusted[@] 95% CI	Unadjusted[@] p	Adjusted[#] OR	Adjusted[#] 95% CI	Adjusted[#] p
Exclusive breastfeeding						
Up to 1 month	.635	.310, 1.30	.214	.630	.289, 1.37	.246
Less than 4 months	.728	.379, 1.40	.341	.672	.328, 1.37	.275
Less than 6 months	.743	.333, 1.66	.468	.683	.291, 1.60	.381
Breastfeeding						
Less than 6 months	.567	.264, 1.21	.145	.528	.233, 1.20	.127
Less than 12 months	.738	.380, 1.43	.369	.647	.311, 1.35	.244
Food intake						
Lipid dense foods	1.26	.634, 2.52	.506	1.15	5.32, 2.47	.728
Sugar dense foods	.471	.176, 1.26	.133	.423	.150, 1.19	.104
Health outcomes						
Diarrhea	.725	.347, 1.51	.392	.696	.322, 1.50	.356
Fever	1.17	.609, 2.25	.634	1.17	.577, 2.37	.663
Respiratory infections	3.07*	1.45, 6.47	.003	3.14*	1.38, 7.17	.006
Hospitalization	1.06	.243, 4.59	.943	.900	.194, 4.17	.893
Anemia	1.57	.783, 3.14	.204	1.75	.824, 3.74	.145
Medication	1.06	.364, 3.08	.917	.962	.294, 3.15	.949
Nutritional status						
LAZ $\leq$ -2 SD	1.43	.369, 5.57	.603	1.14	.279, 4.62	.859
WHZ $\geq$ 2 SD	.243	.053, 1.12	.070	.116*	.014, .952	.045

[@] Bivariate association between outcomes and poverty line status.
[#] Adjusted for maternal age, family structure and maternal education.

CHAPTER 8

Conclusions and Future Directions

Stunting affects 159 million children under the age of five throughout the world, while 41 million children are overweight[5]. In general, poor nutritional and health outcomes are associated with poverty[8,95,104]. Studies have shown an inverse association between income and risk of stunting[38,110], but the association between income and childhood obesity is still controversial[97,121]. Further, most studies reporting an association between nutritional status of children and income include samples from different social strata that could result from differences in overall living conditions associated with income, that is, better access to nutritious foods, health care and medication, clean water, and sanitation, among others. Poverty has several dimensions and can be defined in several ways, not only as monetary (income) poverty. In fact, there is no universal definition of poverty. UNICEF defines "basic needs poverty", for instance, as "lack of essential goods or services", such as clean water or the ability to attend school[37]. Thus, sociodemographic characteristics should also be taken into consideration when investigating the influence of poverty on health and nutrition of individuals. The objective of this dissertation was to determine how social and parental characteristics influence nutritional status of children relative to (income) poverty. Since the sample included only participants from low socioeconomic status, this study was able to avoid living conditions discrepancies between high and low income individuals.

It was hypothesized that children living under extreme poverty would have lower height-for-age *z* score (HAZ) and higher body mass index-for-age *z* score (BMIz) compared to those living above the poverty line, from 1 to 7 years of age, as well as poorer overall health. There were no significant differences in nutritional status between participants who lived above or below the poverty line during infancy and preschool age. However, when children were 7 years old, those who lived below the poverty line had lower HAZ, grew less from 4 to 7 years, and had higher risk of stunting at age 7. Although growth faltering starts immediately after birth, probably resulting from intrauterine growth restriction[84,116], it is possible that milder growth retardation takes longer to become apparent and might be very small, making it difficult for parents and health care practitioners to identify children who are slowing but steadily showing signs of growth retardation from those who are short but healthy children (the healthy children from the reference populations of the growth charts).

The health and nutritional status of children are influenced by both nutrition and living conditions. Frequent infections during the first years of life (symptomatic or asymptomatic), usually related to water and sanitation conditions, are associated with poorer nutritional status[198]. Thus, families living below the poverty line have worse overall living conditions (water, sanitation, and hygiene conditions, for instance), while access to food may be similar between the two groups. Food acquisition among low-income families might not be solely dependent on buying food, as it can be acquired from government programs, school lunch programs, assistance from friends and relatives, home-grown, or donations[112-114]. It is possible that, more than income, living conditions of poor families are associated with poorer nutritional outcomes.

It was of interest to determine whether poverty-related social determinants would be better predictors of nutritional status of low-income children at different ages. Maternal height and paternal education were associated with lower odds of stunting at the three time points (1, 4 and 7 years). Others have suggested that, with respect to child care, men are *advisees* and not *advisors,* and the involvement of men in child care is very limited in most societies[137,139]. Most studies have reported an association between maternal education and childhood nutritional status, but few studies have collected data on paternal education[140,141]. Our findings suggest that fathers may be more involved in caregiving than previously reported, either for feeling more confident in caring for a child or for necessity in helping the mother. LAZ at age 1-year was associated with lower odds of stunting at 4 and 7 years, while BMIz was associated with higher odds of overweight at 4 and 7 years. These findings are in accordance with the current recommendation of early interventions, focusing on the first 1,000 days.

Regarding living conditions, participants living in extended families grew about 1 inch more from birth to 12 months than infants living in nuclear families. This could be due to the help provided by grandmothers during the first year of life of the child, as grandmothers (or other older women) often play roles of both advisors and caregivers by "training" or "teaching" the new mothers[137-139]. We hypothesized the similarities in the nutritional status of children living above of below the poverty line at infancy and preschool age could result from similar infant feeding practices between the two groups, and that the faster growth of infants living in extended families could result from differences in caregiving practices due to the presence of other relatives in the homes. The presence of grandmothers, for instance, could be associated to better breastfeeding practices.

Some studies have found poorer infant feeding styles among women with lower education[154-157] and/or lower SES[159-164] but, again, mostly including women from different socioeconomic statuses. In agreement with other, we found that mothers living below the poverty line were less likely to exclusive breastfeed for 4 and 6 months compared to better-off mothers. Better maternal education was also associated with lower odds of short exclusive breastfeeding duration (SEBF), but after adjusting for confounders, association between SEBF and maternal education lost significance, while strengthening the association with poverty line, indicating the association between poverty status and SEBS is independent of maternal education. Living in extended families was not associated with infant feeding styles.

Although nutritional status of infants living above or below the poverty line were similar, poorer infants were less likely to be exclusive breastfed for 1, 4 and 6 months. These differences did not result in length/height-for-age and BMI-for-age *z* scores at 1 and 4 years, but exclusively breastfeeding is associated with lower likelihood of diarrhea and respiratory infections during infancy[78,81,145,148], while longer breastfeeding duration is associated with slower pace of growth (which is associated with lower odds of obesity later in life)[149], lower risk of obesity during infancy[150] and longer ulnar length[151]. It is possible that the shorter exclusive breastfeeding duration among poorer infants could be associated with the increased risk of stunting and lower linear growth at 7 years.

In general, individuals from low-income families have poorer health outcomes, and nutritional interventions, particularly those focusing on infant and child health, typically target lower income individuals, to alleviate nutritional and health gaps between lower and higher income individuals. Thus, we further investigated whether participation in a nutritional intervention targeting infants feeding practices would affect similarly low-income families living above or below the poverty line. After a 12-months intervention programs, from birth to 12 months of life, infant feeding practices were similar for the two groups, indicating that poverty status did not negatively affect maternal comprehension about infant feeding guidelines. However, despite the overall improvements in occurrence of respiratory infections among intervention participants compared to control, reported previously[15], infants living below the poverty line had about 3 times the risk of having respiratory problems compared to those living above the poverty line. This finding indicates that, even after participating in nutritional interventions, extremely poor individuals are still more vulnerable to worse health conditions. Nutrition interventions mostly involve behavioral changes (in this case, the behavior of the mothers regarding infant feeding styles), but do not change the environment. Living in worse conditions increases the risk of infections. While nutritional interventions could help reduce the severity and duration of such conditions, they have limited ability to reduce the incidence of infections. Moreover, the intervention did not affect the nutritional status of infants in the original study[15], however, we found that those living above the poverty line had higher risk of being overweight at 12 months. Most infant feeding interventions are developed to improve nutritional status by reducing undernutrition rates, and until recent years, childhood obesity was not considered a public health problem in developing countries such as Brazil. Our findings highlight the importance of addressing both undernutrition and overweight conditions when developing a nutritional intervention, particularly in nation going through nutrition transition.

Contrary to our hypothesis, children living below the poverty line did not have higher average BMIz, and, in fact, BMIz at 4 years was positively associated with family annual income. The association between income and risk of childhood obesity in developing countries has been previously reported[95,97,117-119]. Even among low-income families, those slightly better-off might have higher purchasing power and, thus, be more likely to buy industrialized and empty-calorie food items[95,118]. The lack of association between poverty and overweight during infancy and mid-childhood was not surprising. Previous studies have reported the incidence of picky eaters is highest during early infancy, and in most cases, lasts about 2 years[120]. It is possible that prevalence of picky eaters in our study was highest during preschool age and declined during mid-childhood. With that, higher-income mothers in our study could have been more likely to offer industrialized and energy-dense food to their picky eaters at age 4, in order to feed them with their preferred snacks, resulting in overweight at that age. Further studies need to be conducted to assess how income influences the diet of picky eaters.

Finally, we found that taller newborns were less likely to be stunted at 12 months and LAZ at 1 year was associated with lower odds of stunting 4 and 7 years. In addition, pre-gestational maternal overweight and child's BMIz at 1 year were associated with BMIz at 4 and 7 years. Taken together, these findings are in agreement with the current global strategy to alleviate and prevent childhood undernutrition by focusing on the first 1,000 days of life. Pubic health interventions aiming to reduce or alleviate growth retardation should focus on improving pregnancy health status and, thus, reducing the number of preventable LBW and premature babies. Such interventions should also focus on improving nutritional status of infants. In addition, interestingly, social factors were not associated with BMIz at 1, 4 and 7 years. The results for childhood overweight emphasize that the focus on the first 1,000 days should include pre-conception nutrition and health and efforts should be made not only to prevent undernutrition, but also childhood obesity.

Future researches in this topic could include larger samples and inclusion of LBW and premature newborns, to investigate how different poverty dimensions influence the nutritional status of children with different baseline health conditions. Further analyses could also include the use of structural equation modeling, which would allow the identification of interaction among factors, and how such interactions influence the outcomes, allowing the identification of factors that direct influence the nutritional status of children and factors that exert this influence indirectly, by influencing other factors.

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