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DIRECT AND INDIRECT EFFECTS OF CHILDHOOD CONDITIONS ON HEALTH AT OLDER AGES: THE CASE OF BRAZIL

Belo Horizonte
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Orientador: Prof. Dr. Cássio Maldonado Turra
Co-orientadora: Profª. Dra. Luciana Soares Luz do Amaral

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ATA DE DEFESA DE DISSERTAÇÃO

RAQUEL RANDOW BAHIA (Nº DE MATRÍCULA 2019657451)

Às quatorze horas do dia três do mês de setembro de dois mil e vinte e um, reuniu-se por videoconferência a Comissão Examinadora de DISSERTAÇÃO, indicada *ad referendum* pelo Colegiado do Curso em 17/08/2021, para julgar, em exame final, o trabalho final intitulado *"Direct and Indirect Effects of Childhood Conditions on Health at Older Ages: The Case of Brazil"*, requisito final para a obtenção do Grau de *Mestra em Demografia*. Abrindo a sessão, o Presidente da Comissão, Prof. Cássio Maldonado Turra, após dar a conhecer aos(às) presentes o teor das Normas Regulamentares do Trabalho Final, passou a palavra à candidata, para apresentação de seu trabalho. Seguiu-se a arguição pelos(as) examinadores(as), com a respectiva defesa da candidata. Logo após, a Comissão composta pelos(as) professores(as): Cássio Maldonado Turra (Orientador) (Cedeplar/FACE/UFMG); Luciana Soares Luz do Amaral (Coorientadora) (Cedeplar/FACE/UFMG); Laura Lídia Rodríguez Wong (Cedeplar/FACE/UFMG) e Juliana Vaz de Melo Mambrini (Fiocruz Minas) se reuniu, sem a presença da candidata, para julgamento e expedição do resultado final. A Comissão **aprovou** a candidata por unanimidade. O resultado final foi comunicado à candidata pelo Presidente da Comissão. Nada mais havendo a tratar, o Presidente encerrou a reunião e lavrou a presente ATA, que será assinada por todos os membros participantes da Comissão Examinadora. Belo Horizonte, 03 de setembro de 2021.

BANCA EXAMINADORA - participações por videoconferência:

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LAURA LÍDIA RODRÍGUEZ WONG
Coordenadora do Programa de Pós-Graduação em Demografia

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Começo fazendo um apanhado geral de expectativas *versus* realidade do processo de dissertação. As expectativas são sempre mais gostosas! Ah, a definição do tema, me lembro bem quando contei ao professor José Alberto e ele me disse que gostaria muito de saber a resposta desta inquietante pergunta de pesquisa. Eu esperava uma escrita praticamente coletiva, com meus colegas da coorte, com muitas discussões com meus orientadores, sonhava até com a festa após a defesa! A expectativa incluía várias tardes na UFMG, congressos internacionais, a monitoria de TAD, e tanta coisa mais. A realidade, foi um tanto quanto diferente, fomos atropelados pela pandemia e afastados bruscamente para o *home office*. O apoio dos colegas deixou de ser técnico e passou a ser quase um grupo de apoio emocional, as discussões foram transformadas em reuniões virtuais, manter o bom humor se tornou tarefa difícil, e o processo muito mais solitário. Tudo isso, sem pensar na perda do Zé Alberto (ah, que saudade). Na realidade, o convívio se restringiu a família, e Rafa e eu tivemos que deixar de acampar no nosso apartamento e começar a ter móveis (esta parte até que foi boa). Agora prestes a "cruzar a linha de chegada", com o trabalho pronto, ou pelo menos, na última versão, eu ainda sinto um orgulho muito grande do que produzi, e uma gratidão maior ainda pelos que me acompanharam.

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Abstract

The expression 'the long arm of childhood' refers to the long-term effects of childhood conditions on health in old age. According to this theory, inequalities start early in life and can have enduring health consequences across an individual's life (FERRARO; SCHAFER; WILKINSON, 2016). There is still an open agenda to investigate the impacts of exposures in childhood and the role of mediators on health at older ages in developing countries, like Brazil. The general aim is to examine the association between childhood socioeconomic and health circumstances and health outcomes in old age, in Brazil. The present study is based on a nationally representative, population-based survey, the Brazilian Longitudinal Study of Aging (ELSI-Brazil) (LIMA-COSTA et al., 2018). The method applied is the Structured Equation Modeling (SEM). We proposed three additive models for each of the four health outcomes: self-rated health, functional limitation, chronic conditions and a latent variable that includes all three observed variables. Model I measures the direct effect of childhood circumstances on health at old ages. Model II includes the indirect effect of education in the association between childhood and health at old ages. Model III adds health behaviors (physical activity, alcohol consumption, smoking and private health plans) to the second model. All three models control for gender and age. We confirmed the existence of 'the long arm of childhood in Brazil'. The results show that childhood health and socioeconomic status impact directly and positively health outcomes later in life. Moreover, the models for self-rated health, chronic conditions and the latent old age health variable support the indirect association through the mediating role of education. On the other hand, the models for functional limitations at old ages did not support this hypothesis. None of the models show a significant and indirect association between diseases during childhood and health at older ages. Regarding the theoretical models of life course epidemiology, our results support more than one theoretical/conceptual model to explain the determinants of health among the elderly throughout the life trajectory, Critical Period Model as well as Chains of Risk.

Resumo

A expressão *'the long arm of childhood'* se refere aos efeitos de longo prazo das condições da infância na saúde dos idosos. De acordo com esta teoria, as desigualdades se iniciam muito cedo no curso de vida do indivíduo e tem consequências duradouras ao longo da vida (FERRARO; SCHAFER; WILKINSON, 2016). Ainda existe espaço nas agendas de pesquisa que investigam os impactos de exposições negativas experimentadas na infância, bem como o papel de mediadores, nesta associação com as condições de saúde dos idosos em países em desenvolvimento como o Brasil. O objetivo geral é examinar a associação entre condições socioeconômicas e de saúde com as condições de saúde dos idosos no Brasil. O presente estudo utiliza a base de dados populacional representativa nacionalmente, Estudo Longitudinal da Saúde dos Idosos (ELSI-Brasil). O método aplicado foi o Modelos de Equações Estruturais. Nós propusemos três modelos aditivos para cada uma das variáveis dependentes de saúde observadas: autoavaliação de saúde, capacidade funcional e doenças crônicas. E também um modelo para uma variável latente contendo as três variáveis observadas. Modelo I mede os efeitos diretos das condições da infância na saúde dos idosos. Modelo II inclui os efeitos indiretos por meio da educação. Modelo III adiciona os comportamentos de saúde (atividade física, consumo de álcool, tabagismo e plano de saúde privado) ao modelo anterior. Todos os três modelos são controlados por gênero e idade. Nós confirmamos a existência do *'the long arm of childhood'* no Brasil. Os resultados demonstram que as condições de saúde e socioeconômicas da infância impactam diretamente e positivamente nos resultados de saúde na fase idosa. Além disso, os modelos de autoavaliação de saúde, condições crônicas e a variável latente de saúde dos idosos encontram evidencias para confirmar um efeito indireto por meio do papel mediador da educação. Por outro lado, os modelos de capacidade funcional não encontram evidencias suficientes para apoiar esta hipótese. Nenhum modelo encontrou associação significativa para o efeito indireto entre doenças na infância e saúde dos idosos. A respeito dos modelos teórico-conceptuais do Curso de Vida, nossos resultados apontam para mais de um modelo para explicar os determinantes da saúde do idoso, Modelo do Período Crítico assim como Modelo da Cadeia de Riscos.

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SUMMARY

DIRECT AND INDIRECT EFFECTS OF CHILDHOOD CONDITIONS ON HEALTH AT OLDER AGES: THE CASE OF BRAZIL

EFEITOS DIRETOS E INDIRETOS DAS CONDIÇÕES DA INFÂNCIA NA SAÚDE EM IDADES AVANÇADAS: O CASO DO BRASIL

1. INTRODUCTION

Why are some individuals healthy until old ages? Why do some individuals live to old ages without chronic diseases? Why do some people reach 80, 90 years of age without disabilities? And why not others?

Scholars have used life-course theory to answer these questions. The argument is that health status differences start much earlier in life (PALLONI, 2006) and can have enduring health consequences across the years (FERRARO; SCHAFER; WILKINSON, 2016). Health status results from complex physical, psychological, and social factors across an individual's life (BEN-SHLOMO; COOPER; KUH, 2016). Individuals who experience unfavorable contextual factors (socioeconomic status and health conditions) in the period between conception and young adulthood - including intrauterine life, infancy, childhood, and adolescence - tend to have worse health outcomes in old age (GRAHAM; POWER, 2004).

This hypothesis is not new. Researchers of the life course perspective have explored it since the mid-1980s (BARKER *et al.*, 1989; ELDER JR.; SHANAHAN, 2006; ELO; PRESTON, 1992; LUNDBERG, 1993). The topic has gotten ample space in the international literature after the United Nations (2001) recognized the need for additional evidence about how unfavorable health and socioeconomic status in childhood are associated with worse health conditions in old age (AGAHI; SHAW; FORS, 2014; ARPINO; GUMÀ; JULIÀ, 2018; FERRARO; SCHAFER; WILKINSON, 2016; GURALNIK et al., 2006; HARKONMÄKI et al., 2007; HENRETTA; MCCRORY, 2016; HYDE et al., 2006; LORENTI et al., 2020; LUO; WAITE, 2005; MONTEVERDE; NORONHA; PALLONI, 2009; PAKPAHAN; HOFFMANN; KRÖGER, 2017; SANTOS; DUARTE; LEBRÃO, 2019). Hayward and Gorman (2004) named this long-term effect of childhood on health in old ages as 'the long arm of childhood.

The life-course approach provides information on how early-life conditions can affect health in old age. It considers all kinds of experiences, including education, employment trajectories,

marital status, parental background, health behaviors, access to health services, family structure, and community factors (ELDER JR.; SHANAHAN, 2006; KUH *et al.*, 2003; PALLONI, 2006). Knowledge of these factors is essential to address some of the challenges of population aging in a context of persistent inequalities.

Three major conceptual models are built on the perspective of life-course epidemiology: the Critical Period Model, the Accumulation of Risk Model, and the Chains of Risk Model. The Critical Period Model posits that if an unfavorable exposure occurs in some specified life cycle stages (childhood, for example), it alters biological development and has long-term effects on health via a direct and biological imprinting mechanism. The Accumulation of Risk Model, on the other hand, proposes that independent damage or harmful exposure due to disadvantages in childhood increases the poor results additively throughout the life cycle. Finally, the Chains of Risk Model or 'Pathway Model' theorizes that a sequence of linked exposures increases the risk of disease and disability in a cumulatively way. The 'Pathway Model' is the only model that includes social, biological, and psychological risks in early life and allows to measure mediating variables (indirect effects) (BEN-SHLOMO; COOPER; KUH, 2016; BEN-SHLOMO; KUH, 2002). According to prior research, the distinction between the models is more conceptual than empirical (PUDROVSKA; ANIKPUTA, 2014). The theoretical models are more complementary than mutually exclusive (BÖRNHORST; HEGER; MENSEN, 2019).

The direct and indirect effects of the 'long-arm of childhood' have different characteristics. The direct long-term impact represents a physiological effect on health later in life. It may positively associate with health problems if stressors during early life alter personal development and leave permanent damage (BARKER *et al.*, 1989; ELO; PRESTON, 1992). But it can also be negatively associated with health deterioration when unfavorable conditions provide acquired immunity, for example, benefiting an individual’s health. On the other hand, the indirect effect is a non-physiological influence that works through lifestyle and resources across the life cycle. An indirect positive association happens when individuals who were born under unfavorable socioeconomic conditions keep disadvantages through life. They are less likely to go to school, have access to health services, and develop healthy habits, worsening health outcomes at the end of life (CASE; LUBOTSKY; PAXSON, 2002). The indirect negatively association, the selection effect, results from individuals who survived disadvantages conditions might be unusually robust and survive more years (PRESTON; HILL; DREVENSTEDT, 1998).

Populations in Western Europe and the United States of America have provided most of the evidence that supports the existence of pathways connecting childhood to old age. Assuming

that social, economic, cultural, nutritional, and political contexts are specific to each country and cohort, the types of associations and mechanisms behind the life-course approach cannot be easily generalized from one place to others (ABODERIN *et al.*, 2001; KUH *et al.*, 2003). Fortunately, a growing number of population-based surveys about older adults in low- and middle-income countries can help elucidate these associations in different settings (HUANG; SOLDO; ELO, 2011; MCENIRY, 2013; MONTEVERDE; NORONHA; PALLONI, 2009). However, despite the growing empirical evidence, divergences about the explanations behind the 'long arm of childhood' remain (PAKPAHAN; HOFFMANN; KRÖGER, 2017). Different methodological approaches to measuring childhood circumstances, mediators, and health at older ages explain some discrepancies. Therefore, there is still an open agenda to investigate the impacts of exposures across the life span and the role of mediators on health outcomes in many different countries (BEN-SHLOMO; COOPER; KUH, 2016; LORENTI *et al.*, 2020).

In Latin America and the Caribbean, the health of the current elderly is powerfully affected by adverse early-life conditions since they experienced deprivations and poor conditions in childhood (PALLONI; SOUZA, 2013). Like other Latin American countries, Brazil experienced a mortality transition initially due to a decline in the lethality of infectious and parasitic diseases. It mainly happened through exogenous interventions instead of structural changes in living standards, infrastructure, massive public health policies, and improvements in nutritional status (PALLONI *et al.*, 2005). Consequently, life expectancy at birth increased substantially from 50.83 years in 1950 to 76.57 in 2020, helping many individuals to reach older ages. One crucial implication of mortality decline without reducing income and health inequalities is the unequal distribution of disability among the elderly (PALLONI *et al.*, 2005). In 2013, 30% of the elderly reported having disabilities in daily living activities, with significant disparities by region, education, income, wealth, and social background (ANDRADE et al., 2018).

This dissertation aims to provide new results about the 'long arm of childhood' in Brazil. Our main goal is to examine the association between childhood socioeconomic and health circumstances and health outcomes in old age. To do this, we use a nationally representative, population-based survey - the Brazilian Longitudinal Study of Aging (ELSI-Brazil) (LIMA-COSTA *et al.*, 2018) - and Structured Equation Modeling (SEM). The study improves in many aspects the earlier analyses for the country. First, it examines multiple self-reported outcomes of health in old ages – self-rated health, functional limitation, and chronic conditions. Second, it includes two main dimensions of childhood measured according to different variables:

childhood health (self-rated health and childhood illness) and childhood socioeconomic conditions (rural residence in childhood, books in the household, mother's education, self-rated socioeconomic conditions, and school attendance at age 10). Third, the dissertation explores the contribution of direct and indirect effects of early life conditions to health at older ages through the mediating role of education. Finally, our study tests for different theoretical models of life course epidemiology. We attempt to find the one that better explains the determinants of health at older ages throughout the life trajectory of individuals.

1.1 Research questions

The general goal of this dissertation is to examine the association between childhood circumstances - socioeconomic and health – and health outcomes in old age in Brazil.

(I) To examine the association between childhood circumstances and multiple self-reported outcomes of health in old ages

(II) To examine the extent the effects of childhood circumstances are directly and indirectly, associated to health at older ages.

(III) To tests for the theoretical models of life course epidemiology to explain the association between childhood circumstances and health at older ages

1.2 Hypothesis

H1. Individuals who experience unfavorable contextual factors (socioeconomic status and health conditions) in the childhood have worse health outcomes in old age.

H2. The different outcomes of health point to the same conclusion about the association between childhood circumstances and health in old age.

H3. Unfavorable exposures experimented during early life impact indirectly and positively on the health outcomes in old age throughout the life trajectory of individuals.

H4. Unfavorable exposures experienced during early live impact directly and positively, and have a long-term effect on the health outcomes in old age.

2. LITERATURE REVIEW

2.1 Conceptual framework: Life-Course theory

The life-course theory is a field that explores distinctive contributions of a sequence of socially defined, age-related exposures that describe the construction of the life history of an individual biography (ELDER JR.; SHANAHAN, 2006).

Key Concepts

Childhood is defined as the years encompassing infancy through adolescence until the transition to adulthood (MCLEOD; ALMAZAN, 2003). Early-life circumstances include the socio-economic and health conditions in which children grow up. Childhood health is a multidimensional concept that starts in utero and gestation factors. It comprises mental health, childhood illness, nutritional consumption, and other behaviors and factors related to the parental background (PALLONI, 2006). Socioeconomic status is conceptualized as the access to resources and the relative position in a hierarchical social structure (PAKPAHAN; HOFFMANN; KRÖGER, 2017). Socioeconomic conditions in childhood are related to familial, neighborhood, and school environment factors that promote physical and psychosocial exposures, such as opportunities, behaviors, stress, education, crowding, exposure to crime, violence, and toxins (COHEN et al., 2010).

Mechanisms – Theoretical Models

Three main theoretical models relate early life conditions with health at older ages. They are the Critical Period Model ('Timing model'), the Accumulation of Risk Model, and the Chains of Risk Model ('Pathway Model') (ABODERIN et al., 2001; BEN-SHLOMO; COOPER; KUH, 2016; BEN-SHLOMO; KUH, 2002; KUH et al., 2003).

The Critical Period Model or 'Timing model' assumes that exposures experienced during specific time windows might impact health in old age, via biological imprinting, as a direct effect. This developmental period depends on the outcome of interest. For example, according to the Barker hypothesis, the nutritional status in the uterus may induce permanent changes in health (BARKER et al., 1989). Cohen et al. (2010) provide other examples of exposures that increase the risk of disadvantageous health outcomes. According to them, during infancy, exposures to unfavorable environments may disrupt cortical development, resulting in problems

with brain function. During childhood, exposure to worse psychosocial environments may lead to decreased cortical neurogenesis. Family stressors may accelerate a girl's puberty; over or undernutrition may affect the timing of the girl's puberty and accrual of peak bone mass, leading to fracture and osteoporosis in old ages (COHEN et al., 2010).

The Accumulation of Risk Model theorizes that separate, independent, and uncorrelated exposures accumulate to cause long-term direct damage to health (KUH et al., 2003). Based on this model, the initial disadvantage will persist or even grow over time and increase the risk of adverse events later in life (FERRARO; SCHAFER; WILKINSON, 2016). The duration and the magnitude of exposures that occurred through the life course are accumulated to health outcomes. In this model, when the exposure occurs is not relevant, in contrast to the timing model (COHEN et al., 2010).

The Chain of Risk Model posits that a sequence of linked and correlated disadvantage exposures cumulatively increases the risk of disability during the life cycle. Also called a 'Pathway Model', it includes mediating factors that indirectly connect early-life conditions with old age health outcomes (PUDROVSKA; ANIKPUTA, 2014). The primary assumption of this model is that a privileged start in life (e.g., more educated parents with higher incomes and more prestigious occupations) increases the chances of achieving an advantageous socioeconomic position in adult life (HAAS, 2007). Conversely, being born into poverty increases the risk of continuing to be impoverished (CASE; LUBOTSKY; PAXSON, 2002). Graham and Power (2004) hypothesize that indirect effects also work through educational and social trajectories. For example, parental background impacts children's performance at school, which changes the likelihood of employment in adulthood and health in old age. Growing up without social opportunities increases the chances of early cohabitation and parenthood, reducing education attainment and income, which may deteriorate health later in life.

There is no consensus and no clear definition of the exact mechanisms linking early-life conditions to health outcomes later in life (MONTEVERDE; NORONHA; PALLONI, 2009). Therefore, the models are probably complementary (BÖRNHORST; HEGER; MENSEN, 2019).

2.2 Direct and indirect effects

According to Preston, Hill, and Drevenstedt (1998), there are a few types of relations between childhood circumstances and conditions later in life: (I) Scarring (direct and positive); (II)

Acquired Immunity (direct and negative); (III) Correlated Environments (indirect and positive); and (IV) Selection (indirect and negative). The direct effect refers to childhood circumstances that physiologically affect old-age health. It is unmediated by other variables, as preconized by the Critical Period Model and the Accumulation of Risk Model. The indirect effect is associational, meaning that the relations are mediated by intervening variables via the 'Pathway Model'.

The first set of direct effects (positive), the scarring effects, are unfavorable exposures during early life that directly affect health in old age, leaving an imprint on development and permanently impair (PRESTON; HILL; DREVENSTEDT, 1998). Some scholars establish a well-defined direct relationship between specific diseases in childhood and conditions later in life, such as tuberculosis, hepatitis B and cirrhosis, rheumatic fever, and heart disease (BLACKWELL; HAYWARD; CRIMMINS, 2001; ELO; PRESTON, 1992). According to Haas (2007), the disadvantage experienced in early life impacts the development of cognition, motoric, and linguistic functions. It could have a lasting effect on old age health. Miller, Chen, and Parker (2011) theorize that childhood psychological stressors could remodel tissues and organs through epigenetic markings. The consequence of this process is an exaggerated response to stress and persistent inflammation that culminate in adult chronic diseases.

Another direct effect is the acquired immunity (negative). As opposed to the scarring effects, the association is negative, and it happens when individuals exposed to harmful conditions early in life develop immunity and obtain more resistance to diseases in adulthood (PRESTON; HILL; DREVENSTEDT, 1998).

Concerning the indirect effects, the correlated environments are disadvantages experienced early in life that increase the chance of being in an adverse socioeconomic status in adulthood. For example, through fewer opportunities to study and work (GRAHAM; POWER, 2004). Those born into a disadvantaged group may remain in lower socioeconomic positions in adulthood, more likely to have worse educational performance, and, consequently, adopt more detrimental health-related behaviors, producing worse health in old age (PAKPAHAN; HOFFMANN; KRÖGER, 2017).

Finally, the selection effect is indirect and negative. Individuals who survive disadvantages early in life might be more robust and survive to older ages (HAYWARD; GORMAN, 2004). According to individual characteristics, the most fragile individuals did not survive until old ages (GOMES, 2011).

2.3 Evidence linking childhood conditions with health at older ages

The 'long arm of childhood' has been intensively investigated in high-income countries. Earlier studies have supported the hypothesis that unfavorable circumstances during childhood are associated with worse health outcomes later in life. However, findings on the 'long arm of childhood' in high-income countries cannot be generalized to the context of low- and middle-income countries (HUANG; SOLDO; ELO, 2011; MONTEVERDE et al., 2020; MONTEVERDE; NORONHA; PALLONI, 2009; PALLONI, 2006). In these other two groups of countries, must consider three factors before discussing the association between early-life conditions and health in old ages. First, a larger proportion of the current elderly population experienced poor living conditions during childhood, characterized by malnutrition, high rates of infectious diseases, and poverty, when compared to the developed countries (HUANG; SOLDO; ELO, 2011; MONTEVERDE et al., 2020; MONTEVERDE; NORONHA; PALLONI, 2009; PALLONI et al., 2005; PEELE, 2019). Second, many individuals that lived vulnerable lives during childhood still live in precarious conditions in old ages (MONTEVERDE et al., 2020). Third, the demographic transition in middle and low-income countries has been characterized by accelerated mortality decline due to medical and public health interventions, despite no significant improvements in living standards (MCENIRY, 2013; MCENIRY; MCDERMOTT, 2015; PALLONI et al., 2005).

Critical Period Model

Several pioneering studies have found evidence to support the Critical Period Model in high-income countries (BARKER et al., 1989; BARKER, 2002; BLACKWELL; HAYWARD; CRIMMINS, 2001; ELO; PRESTON, 1992; RAVELLI; STEIN; SUSSER, 1976). The Barker Hypothesis showed that the mother's undernutrition during pregnancy induces changes in the child's structure, physiology, and metabolism, resulting in permanent damage and illness later in life. This mechanism is called by the author 'fetal programming' (BARKER et al., 1989; BARKER, 2002). Also, a study conducted with the military who were born during the Dutch Famine of 1944-45 concluded that the cohort that experienced famine during the first and second trimesters of pregnancy (the time of hypothalamic differentiation) had a higher frequency of obesity later in life (RAVELLI; STEIN; SUSSER, 1976). Elo and Preston (1992) argued that an infection experienced during childhood could manifest later in life or create chronic afflictions that affect adult health and mortality. For example, respiratory tuberculosis can remain latent in individuals for many years. Hepatitis B can lead to cirrhosis and liver

cancer, and rheumatic fever is related to damage to the heart valves and can promote rheumatic heart disease later in life. Using data from the Health and Retirement Study (HRS), Blackwell, Hayward, and Crimmins (2001) concluded that individuals who experienced poor health conditions during childhood (missed school, or were restricted from sports, or remain in bed at home for at least one month due to a health condition) were more likely to have chronic illnesses, such as cancer, lung diseases, arthritis, and cardiovascular diseases. The association is highly persistent when life-cycle conditions are controlled.

More recently, two other studies have found additional empirical evidence of the mechanisms proposed by the Critical Period Model (ARPINO; GUMÀ; JULIÀ, 2018; CASE; FERTIG; PAXSON, 2005). Although the studies use different variables and outcomes, in both cases, the authors concluded that childhood health retains a strong association with health outcomes in later life, even after accounting for adulthood conditions, which suggests a direct effect through biological imprinting. On the other hand, Pakpahan, Hoffmann, and Kroger (2017) did not find evidence to support the Critical Period Model. They believe that variables beyond their study's scope could mediate the direct effect of childhood conditions on health.

Other studies also reported that childhood conditions are a significant predictor of health outcomes among the elderly living in low- and middle-income countries. These studies support the biological scarring mechanism (MONTEVERDE et al., 2020; PEELE, 2019; WANG et al., 2018). In a study for Indonesia, the author reached a similar conclusion. Childhood infectious diseases were associated with increased odds of hypertension and diabetes in old ages, regardless of adulthood conditions (PEELE, 2019). One Chinese study shows that childhood health is strongly related to self-reported health, cognition, and physical function in old ages, even after adjusting for adulthood conditions and the socioeconomic status during childhood. The authors used fluctuation in grain production during the fetal period and 24 months after birth to address endogeneity problems as a proxy for nutrition during pregnancy. The results confirmed the association described by the Barker hypothesis (WANG et al., 2018). In Argentina, poverty experienced in childhood reflected in 94% higher probability of elderly reporting disability in some daily living activities (ADL), after controlling by age, gender, education, and behavior risks. The authors concluded that this finding confirms the scarring mechanism due to the high levels of poverty and indigence among children. The effects of adverse experiences early in life seem to persist even if conditions improve during adulthood (MONTEVERDE et al., 2020).

One comparative analysis performed by McEniry and McDermott (2015) for seven middle-income countries showed that individuals born between 1930-1960 living in urban areas, exposed to unhealthy environments were more likely to report adverse health conditions. The results partially support the Barker hypothesis. Individuals born in impoverished nutritional conditions with access to a high saturated fat Western-style diet may have chronic diseases later in life. Although the results suggest the existence of the Critical Period Model, according to the authors, the nature of the study does not allow to define the precise mechanism that connects early-life conditions with older adult health.

Accumulation of Risk Model

There is not much evidence supporting the Accumulation of Risk Model. Because disadvantages may not unilaterally lead to adverse outcomes in old ages (FERRARO; SCHAFER; WILKINSON, 2016). One study from Scotland provides evidence that cumulative differential lifetime exposures promote health damage and premature death (SMITH et al., 1997). Another study that uses data from the China Health and Retirement Longitudinal Survey (CHARLS) also found support for cumulative advantage/disadvantage effects. The analysis showed that early-life disadvantages influence health outcomes regardless of socioeconomic conditions during adulthood. Therefore, upward mobility over the life cycle does not compensate for early-life economic hardship (WEN; GU, 2011). In Latin America, a study from Chile showed that women with non-poor childhood socioeconomic situations (parental occupation and self-report socioeconomic position) and who reached high educational attainment would be less likely to have chronic conditions in old ages (MADERO-CABIB; AZAR; PÉREZ-CRUZ, 2019). However, Pudrovska and Anikputa (2014) found no evidence to support the model from participants in the Wisconsin Longitudinal Study. According to their study, unfavorable socioeconomic conditions during childhood, adulthood, and later life do not addictively increase mortality and health disadvantages.

Chains of Risk Model or 'Pathway Model'

The situation is different regarding the Chains of Rick Model. Many studies from high income countries have examined the pathways that relate early-life conditions to health outcomes (AGAHI; SHAW; FORS, 2014; ARPINO; GUMÀ; JULIÀ, 2018; FORS; LENNARTSSON; LUNDBERG, 2009; GURALNIK et al., 2006; HENRETTA; MCCRORY, 2016; LUO; WAITE, 2005; MONTEZ; HAYWARD, 2014; MURAYAMA et al., 2018; PAKPAHAN; HOFFMANN; KRÖGER, 2017; PALLONI, 2006; TAMPUBOLON, 2015; TUBEUF; JUSOT;

BRICARD, 2012). Palloni (2006) formulates a simplified Chains of Risk Model that explicitly links early-life conditions and adult health and socioeconomic status. This link operates through two mechanisms: first, a direct effect on health risks, and second, an indirect effect, working through complex paths leading to health in old ages. The model suggests that childhood health is influenced by parental health and family background, affecting the individual's social trajectory and health in old age.

Many scholars have concluded that childhood health has a significant and direct association with old age health after controlling adulthood conditions. However, socioeconomic status in childhood is indirectly associated with health at older ages. Adulthood conditions mainly mediate its effect (AGAHI; SHAW; FORS, 2014; ARPINO; GUMÀ; JULIÀ, 2018; HENRETTA; MCCRORY, 2016; LEE, 2017; LUO; WAITE, 2005; MONTEZ; HAYWARD, 2014; PAKPAHAN; HOFFMANN; KRÖGER, 2017; TUBEUF; JUSOT; BRICARD, 2012).
One of the first studies to present evidence for the 'Pathway Model' was the work conducted by Luo and Waite (2005). They compared six health outcomes: self-rated health, functional limitations, chronic conditions, depressive symptoms, self-rated memory, and cognitive functioning. The authors showed that childhood health has a direct and positive effect on all six outcomes. However, childhood socioeconomic status was attenuated when educational attainment and household income were included in the model. Education usually plays an important mediating role (HENRETTA; MCCRORY, 2016; TAMPUBOLON, 2015), but other adult socioeconomic conditions (occupation, income, and wealth) may also be important (PAKPAHAN; HOFFMANN; KROGER, 2017).

Studies reached similar conclusions for non-Western countries, even considering the influence of social, cultural, and historical contexts. For example, in South Korea, the association between social class in early life and functional health in old ages is reduced by adult socioeconomic status (LEE, 2017). Among the elderly Japanese, 75.5% of the relationship between childhood socioeconomic position and functional decline is mediated by socioeconomic status during adult years (MURAYAMA et al., 2018)

It is well established that individuals with more schooling, higher income, and occupational status have better health (PRESTON; TAUBMAN, 1994). Childhood conditions affect educational attainment, changing life-course trajectories (family composition and employment trajectories), and health in old age. However, the mediating role of educational attainment varies across populations. Some previous studies have provided evidence of only partial effects (HENRETTA; MCCRORY, 2016; LEE, 2017; LUO; WAITE, 2005; MONTEZ; HAYWARD,

2014). Others found evidence that education almost entirely mediates the association between early-life conditions and health in old ages (ARPINO; GUMÀ; JULIÀ, 2018; MURAYAMA et al., 2018; PAKPAHAN; HOFFMANN; KRÖGER, 2017).

The Chains of Risk Model provides more empirical evidence in the literature for low- and middle-income countries. Also, the studies reach similar conclusions despite differing about the methodology - health outcomes, childhood incomes, and adult conditions included in the models (ARAÚJO et al., 2014; CHIAO; BOTTICELLO; FUH, 2014; HUANG; SOLDO; ELO, 2011; KENDIG et al., 2017; KOBAYASHI et al., 2017; LI et al., 2020; MAHARANI, 2019; NGUYEN et al., 2008; RUIZ-PANTOJA; HAM-CHANDE, 2007). For example, a study from Mexican Health and Aging Study (MHAS) reported that adult lower-body functional limitation is significantly correlated with childhood nutritional deprivation and health problems before age 10 years. These finds are robust and the association is attenuated only to a modest degree after controlling for socioeconomic status, smoking, body mass index, and chronic conditions during adulthood. Family background (father's occupation and mother's education) was no longer statistically significant after adjustment for life-cycle mediating variables (HUANG; SOLDO; ELO, 2011).

Evidence from non-Western low- and middle-income countries show similar findings to Western populations, despite their cultural differences (CHIAO; BOTTICELLO; FUH, 2014; KENDIG et al., 2017; LI et al., 2020; MAHARANI, 2019). A recent study carried out in China shows that the risk of late-life frailty was 4.8% lower to those who lived in a safe neighborhood as a child, 1.5% lower to individuals who have higher paternal education attainment, and 2.9% lower to those with better childhood health status than their disadvantageous counterparts (LI et al., 2020). Kendig et al. (2017) supported these findings by concluding that the impact of poor childhood health on later life health among Chinese older adults could be compensated for adulthood social and economic position. The decomposition analysis shows that the mediating variables were 15% living standard, 10.8% urban residence, 7.3% educational attainment, 6.5% health insurance, and 6% marital status, resulting in 45.5% of indirect influence.

The older population of South Africa is an interesting case to analyze the life-course perspective, due to the experience of the Apartheid until 1994, characterized by few educational opportunities, limited access to health services, and low living conditions for black people. The results show that having poor self-rated health during childhood and a father's occupation was associated with lower cognitive scores during old ages. The association between childhood health and health outcome is not mediated by educational attainment (directly associated), while

the father's occupation is mediated (indirectly associated). One explanation provided by the authors is that the father's occupation status affects the socioeconomic position and the chance of receiving education, and even a poor-quality education provides basic literacy and general cognitive skills (KOBAYASHI et al., 2017).

Finally, Case, Lubotsky and Paxson (2002) and Case, Fertig and Paxson (2005) offers explanations on how family background affects health in old age. Children born to poorer women are exposed to more inadequate prenatal care, worse maternal environment, are more likely to suffer from infectious and chronic conditions, and more impoverished parents cannot provide investments to maintain good health. These less-healthy children may spend more days in bed and miss more school. More impoverished children enter adulthood with lower health status, lower socioeconomic status, and less education, leading to more pronounced differences in health when they become older.

Evidence of multiple explanations (more than one model)

At least five studies produced empirical evidence to more than one model. These authors conclude that the Critical Period Model adequately explains the direct effect (childhood health). On the other hand, the Chains of Risk Model indicates how the influence of socioeconomic status early in life indirectly affects health outcomes mediated by life-course trajectories. (ARPINO; GUMÀ; JULIÀ, 2018; CASE; FERTIG; PAXSON, 2005; FORS; LENNARTSSON; LUNDBERG, 2009; GREENFIELD; MOORMAN, 2019; TUBEUF; JUSOT; BRICARD, 2012)

Arpino, Gumà, and Julià (2018) report that the effect of childhood health in self-perceived health in old ages is mediated neither by education nor by life-course trajectory (employment, partnership, fertility). At the same time, the effect of childhood socioeconomic status is mainly mediated by the educational course. The study from Case, Fertig, and Paxson (2005) reach the same conclusion. They found evidence confirming the fetal origins hypothesis (Critical Period Model) and childhood factors affecting initial adult social position, affecting health outcomes ('Pathway Model'). Tubeuf, Jusot, and Bricard (2012) report that early-life conditions represent 24% of the overall health inequality, when indirect role on education attainment and adult lifestyle were considered, to a representative British cohort born in 1958. The most relevant indicators that influence health in old age are the father's absence at the time of birth, financial hardship (direct effect), and obesity at 16 years old (indirect effect). Greenfield and Moorman (2019) and Fors et al. (2009) have investigated the impact of childhood conditions in cognition

later in life. The authors discuss two distinct and simultaneous pathways of how childhood conditions might influence later-life cognition. The first pathway comprises direct mechanisms affecting neurophysiological development. Examples of exposures include environmental toxins, infectious diseases, chronic stress, and nutritional status. The second pathway refers to indirect mechanisms regarding proximal risk and protective factors throughout childhood and adulthood; examples include educational attainment and personal relationships in adulthood.

According to Palloni (2006), the critical period and accumulation of risk models do not tell the entire story. The strength of the impact of early life conditions depends on complex paths. So, he suggests dealing with this complicated relationship by adding higher-order interactions (indirect effects) through the Chains of Risk Model.

On the other hand, chronic conditions in older women in Chile also indicate evidence for more than one theoretical model independently and simultaneously. Concerning the mechanisms of the Critical Period Model, the authors conclude that self-reported socioeconomic position during childhood affects chronic diseases in old ages. Also, they found an independent effect from continued exposures during childhood and adulthood related to the Accumulation of Risk Model (MADERO-CABIB; AZAR; PÉREZ-CRUZ, 2019). A revision of 20 articles from developing countries, from Latin American and the Caribbean and China, found a strong association between early-life conditions and adult health outcomes – chronic conditions, functionality, cognition, and mortality. Evidence supports all three models: Critical Period, Chains of Risk, and Accumulation of Risk. According to the author, many questions remain. There is insufficient information among the reviewed studies on how exactly these mechanisms operate in low- and middle-income countries. Also, the measurement of childhood conditions and adult health outcomes are broad and imprecise (MCENIRY, 2013).

2.5 What we already know about this topic in Brazil

Campos (2009) proposed a conceptual model about how socioeconomic conditions across the life-course affect health outcomes through structural and intermediary and individual-level determinants. In his model, the intrauterine life and childhood conditions may affect, directly and indirectly, health in the subsequent phases of the life cycle. The structural determinants in early life refer to socioeconomic conditions and can be represented by financial situation, working during childhood, childhood environment, parental educational attainment, family

composition, and other factors related to social conditions. The intermediary determinants in early life are housing conditions, access to health care services, and behavioral risks. The individual-level comprises characteristics related to health, such as birth weight, exposure to diseases, emotional, physical, and cognitive functions. The author tested his conceptual model using data from São Paulo (Brazil). The results show evidence about the effect of all three determinants, structural (living in a rural area), intermediary (hunger), and individual characteristics (diseases). Self-report health in old age is directly associated with living in a rural area in the first 15 years and indirectly associated with hunger during childhood. Also, the number of chronic diseases in old ages is directly associated with disease in childhood; the functional limitation is directly related to the number of diseases in childhood and indirectly associated with hunger during childhood.

Considering that being born at different times may reflect differences in the distribution of health status at old ages, there is a growing interest in investigating the 'long arm of childhood' in Brazil due to the rapid population aging occurring in an unfavorable context. There are at least two cohort studies and some other cross-sectional analyses that include the health conditions of the older population and indicators of their early life conditions (AITSI-SELMI et al., 2013; ARAÚJO et al., 2014; BATTY et al., 2009; LEBRÃO et al., 2018). The baselines of the cohort studies were collected in 1978 (Ribeirão Preto Birth Cohort) and 1982 (Pelotas Birth Cohort). Therefore, cohort members have reached only adult ages. The main advantage of using panel studies is that it provides data on specific individuals at different periods, accounting for their own experiences (GLENN, 2003).

Some studies based on the 1982 Pelotas Birth Cohort confirmed the existence of an association between early-life conditions and health outcomes (BARROS et al., 2006; GIGANTE et al., 2006, 2013; LORET DE MOLA et al., 2016; PERES et al., 2011; SCHUCH et al., 2019).
Gigante et al. (2006) demonstrate that height at age 19 is positively associated with family income, smoking during pregnancy, and birth weight. Barros et al. (2006) created four socioeconomic trajectories: always poor, never poor, downwardly mobile, and upwardly mobile. The results show a strong association between relative position and height at adulthood for both sexes. Gigante et al. (2013) conclude that family income at birth is directly related to body mass index (BMI) among 24-years-old men, but no association was detected among women. The group who experienced poverty in early life had the highest association. Loret de Mola et al. (2016) show that the risk of having a severe depressive symptom at 30 years was higher among those not breastfed for at least six months, resulting in consistent after controlling

for confounding variables. Peres et al. (2011) use socioeconomic trajectories as income at age 24 years and find a gradient in oral health across the socioeconomic groups. The author's findings support the Critical Period, Accumulation of Risk, and Social Mobility models in explaining that those who experienced poverty had the worst oral health and less favorable associated behaviors (smoking, dental hygiene). More recently, a study corroborates the Critical Period theory. The authors identify a direct effect between early life socioeconomic conditions and periodontitis in adulthood after controlled for mediators (SCHUCH et al., 2019).

On the other hand, other scholars based on the 1982 Pelotas Birth Cohort did not find an association between early conditions and health (BATTY et al., 2009; GIGANTE et al., 2007; HORTA et al., 2006; VICTORA et al., 2006). According to Gigante et al. (2007) poor nutrition in early life is not associated with overweight and obesity at the age of 18 years. Other studies have used the same birth cohort to verify that breastfeeding is neither related to blood pressure among adolescents (HORTA et al., 2006) nor related to cholesterol (blood lipid levels) in early adulthood (VICTORA et al., 2006). Batty et al. (2009) did not find evidence between diarrhea (a proxy for dehydration) in infancy (12-20 months of life) and early adulthood systolic or diastolic blood pressure at age 23 years. The study hypothesized that acute dehydration in early life might biologically be programming to a permanent increased blood pressure via salt retention.

A study from 1978/79 Ribeirão Preto Birth Cohort investigates the association between childhood socioeconomic position, based on family income at birth and markers of adiposity in adulthood (body mass index, waist circumference, waist-to-hip ratio). The authors concluded that retain a high socioeconomic status from childhood to adulthood or upward mobility from a worse social position to a better one had a protective effect against adiposity in women. However, higher childhood socioeconomic position was related to higher adiposity for men (AITSI-SELMI et al., 2013).

The survey Salud, Bienestar y Envejecimiento en América Latina y El Caribe (SABE) is a multi-cohort longitudinal study that allows scholars to investigate the life-course conditions of the elderly living in the region (LEBRÃO et al., 2018). The survey was conducted in seven urban centers of Latin American and the Caribbean, including São Paulo (Brazil), in 2000, 2006, and 2010. The sample is longitudinal and representative of the urban population 60 years and older. Several studies have been conducted using the SABE, and their main conclusions about the 'long arm of childhood' are discussed next.

Monteverde and colleagues showed that the probability of being disable among the elderly who experienced poor conditions in childhood is 0.20. It reduces to 0.14 for those who experienced better early conditions. According to the authors, the main pathway of this association is through disability-inducing chronic illnesses. However, the results do not support the Critical Period Model instead of alternative mechanism/models (MONTEVERDE; NORONHA; PALLONI, 2009).

Gomes and colleagues showed that older adults who had not lived in the rural area until 15 years of age experienced a death rate approximately 20% lower than those who did. However, when including adulthood conditions in the statistical models, the association loses significance (GOMES, 2011; GOMES et al., 2015).

Another study investigated differences in mortality between the two waves of SABE (2000 and 2006) and found an increase in the death rate by 54% for those born in the rural area (SANTOS; LEBRÃO; DUARTE, 2011). Also, individuals who lived five or more years in a rural area during childhood, especially those with at least one disease among nephritis, hepatitis, measles, tuberculosis, rheumatic fever, asthma, and chronic bronchitis, expect to self-report worse health in old ages (SANTOS; DUARTE; LEBRÃO, 2019).

Using data from the Sao Paulo Ageing & Health Study (SPAH), another research group found a significant association between dementia and socioeconomic status in childhood (born in the rural area). However, the effect is attenuated when socioeconomic status in adulthood is included in the regression model The authors discuss that the effect is partially indirect and early life disadvantage may operate through biological mechanisms and opportunities in life (SCAZUFCA et al., 2008). Araujo et al. (2014) use data from the Longitudinal Study of Adult Health (ELSA-Brazil). The study collected data on active and retired public servants in six universities or research institutions. The authors report an independent association between maternal educational attainment and performance in four cognitive tests (memory, learning, concentration, language). The relationship does not change with educational attainment, indicating a direct effect. These results implicate that the influence of maternal education on cognitive performance persists during adulthood; the main reasons are the learning environments, intellectual stimulation, and mentorship.

Finally, Andrade et al. (2018) and Félix-Beltrán and Seixas (2021) use data from the ELSI-Brazil, a nationally representative survey of individuals 50 years and older. Parental education accounts for only a tiny share of the inequality in daily living activities, about 5%, while

socioeconomic conditions in adulthood determine most of the disparity in this distribution (ANDRADE et al., 2018). Félix-Beltrán and Seixas (2021) found an association between older adults who experienced hunger during childhood and higher odds of developing diabetes and osteoporosis later in life. However, they did not found association with other diseases studied (hypertension and rheumatism).

In conclusion about the literature review, the literature supports the association between early-life conditions and delayed effects in old age health. Most of the researches recognized that these associations have two components, direct and indirect effects. A better understanding of these delayed effects and the mediators is especially needed in the context of middle and low-income countries due to changes in the composition of new cohorts of elderly.

3. METHODOLOGY

3.1 Data

We use data from the Brazilian Longitudinal Study of Aging (ELSI-Brazil). ELSI-Brazil is conducted by the Fundação Oswaldo Cruz (FIOCRUZ, Minas Gerais) and the Universidade Federal de Minas Gerais (UFMG) and it was funded by the Brazil's Ministry of Health. The study was designed and harmonized to allow international comparisons with other nationally longitudinal studies of aging, such as the HRS in the United States, SHARE in Europe, MHAS in Mexico, CHARLS in China, The Costa Rican Longevity and Healthy Aging Study (CRELES), Health and Ageing in Africa (HAALSI), among others (LIMA-COSTA et al., 2018). ELSI is a nationwide household survey representing noninstitutionalized individuals aged 50 years or older. The survey is longitudinal. However, we use the first wave (baseline survey). It was collected between 2015 and 2016 and comprised 9,412 interviews with residents of 70 municipalities in the five regions of Brazil.

The complex sampling of ELSI-Brazil was designed using geographical stratification developed by the Instituto Brasileiro de Geografia e Estatística (IBGE). Households and the residents aged 50 years or older eligible for interview were selected based on the stratification of primary sampling units. 70 municipalities were randomly selected. The municipalities were allocated into four strata based on population size. In the first stratum, researchers randomly selected 18 out of 4,420 municipalities with a population size up to 26,700. In the second stratum, 15 out of 951 municipalities with a population between 26,701 and 135,000 were selected. The research team chose 14 out of 171 municipalities with a population between 135,001 and 750,000 inhabitants in the third stratum. Finally, all cities with a population larger than 750,000 were included in the sample.

In the first, second, and third stratum, eight census tracts were selected in each municipality. In the fourth stratum, the research team included 176 census tracts. The research team chose the households for interviews in the census tracts, following several criteria. A household was not eligible if (i) there was not at least one resident aged 50 years or older, (ii) when it was vacant, (iii) when it was a collective household, (iv) when the respondent had a disability that prevented him from answering the questionnaire, and there was no substitute informant. The first eligible household must have at least one resident 50 years of age or older. After a jump of four houses,

the second household was selected, and the next households followed the same procedure until reaching the planned number of interviews. Each household answers the "Household Module", which includes questions about household characteristics and accessibility. All residents aged 50 years and older were invited to answer the "Individual Module and physical measurements". The planned number of participants was 10,000. Of these, 9,412 individuals participated. The sample weights were design to account for differential probability of selection and differential nonresponses and differ for each stratum. It is required to use sample weights and geographical stratification to population inference. The interviewees signed separate informed consent forms, and the ELSI-Brazil has ethical approval by the ethics board of FIOCRUZ (CAAE 34649814.3.0000.5091) (LIMA-COSTA et al., 2018).

The advantages of using ELSI-Brazil in this study are: i) it is nationally representative data of the elderly Brazilian; ii) it is a study designed to investigate the aging in Brazil, covering the main aspects of life-course conditions (functional limitation, cognitive function, health status, use of medication and health care services, frailty phenotype, social support, sociodemographic information, housing conditions, early life and childhood conditions, among others); iii) ELSI-Brazil is comparable to other international longitudinal data; and iv) it is available and free of charge at the ELSI-Brazil homepage (http://elsi.cpqrr.fiocruz.br/).

3.2 Variables

This study included three dependent variables, seven explanatory variables for childhood conditions, and six variables for adulthood and old age conditions. In addition to the observed variables, estimated from the dataset and treated as independent, we also included latent variables, unobserved and constructed by the observed variables. All the variables were manipulated in such a way that the higher the score, the more favorable the situation (PAKPAHAN; HOFFMANN; KRÖGER, 2017).

3.2.1 Dependent Variable

The World Health Organization (1948) has defined health as "a state of complete physical, mental, and social wellbeing and not merely the absence of disease or infirmity". In this study,

only the physical dimension of old-age health is measured according to three observed variables: self-rated health, functional limitations, and chronic conditions. We proposed four models, three for each dependent variable and the fourth model with a latent variable that includes all three observed variables.

Self-rated health is a holistic measure that captures the subjective view about health. Previous studies show that self-rated health provides a broad picture of the general health status, correlated with morbidity and mortality (ARPINO; GUMÀ; JULIÀ, 2018; LUO; WAITE, 2005). We use the following question: “In general, how you assess your health?” The possible answers are very good or excellent, good, regular, poor, very poor, and didn't know or didn't answer. In this study, self-rated health was categorized into three groups: good health (excellent and good), regular health, and poor health (poor and very poor).

Functional limitation captures autonomy and the need for help to perform daily living activities. It also reflects an individual's global health and the presence of adverse health conditions (LADITKA; LADITKA, 2018; MONTEVERDE; NORONHA; PALLONI, 2009). Following the standard practice in the literature, an individual was classified as disabled whether she self-reported any limitation (little, great, unable) on Activities of Daily Living (ADLs), namely, (i) walking across a room, (ii) dressing, (iii) bathing, (iv) eating, (v) getting in or out of bed, (vi) toileting. In this study, we categorized the individuals in a binary variable if they have any limitations or not.

Chronic conditions, the World Health Organization (WHO) defines multimorbidity as the coexistence of two or more chronic diseases (WHO, 2016). In ELSI-Brazil, the questionnaire asked for previous medical diagnoses of some self-reported chronic conditions: hypertension, diabetes, heart diseases (angina, heart failure), stroke, asthma, lung diseases, arthritis, rheumatism, and cancer. The chronic conditions were categorized into six groups in this study, from no morbidity to five or more morbidities.

3.2.2 Independent Variables

Childhood

Childhood health status is a multidimensional concept that includes physical and mental dimensions and childhood socioeconomic conditions. Therefore, one should not use a one-

dimensional indicator (PALLONI, 2006). The ELSI-Brazil includes only retrospective questions. Although less accurate and subject to recall bias, retrospective data have the advantage of being more accessible, cheaper, and quicker to collect than direct assessments (LAM; O'FLAHERTY; BAXTER, 2019; LUO; WAITE, 2005). We measure early-life conditions two observed variables of childhood health and a latent variable representing childhood socioeconomic conditions.

Self-rated health in childhood - It captures the state of physical, mental, and social wellbeing (KENDIG *et al.*, 2017; PAKPAHAN; HOFFMANN; KRÖGER, 2017). The ELSI-Brazil asks about self-reported health between birth and 15 years old with five possible answers (excellent or very good, good, fair or poor). We operationalized the variable as categorical with two groups: excellent health and good health; fair health and poor health.

Childhood Illness - ELSI-Brazil included a long list of diseases during childhood: measles, rubella, chickenpox, mumps, diphtheria, whooping cough or scarlet fever; poliomyelitis; asthma or another respiratory problem; allergy (other than asthma); severe diarrhea; meningitis or encephalitis; chronic ear problems; some problem with speech; difficulty seeing, even wearing glasses; tuberculosis.

The latent variable of childhood socioeconomic conditions included five observed variables: rural residence in childhood, books in the household, mother's education, self-rated socioeconomic conditions, school attendance at age 10. These variables are frequently used in the international literature and have less than 10% of missing data in ELSI (MONTEVERDE; NORONHA; PALLONI, 2009; MONTEZ; HAYWARD, 2014; PAKPAHAN; HOFFMANN; KRÖGER, 2017).

Self-rated socioeconomic conditions - Socioeconomic status of children was defined by Pakpahan *et al.* (2017) as a relative position of an individual within a hierarchical social structure. The question in ELSI-Brazil is, "Considering your childhood, between birth and the age of 15, would you say that your family is above or within the average, poor, had an irregular financial situation." We categorized them into four groups: above average, within average, irregular, and poor.

Mother's education - according to Guralnik et al. (2006), a mother's educational attainment is a strong predictor of adulthood health, as higher levels of education influence healthier lifestyle habits in childhood, which remain into adulthood. Parents' educational attainment is the key to

developing the individual's human and social capital (GREENFIELD; MOORMAN, 2019). In this study, mother's education was operationalized as a categorical variable the following groups: did not know how to read or write/ never studied, less than eight years of formal education, 8 to 10 years of formal education, and 11 or more years of formal education (high school or higher).

Rural residence in childhood - in general, in Latin American and Caribbean countries, those who used to live in the rural areas experienced worse conditions and were more vulnerable to infectious and parasitic diseases (GOMES, 2011; SANTOS; LEBRÃO; DUARTE, 2011). Also, in low and middle-income countries, the rural residence is still an important indicator of general disadvantages in socioeconomic status in terms of access to health facilities, essential services, and risk of infectious diseases (LI *et al.*, 2020; MONTEVERDE; NORONHA; PALLONI, 2009; RUIZ-PANTOJA; HAM-CHANDE, 2007). In this study, rural residence until 15 years old is a binary variable: rural or urban residence.

Books in the household are a proxy for cultural background and how parents gave value to a child's education. In this study, the variable is binary (yes or no) and measures books at home at ten years old. (ARPINO; GUMÀ; JULIÀ, 2018; PAKPAHAN; HOFFMANN; KRÖGER, 2017).

The *Attending school during childhood* variable measures school attendance at the age of 10.

Adult and old age conditions

We assessed socioeconomic conditions during adulthood by respondents' formal education. Education reflects personal knowledge, information, resources, and skills (ARPINO; GUMÀ; JULIÀ, 2018). It was categorized less than 4 years of formal education, 5 to 11 years of formal education and 12 or more years of formal education.

We represented old age conditions according to health behaviors. The observed variables are physical activity, alcohol consumption, smoking, and access to private health plans. Physical activity was dichotomized as active and non-active, measured according to the number of days in the last week that the person walked for at least ten continuous minutes at home or work as a form of transport, leisure, pleasure, or exercise. Alcohol consumption indicates whether the person never drinks, drinks less than once a month, or usually drinks at least once a month.

Smoking was categorized as currently smoking, former smoker, never smoker. The ownership of private health plans (health insurance) is a binary variable (yes/no).

Additionally, our models include controls for gender (male/female) and age groups (50-59, 60-69, 70-79, 80 or more completed years).

3.3 Statistical Method

We estimated a Structured Equation Modeling (SEM) to assess the 'long arm of childhood' in old age health conditions in Brazil. We fitted three additive models for each of the four health outcomes: a latent variable of old age health, self-rated health, functional limitation, and chronic conditions.

Structured Equation Modeling is a multivariate technique that allows examining a series of dependence relationships simultaneously. SEM combines confirmatory factor analysis, path analysis, and regression to estimate a system of equations. The factor analysis allows us to create latent variables/constructs, and the regressions assess the relationships between the variables. SEM is used to validate the theoretical model by decomposing the relationship between the outcome (health at old ages) and the independent variables into direct, indirect, and total effects (BERAN; VIOLATO, 2010; HAIR; ANDERSON; BABIN, 2009).

The use of SEM has a number of advantages; first, the total effect can be decomposed into direct and indirect effects rather than showing only the significance of the relationships (non- SEM studies). Also, SEM creates hypothetical constructs/latent variables for a combination of multiple observed variables. Third, the model is expressed diagrammatically via graphical visualization. Fourth, SEM estimates the coefficients simultaneously for all variables, rather than regular separate regressions. Finally, SEM allows estimating multiple interrelated dependence relationships, meaning a series of independent and interdependent regressions based on theory (HAIR; ANDERSON; BABIN, 2009; NEVES, 2018; VIOLATO; HECKER, 2007)

In SEM, observed variables are included in the dataset, while a variable is considered latent when it is not observed directly. Latent variables or constructs are unobservable concepts that cannot be measured directly without error. A latent variable is composed of at least three related observed/manifest variables. They are constructed through factor loadings of each observed variable, representing how reliably each observed variable reflects the latent variable. The

relevance of using latent variables is because each observed variable alone cannot represent all the context of an unobserved variable. Also, the latent variable allows one to deal with inaccurate information (TAMPUBOLON, 2015). For example, the latent variable "Childhood Socioeconomic Conditions" represents a broad context greater than the simple sum of observed variables. As a rule of the thumb, a factor loading is considered strong enough when it is at least |0.3| (BYRNE, 2011).

We employed an ordinal probit for estimating the parameters of SEM because the dependent variables are categorical variables with more than two possible outcomes (discrete responses) ordered. The parameters were carried out using Stata 13.0, with '*gsem*' to fit generalized SEMs (ordinal responses). The ordered probit produces predictions about the probabilities related to the possible answers ranging on a scale. In this case, the coefficients cannot be interpreted as regular OLS because they are in log-odds units.

In the current study, Model 1 measures the direct effects of childhood conditions on health at old ages. Model II includes the indirect effect of education in the association between childhood conditions and health at old ages. Model III adds health behaviors (physical activity, alcohol consumption, smoking, and private health plans) to Model II. All three models control for gender and age.

The indirect effects were computed by multiplying the coefficients of mediation. The total effect is equal to the sum of the direct and the indirect effects. Following the representation of Tubeuf et al. (2012), where α represents the direct effect, β. φ the mediating effect (indirect effect) and L the total effect, we can describe the effects as:

Direct effect	α
Indirect effect	$\beta \cdot \varphi$
Total effect	$L = \alpha + (\beta \cdot \varphi)$

Before estimating the structural equation model, we used the software R for data preparation and performed a descriptive analysis. The variables were categorized so that the higher the score, the more favorable the situation (PAKPAHAN; HOFFMANN; KRÖGER, 2017). We excluded the individuals who answered the dependent variables as "does not know/did not answer". We employed the Hot-Deck imputation to handle missing data in the survey using the VIM package. This method involves replacing missing information on independent variables using a value of a similar respondent that has complete data (ANDRIDGE; LITTLE, 2010).

After performing the estimation of the parameter of SEM, we estimate the goodness of fit and select an optimal model based on model comparison. In generalized SEM, there are no practical ways to judge the fit in absolute terms. Therefore, we used Akaike's information criterion (AIC) and the Bayesian information criterion (BIC) for comparing the trade-off between goodness of fit and complexity of the model. Both AIC and BIC increase with the negative log-likelihood and penalize the number of parameters in the model (complexity of the model). The model with the smaller (in absolute value) AIC and BIC among the competing models is the best (LIN; HUANG; WENG, 2017).

4. RESULTS

This chapter examines the association between childhood conditions - socioeconomic and health – and health at older ages. It consists of (4.1) Theoretical Model, (4.2) Descriptive analysis, (4.3) Validation of latent variable, (4.4) Estimated Parameters of Structured Equations Modeling, and (4.5) Summary of Major Findings.

4.1 Theoretical Model

Figure 1 presents a Path Diagram of the 'long arm of childhood' in old age health. A path diagram is a simplified schematic representation of a system of simultaneous equations (SEM). The circles and ellipses represent latent variables (constructs), rectangles and boxes contain observed or manifest variables, and the single-headed straight arrow (one-way arrow) represents the effect of one variable on another (BYRNE, 2011; HAIR; ANDERSON; BABIN, 2009). The Path Diagram in Figure 1 illustrates our Model III with the latent variable for old age health. We described the childhood conditions on the left side of the diagram, including the latent variable of childhood socioeconomic conditions (CHILDSES) and two observed variables of childhood health (Self-rated health and childhood illness). The right side represents the latent variable for old age health conditions, comprising self-rated health, functional limitations, and chronic diseases. It also includes the controls for age, gender, and health behaviors (physical activity, alcohol consumption, smoking, and private health plans). In the middle, mediating the two stages (childhood and old age) is educational attainment. The associations between childhood conditions and health in old age are represented by the cross-lagged paths (arrows).

The arrows in the path diagram represent the two possible effects of childhood conditions on health at old ages. The $\alpha 1$, $\alpha 2$, and $\alpha 3$ arrows represent the direct effects of childhood health and socioeconomic conditions on health in old age, unmediated by any intervening variables. The $\beta 1$, $\beta 2$, and $\beta 3$ arrows represent the routes beyond early life conditions that could influence old age health, operating through education (φ), called indirect effects. According to the indirect impact, childhood conditions determine educational attainment, affecting health in old age.

Graham and Power (2004) called this mechanism the educational trajectory. It is calculated by multiplying the coefficients of the mediation analysis (β1. φ) + (β2 . φ) + (β3 . φ).

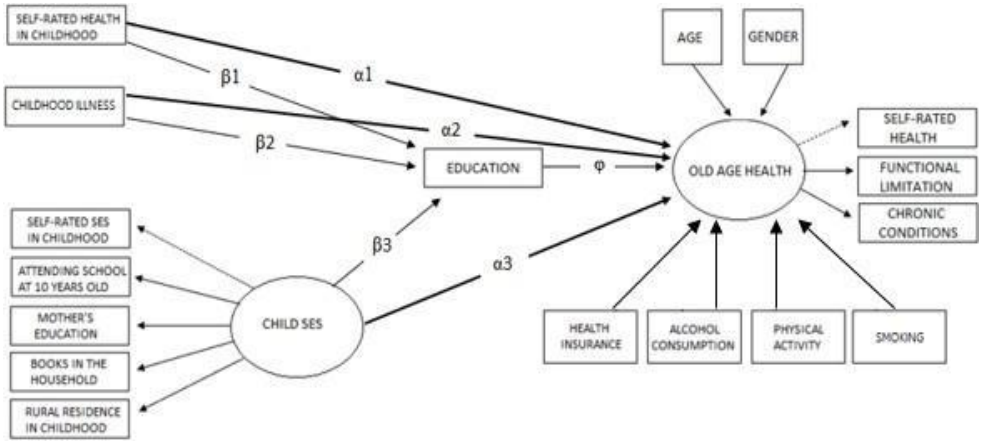

Fig. 1 Path Diagram of the 'long arm of childhood' on old age health, the direct and indirect effects of early-life conditions.

4.2 Descriptive analysis

The descriptive analysis included all 9,412 individuals who participated in ELSI-Brazil 2016. According to Table 4.1.1, the mean age is 62.5 years, and almost half of the sample is younger than 59 years. The majority is female (54%), and more than half of the sample is currently married (63%). Regarding education, 13% never studied, 51% has less than eight years of schooling, and about 24% completed high school education or received more formal education.

Table 4.1.1 also presents descriptive statistics for the health conditions of elderly participants of ELSI-Brazil. About 44% of individuals self-reported regular health and 43% good health. The majority reported not having limitations in performing one or daily living activities (84%), and the most limiting activity for the elderly is dressing (12%) and getting in or out of bed (9%). About 64% of the sample has one or more chronic diseases, and 36% have no disease.

Missing data in the dependent variables included in this study are 0.19% for self-rated health (18 cases), 3.17% for chronic conditions (298 cases), and 0.15% for disability (14 cases).

Table 4.1.1: Sociodemographic and health characteristics of the Brazilian elderly participants in the ELSI-Brazil 2016

Variables	Category	(95% Confidence Interval) *
Gender	Male	46% (43-49%)
	Female	54% (51-57%)
Age	Mean	62.5 years (61.7-63.3)
	50-59	47% (44-52%)
	60-69	30% (27-31%)
	70-79	16% (14-18%)
	80 +	07% (06-08%)
Education (Years of schooling)	0 to 4	51% (47-55%)
	5 to 11	43% (39-48%)
	12 or more	08% (07-09%)
	Missing	0.05% (n=49)
Marital status	Single	11% (10-13%)
	Married/ live together	63% (61-66%)
	Divorced or separated	10% (09-11%)
	Widow(er)	15% (13-17%)
Self-rated health	Very good or good health	43% (41-46%)
	Regular health	44% (43-46%)
	Poor health	12% (10-13%)
	Missing	0.02% (n=18)
Activities of Daily Living	Walking across a room	05% (04-06%)
	Dressing	12% (12-14%)
	Bathing	06% (05-07%)
	Eating	02% (01-03%)
	Getting in or out of bed	09% (08-10%)
	Toileting	04% (03-05%)
Functional limitation	Limitation in one or more ADLs	16% (14-18%)
	No limitations in any ADLs	84% (82-86%)
	Missing	0.0015% (n=14)
Chronic conditions**	No disease	36% (34-38%)
	One disease	38% (36-40%)
	Two diseases	18% (16-20%)
	Three or more	0.8% (0.6-1%)

* all statistics accounted for complex sample design and survey weights.

** *Missing cases:* hypertension (n=17), diabetes (n=53), heart failure (n=16), heart diseases (angina) (n=63), insufficient heart (n=37), stroke (n=8), asthma (n=12), lung diseases (n=18), arthritis or rheumatism (n=70), cancer (n=11). *Total Missing cases*: 298 individuals.

Table 4.1.2 shows the distribution of childhood conditions according to self-rated health at older ages. This table presents the results for the sample used in the study - 9,390 individuals - after excluding missing cases for self-rated health. Overall, individuals who reported poor health in old ages are more likely to report worse health conditions during early life, rural residence during childhood, parents with low educational attainment, and poor socioeconomic conditions.

There is also a positive relationship between socioeconomic conditions in childhood and health in old ages. The prevalence of rural residence is higher among the individuals who self-reported poor health (69%) than good health (54%). Among individuals with poor health, 39% did not attend school at ten years old, while this prevalence is 20% among individuals with good health. Also, 65% of individuals did not have books at home, and 68% reported poor financial conditions during childhood, compared to 51% and 52%, respectively, among individuals with good health.

On the other hand, among individuals with good health, 5% of their mothers attended 11 years or more of formal education, while this prevalence is only 1% among individuals with poor health. 46% of individuals with good health had books at home during childhood, while only 32% had poor health. As for health conditions during childhood, 14% of those who reported poor health at old ages also reported poor health conditions during firsts years, more than twice the number of those who reported regular (7%) or good health (4%). The mean number of childhood illnesses is higher among those who reported poor health (1.56 morbidities) than among individuals with regular health (1.39 morbidities) and good health (1.24 morbidities).

Table 4.1.2: Descriptive statistics for childhood conditions according to the self-rated health in old ages (n=9,390)

Variables of Childhood	Category	Self-rated Health at old ages – (%)*		
		Good health at old ages	Regular health at old ages	Poor Health at old ages
Rural residence in childhood	Yes	53.9	63.9	69.3
	No	45.9	35.9	30.5
Mother's education	0 (never studied)	44.5	53.2	61.4
	Less than 8	37.3	31.7	24.2
	8 to 10	04.4	02.5	02.8
	11 or more	04.6	02.2	01.4
Attending school at ten years old	Yes	78.5	73.6	59.9
	No	20.5	25.7	39.4
Books in the household	Yes	46.6	41.6	32.1
	No	51.0	56.2	65.7
Self-rated socioeconomic conditions	Above average	06.4	04.0	04.2
	Within average	25.6	20.7	15.4
	Poor	52.4	59.5	68.4
	The financial status varied a lot	15.2	15.5	11.4
Self-rated health in childhood	Excellent	30.3	19.4	19.8
	Good	55.4	53.0	49.0
	Regular	10.1	20.2	16.4
	Poor	03.9	07.2	14.3
Childhood Illness	Mean	1.24	1.39	1.56

* all statistics considered the complex sample design and survey weights.

4.3 Validation of latent variable

The factor loading on latent variables shows how observed variables fit together (the correlation between them) to form the latent constructs (Table 4.3). Also, the factor loading represents the latent variance explained by that indicator, reflecting the importance of each variable to the construct (BYRNE, 2011). In Models I to III, all the factor loading was reasonably correlated with the latent, and all the factor loadings are statistically significant. Also, each latent variable

has moderate levels of internal consistency (latent Childhood SES alpha de Cronbach 0.53 and latent Old age health alpha de Cronbach 0.40). Concerning the latent variable Old Age Health, the most relevant observed variable is chronic conditions. For Childhood SES, mother's education and school at ten years old are both important. Additionally, it is important to notice that Childhood SES is composed of two distinct dimensions, expressing the correlation between the variables. The first includes self-rated socioeconomic conditions, mother's education and rural residence in childhood, and the other is composed by attending school at ten years old and books in the household.

Table 4.3. Factor loading on the latent variables, Models I, II e III.

Latent variables	Observed Variables	Factor Loading**		
		Model I	Model II	Model III
Old age health	Self-rated health	1*	1*	1*
	Functional Limitation	1.16	1.07	1.18
	Chronic conditions	0.71	0.64	0.63
Childhood SES	Self-rated socioeconomic conditions	1*	1*	1*
	Mother's education	4.80	5.33	5.33
	Attending school at ten years old	-6.16	-6.81	-6.81
	Books in the household	-3.00	-2.89	-2.89
	Rural residence in childhood	3.34	4.27	4.27

*By default, Stata fixes the factor loading of the first observed variable as 1.

** All the factor loadings are statistically significant at $p < 0.01$

4.4 Estimated Parameters for the Structured Equation Modeling

This section presents the results of structured equations modeling for Models I to III for each dependent variable separately. Model I measures the direct effect of childhood circumstances on health at old ages. Model II includes the indirect effect of education in the association between childhood and health at old ages. Model III adds health behaviors (physical activity, alcohol consumption, smoking and private health plans) to the second model. All three models control for gender and age.

4.4.1 The associations of childhood conditions and health at old ages (Latent Variable)

Table 4.4.1 shows the estimated parameters for Models I to III for the latent variable old age health, including the AIC and BIC measures. The latent variable represents a multidimensional concept of health by combining three dimensions: self-rated health, functional limitations, and chronic conditions. It represents a broader context than the simple sum of health indicators while reducing the impact of measurement errors (PAKPAHAN; HOFFMANN; KRÖGER, 2017).

The coefficients for the childhood health indicators and childhood SES are positive and statistically significant. Higher childhood SES, and better childhood health, are directly and positively associated with better health at old ages. Also, according to Model I, gender is not statistically significant, and age is significant and positive. In Model II, after adding the education variable, the coefficient for childhood SES reduces, but it remained statistically significant. For instance, education is associated with health at old ages, uncovering the indirect effect in the model. The coefficients for self-rated health and diseases keep both magnitude and significance, suggesting a persistent direct association with health at old ages.

Model III controls for health behaviors and health insurance. Alcohol consumption, physical activity, and health insurance are all statistically significantly associated with health at old ages.

After controlling for health behaviors measures, the coefficient for childhood SES reduces once more, but the coefficients for childhood health indicators remain the same as in Models II and I. All coefficients remain statistically significant. In other words, the direct relation of childhood conditions and health at old ages is significant, even after controlling by education and health-related risks. Concerning the educational attainment indirect path, the coefficients remain almost the same as in Model II. Childhood SES is positively associated with old age health, directly and indirectly. The effects are lower for childhood self-rated health and diseases.

According to the goodness of fit measures, Model I provides the best fit. Adding more complex structures in Models II and III increased the penalty term in AIC and BIC measures (LIN; HUANG; WENG, 2017). When comparing only Models II and III, Model III offers the best fit.

Table 4.4.1: Parameter estimates of SEM for Models I to III, dependent variable: latent of old age health

	Independent variable	(Model I)	(Model II)	(Model III)
Old age health (Latent Variable)	Childhood self-health (α1)	0.28***	0.28***	0.28***
	Childhood illness (α2)	0.16***	0.16***	0.16***
←	Childhood SES (α3) – Latent Variable	0.98***	0.83***	0.54***
	Gender	-0.04*	-0.04*	0.03
	Age	0.16***	0.14***	0.12***
	Education (φ)			
	Less than 4 years of formal education		0.30***	0.27***
	5 to 11 years of formal education		0.25***	0.21***
	Health insurance			-0.10***
	Physical Activity			-0.05***
	Alcohol consumption			-0.22***
	Smoking			0.13
Indirect Effect	Education ← Childhood self-health (β1)			
	Less than 4 years of formal education		0.09	0.09
	5 to 11 years of formal education		0.23***	0.23**
	Education ← Childhood illness (β2)			
	Less than 4 years of formal education		0.11**	-0.11***
	5 to 11 years of formal education		-0.09***	-0.09***
	Education ← Childhood SES (β3)			
	Less than 4 years of formal education		18.70***	18.75***
	5 to 11 years of formal education		7.30***	7.30***
AIC		116045	130705	130417
BIC		116280	131011	130752

***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.1$.

4.4.2 The associations of childhood conditions and self-rated health at old ages

Table 4.4.2 shows the results for self-rated health at older ages as the dependent variable. Self-rated health is a holistic indicator that can capture how individuals feel about their physical, mental, and social wellbeing. It also provides a broad picture of the general health status (ARPINO; GUMÀ; JULIÀ, 2018).

The results are very similar when compared to the latent variable model. According to Model I, all indicators of childhood conditions were positively and significantly associated with self-

rated health. After adding the education variable in Model II, the coefficient for childhood SES reduces but remains statistically significant. The coefficients for self-rated health and diseases during childhood do not change. Education is a mediating factor between childhood self-rated health and SES and self-rated health at older ages.

In Model III, after controlling for all covariates, age, gender, physical activity, and health insurance are significantly associated with self-rated health at old ages. The direct effects of early life conditions remain significant, although the magnitude of the coefficient reduces for childhood SES. The reason is its stronger indirect effect through education. Overall, childhood SES has the strongest association with self-rated health.

Corroborating the findings from the latent variable model, Model I shows the best fit, and Model III offers a better fit than Model II.

Table 4.4.2: Parameter estimates of SEM for Models I to III, dependent variable: self-rated health

	Independent variable	(Model I)	(Model II)	(Model III)
Self-health	Childhood self-health (α1)	0.18***	0.18***	0.18***
←	Childhood illness (α2)	0.07***	0.07***	0.07***
	Childhood SES (α3) – Latent Variable	0.64***	0.52***	0.38***
	Gender	0.01**	0.01***	0.05***
	Age	-0.01**	-0.01**	-0.02**
	Education (φ)			
	Less than 4 years of formal education		0.16***	0.14***
	5 to 11 years of formal education		0.14***	0.11***
	Health insurance			-0.08***
	Physical Activity			-0.02***
	Alcohol consumption			-0.10**
	Smoking			0.06
Indirect Effect	Education ←Childhood self-health (β1)			
	Less than 4 years of formal education		0.09	0.09
	5 to 11 years of formal education		0.23**	0.23**
	Education ←Childhood illness (β2)			
	Less than 4 years of formal education		-0.11***	-0.11***
	5 to 11 years of formal education		-0.09**	-0.09**
	Education ←Childhood SES (β3)			
	Less than 4 years of formal education		18.75**	18.75**
	5 to 11 years of formal education		7.33***	7.33***
AIC		94055	108849	100063
BIC		94204	109070	100312

***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.1$.

4.4.3 The association of childhood conditions and functional limitations at old ages

Table 4.4.3 shows the results for the model with functional limitations as the dependent variable. Functional limitation incorporates measures of independence and autonomy in performing daily activities. It also reflects overall health and the presence of disabilities (AGAHI; SHAW; FORS, 2014; GURALNIK et al., 2006; LADITKA; LADITKA, 2018).

The results are comparable to those for the latent variable and self-rated models. All indicators of childhood conditions are positively and significantly associated with functional limitations. However, according to Models II and III, education is not related to functional limitations. Therefore, there is no indirect association between childhood circumstances and functional limitation in old ages. Model I fits the data better than Models III and II.

Table 4.4.3: Parameter estimates of SEM for Model I to III, dependent variable: Functional Limitations

	Independent variable	(Model I)	(Model II)	(Model III)
Functional Limitation	Childhood self-health (α1)	0.05***	0.05***	0.05***
	Childhood illness (α2)	0.03***	0.03***	0.03***
←	Childhood SES (α3) – Latent Variable	0.23***	0.23***	0.16***
	Gender	-0.01	-0.01	0.01
	Age	0.05***	0.04***	0.03***
	Education (φ)			
	Less than 4 years of formal education		0.03	0.02
	5 to 11 years of formal education		0.02	0.01
	Health insurance			-0.01*
	Physical Activity			-0.02***
	Alcohol consumption			-0.03*
	Smoking			0.01
Indirect Effect	Education ← Childhood self-health (β1)			
	Less than 4 years of formal education		0.09	0.09
	5 to 11 years of formal education		0.23**	0.23**
	Education ← Childhood illness (β2)			
	Less than 4 years of formal education		-0.11***	-0.11***
	5 to 11 years of formal education		-0.09***	-0.09***
	Education ← Childhood SES (β3)			
	Less than 4 years of formal education		18.75***	18.75***
	5 to 11 years of formal education		7.33***	7.33***
AIC		74976	89750	89549
BIC		75126	89970	89799

***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.1$.

4.4.4 The association of childhood conditions and chronic conditions at old ages

Our final model uses chronic conditions as the dependent variable. Chronic conditions are related to the demand for health care and are among the most used indicators in the literature of "the long arm of childhood" (BLACKWELL; HAYWARD; CRIMMINS, 2001; MCENIRY, 2013).

According to Table 4.4.4., only childhood illness and self-rated health are associated with chronic conditions at old ages. There is an indirect association through education. Overall, childhood SES has the strongest indirect association with chronic conditions. As for the other health models, Model I provides the best fit.

Table 4.4.4: Parameter estimates of SEM for Model I to III, dependent variable: Chronic Conditions

	Independent variable	(Model I)	(Model II)	(Model III)
Chronic Conditions	Childhood self-health (α1)	0.11***	0.10***	0.10***
	Childhood illness (α2)	0.14***	0.14***	0.14***
←	Childhood SES (α3) – Latent Variable	0.13*	0.01	-0.07
	Gender	-0.01***	-0.01***	-0.01***
	Age	0.22***	0.22***	0.20***
	Education (φ)			
	Less than 4 years of formal education		0.07**	0.07**
	5 to 11 years of formal education		0.11**	0.11**
	Health insurance			0.07***
	Physical Activity			-0.02***
	Alcohol consumption			-0.14**
	Smoking			0.13
Indirect Effect	Education ← Childhood self-health (β1)			
	Less than 4 years of formal education		0.09	0.09
	5 to 11 years of formal education		0.23**	0.23**
	Education ← Childhood illness (β2)			
	Less than 4 years of formal education		-0.11***	-0.11***
	5 to 11 years of formal education		-0.09**	-0.09**
	Education ← Childhood SES (β3)			
	Less than 4 years of formal education		18.75**	18.75**
	5 to 11 years of formal education		7.33***	7.33***
AIC		94055	108849	108779
BIC		94204	109070	109028

***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.1$.

4.5 Summary of Major Findings

The results show that childhood health and socioeconomic status impact directly and positively health outcomes later in life. Moreover, the models for self-rated health, chronic conditions and the latent old age health variable support the indirect association through education. On the other hand, the models for functional limitations at old ages did not support this hypothesis.

5. DISCUSSION

Using a nationally representative population-based survey (ELSI-Brazil), we examined "the long arm of childhood" in Brazil. We confirmed the existence of an association between childhood health and socioeconomic conditions and health in old ages. We found both direct and indirect effects through the mediating role of education. Following the scheme proposed by Preston, Hill, and Drevenstedt (1998), there is evidence for both the scarring effect (positive and direct effect – physiological) and correlated environments (positive and indirect effect – associational).

Regarding the theoretical models of life course epidemiology, our results support more than one theoretical/conceptual model to explain the determinants of health among the elderly throughout the life trajectory.

The persistent direct effect of childhood self-health, childhood illness, and childhood socioeconomic conditions on health in old age, when controlling for life-cycle conditions, support the Critical Period Model. According to the model, exposures experienced during specific windows of time can impact health in old age, via biological imprinting, as a direct long-term effect (BEN-SHLOMO; KUH, 2002). Our results confirm the mechanism proposed by Arpino, Gumà, and Julià (2018) and Case, Fertig, and Paxson (2005). The association between health conditions during childhood and health outcomes in old ages does not change after accounting for adulthood conditions (education and health behaviors), suggesting a consistent direct effect operating through biological imprinting.

The results from the models of self-rated health in old ages and the latent variable of old age health provide evidence for the Chains of Risk or 'Pathway Model'. According to it, a sequence of linked exposures and correlated disadvantages increases the risk of disease and disability cumulatively. The 'Pathway Model' also investigates the mediating/indirect effect of some variables. We found that childhood health has a direct and positive impact on all four health outcomes. In contrast, the effect of childhood socioeconomic status is both direct and indirect. The direct effect was attenuated when educational attainment and health behaviors were included in the model. Pakpahan, Hoffmann, and Kroger (2017) proposed that upward mobility in adulthood could compensate for the unfavorable socioeconomic position during childhood. However, the authors did not expect to find a compensatory effect for worse childhood health

conditions. Our results corroborate their conclusion due to the nature of the direct effect of childhood health and the indirect effect of socioeconomic status.

According to the Pathway model, children born from privileged families can achieve a better health outcome at older ages. The explanations include better access to health care from prenatal to adulthood, the presence of educated parents with higher incomes, better maternal environments, less contact with infectious diseases, and more time at school. Therefore, some authors conclude that the Critical Period Model is better to explain the direct effect of childhood health on old-age health, whereas the 'Pathway Model' explains better the influence of socioeconomic status early in life indirectly on health outcomes through the mediation of life-course trajectories. Our results corroborate both approaches.

Also, our findings are in agreement with the national literature on the "long arm of childhood". Our results validate the conceptual model proposed by Campos (2009) about the structural and intermediated determinants of life-course affecting health in old ages and are consistent with results from studies using SABE (São Paulo representing Brazil) (GOMES, 2011; MONTEVERDE; NORONHA; PALLONI, 2009; SANTOS; DUARTE; LEBRÃO, 2019; SANTOS; LEBRÃO; DUARTE, 2011). Monteverde, Noronha, and Palloni (2009) and Campos (2009) concluded that early life conditions influence health outcomes in old ages. However, they did not confirm the theoretical/conceptual model behind the association. Our study moves a step forward by identifying the routes through which the childhood conditions act for defining health conditions in old age. Finally, Gomes et al., 2015 showed that having lived in a rural area until 15 years of age increases death risk at older ages. However, the direct effect loses statistical significance when adulthood conditions are included in the model. Although we did not measure mortality risk, we found both persistent direct and indirect effects, which may be a consequence of differences in the outcome (health x mortality) and the specification of our models that include many more variables.

Test of goodness of fit (AIC and BIC) indicates that the more parsimonious model is the best (Model I). However, the indirect effect is theoretically justified because childhood circumstances impact educational attainment, which affects income trajectories, access to health services, and shape preferences for primary lifestyle behaviors (HAYWARD; GORMAN, 2004; MONTEZ; HAYWARD, 2014).

The dissertation has some limitations. First, ELSI-Brazil uses retrospective measures of childhood circumstances that may contain recall bias. It may be difficult for elderly individuals

to remember childhood conditions. In addition, respondents in worse health conditions may have more trouble remembering the events. This process may influence recollections and evaluations of childhood circumstances and could affect the associations we found. Yet, earlier studies have shown that for some variables – e.g., parents' education - retrospective questions are consistently reported by the elderly (CAMPOS, 2009; FERRARO; SCHAFER; WILKINSON, 2016; HAAS, 2007; KENDIG et al., 2017; LUO; WAITE, 2005). In our models, the mother's education is one of the most critical factors composing the latent of childhood SES

Second, the ELSI-Brazil sample is subject to a selection effect. The selection bias means that only the individuals who survived until age 50 or more are included in the analysis. Since the frailest and disadvantaged cohort members have a higher risk of dying at younger ages, the surviving members could differ from the original cohort (VAUPEL; YASHIN, 1985). Selection bias may underestimate the effect of early-life conditions since individuals who experienced the worse conditions during childhood may have died before reaching 50 years or more. However, for the case of Brazil, this selection effect is expected to be minor due to the infant mortality decline that it is underway since the 1930s (GOMES, 2011; GOMES et al., 2015; MONTEVERDE; NORONHA; PALLONI, 2009).

The third limitation concerns the health outcomes among the elderly. Psychosocial, cultural, socioeconomic factors and the respondent's emotional issues influence self-reported health variables (GOMES et al., 2015). Also, we only measure the physical aspects of health in our study. Thus, we still do not know the effects on mental/cognitive and psychosocial aspects of health.

Another methodological limitation concerns the use of generalized models and categorical outcomes. Generalized linear structural equations modeling does not allow testing the traditional chi-squared fit. Consequently, to assess the goodness of fit of different models, we needed to use AIC and BIC measures. Another limitation of GSEM is its parameters; they cannot be interpreted as odd-ratios (CHRIST et al., 2014).

Finally, there are also limitations in the data used. The cross-sectional nature of the first wave of ELSI-Brazil hindered us from measuring temporal associations (DE CASTRO et al., 2018). Also, the survey did not include the institutionalized population (living in nursing homes, incarcerated, and others) and the disabled people without informants. This group is relevant, particularly considering the higher prevalence of disability and chronic conditions than the average elderly (FERRARO; SCHAFER; WILKINSON, 2016; GOMES, 2011).

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Appendix A

Table A.1. Factor loading from latent variables – self-rated health

Latent variable	Observed Variables	Factor Loading		
		Model I	Model II	Model III
Childhood SES	Self-rated socioeconomic conditions	1*	1*	1*
	Mother's education	4.75	4.89	4.89
	Attending school at ten years old	-6.02	-8.74	-8.74
	Books in the household	-2.93	-2.71	-2.72
	Rural residence in childhood	3.29	3.85	3.85

*By default, Stata fixes the factor loading of the first observed variable as 1.

Table A.2. Factor loading from latent variables – functional limitations

Latent variable	Observed Variables	Factor Loading		
		Model I	Model II	Model III
Childhood SES	Self-rated socioeconomic conditions	1*	1*	1*
	Mother's education	4.77	5.34	5.34
	Attending school at ten years old	-6.20	-6.80	-6.80
	Books in the household	-3.03	-2.90	-2.90
	Rural residence in childhood	3.34	4.27	4.27

*By default, Stata fixes the factor loading of the first observed variable as 1.

Table A.3. Factor loading from latent variables – Chronic diseases

Latent variable	Observed Variables	Factor Loading		
		Model I	Model II	Model III
Childhood SES	Self-rated socioeconomic conditions	1*	1*	1*
	Mother's education	4.77	5.33	5.33
	Attending school at ten years old	-6.18	-6.79	-6.79
	Books in the household	-3.05	2.90	-2.90
	Rural residence in childhood	3.34	4.27	4.28

*By default, Stata fixes the factor loading of the first observed variable as 1.

Appendix B

Table B1. Distribution of the dependent variables according to chronic conditions (N=9,152)

Variables of childhood	Category	Chronic conditions at old ages *		
		No chronic conditions	One chronic condition	Multimorbidity
Rural residence in childhood	Yes	56.7	58.9	61.0
	No	42.9	40.9	38.8
Mother's education	0 (never studied)	47.7	49.0	50.8
	Less than 8	36.0	24.8	31.3
	8 to 10	3.7	3.9	3.1
	11 or more	3.6	3.5	2.8
Attending school at ten years old	Yes	76.1	74.6	74.3
	No	23.9	24.5	25.1
Books in the household	Yes	45.5	44.4	41.9
	No	52.5	54.3	56.1
Self-rated socioeconomic conditions	Above average	5.1	5.1	4.9
	Within average	23.5	23.2	21.7
	Poor	51.3	55.4	59.2
	The financial status varied a lot	19.8	15.3	13.3
Self-rated health in childhood	Excellent	26.6	27.1	22.9
	Good	57.4	54.8	52.3
	Regular	12.4	13.0	17.5
	Poor	3.2	4.7	7.8
		56.7	58.9	61.0
Childhood Illness	Mean	1.12	1.24	1.43

* all statistics considered the complex sample design and survey weights.

Table. Distribution of the dependent variables according to the functional limitations (N=9,393)

Variables of childhood	Category	Disability at old ages *	
		Individuals with functional limitation	Individuals without functional limitation
Rural residence in childhood	Yes	67.5	58.8
	No	32.1	41.0
Mother's education	0 (never studied)	58.5	48.7
	Less than 8	25.7	34.7
	8 to 10	01.7	03.6
	11 or more	01.5	03.4
Attending school at ten years old	Yes	62.7	76.5
	No	36.0	22.9
Books in the household	Yes	37.2	43.7
	No	58.9	54.4
Self-rated socioeconomic conditions	Above average	4.7	5.1
	Within average	17.5	23.1
	Poor	63.3	56.3
	The financial status varied a lot	13.8	15.0
Self-rated health in childhood	Excellent	18.5	25.3
	Good	51.9	53.9
	Regular	17.2	14.9
	Poor	11.5	05.6
Childhood Illness	Mean	1.31	1.53

* all statistics accounted for complex sample design and survey weights.