Life Course Socioeconomic Position, Intergenerational Social Mobility, and Hypertension Incidence in ELSA-Brasil

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BACKGROUND

Life course epidemiology is a powerful framework to unravel the role of socioeconomic position (SEP) disparities in hypertension (HTN). This study investigated whether life course SEP is associated with HTN incidence. Specifically, to test whether cumulative low SEP throughout life and unfavorable intergenerational social mobility increased HTN incidence.

METHODS

Longitudinal analysis of 8,754 ELSA-Brasil participants without HTN or cardiovascular in visit 1 (2008–2010). The response variable was the incidence of HTN between visits 1 and 2 (2012–2014). The explanatory variables were childhood, youth, and adulthood SEP, cumulative low SEP, and intergenerational social mobility. Associations were estimated by incidence rate ratios (IRRs) obtained by generalized linear models, with Poisson distribution and logarithmic link function, after adjustment for sociodemographic, behavioral, and health factors.

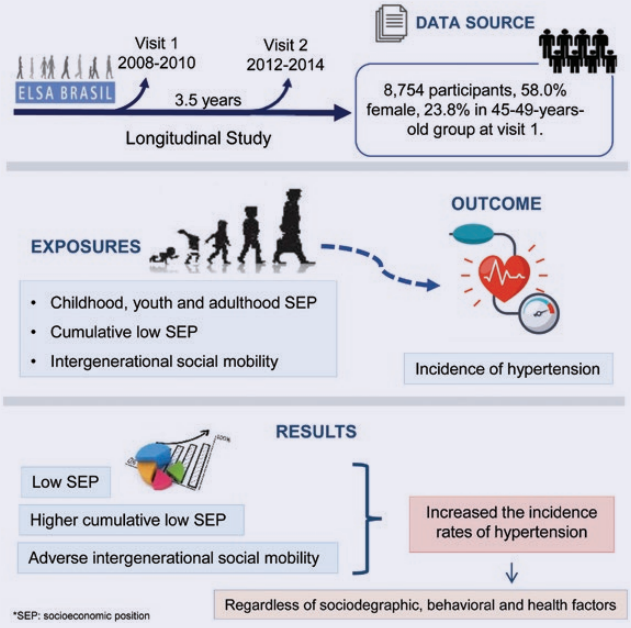
RESULTS

The incidence of HTN was 43.2/1,000 person-years, being higher in males, elderly (70–74 years), self-declared black, and low SEP individuals. After considering sociodemographic factors, low SEP in childhood, youth, and adulthood remained statistically associated with increased HTN incidence. Individuals in the third (IRR: 1.26; 95% confidence interval (CI): 1.11–1.44) and fourth top quartiles (IRR: 1.29; 95% CI: 1.11–1.49) of cumulative low SEP, vs. first, as well as those with low stable intergenerational trajectory (IRR: 1.29; 95% CI: 1.16–1.43), vs. high stable, also had increased HTN incidence rates.

CONCLUSIONS

Socioeconomic disparities at all phases of the life cycle appear to raise HTN incidence rates, being the individuals with greater accumulation of exposure to low SEP and with more unfavorable intergenerational mobility at greatest risk, even in a short follow-up time.

GRAPHICAL ABSTRACT



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Hypertension (HTN) is one of the main modifiable risk factor for cardiovascular diseases (CVDs), accounting for 19.0% of deaths annually worldwide,[1] and is particularly relevant in low- and middle-income countries.[2] The etiology

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of HTN is complex and involves genetic, behavioral, and psychosocial factors. Low socioeconomic position (SEP) in childhood[3,4] and adulthood[5–8] have been consistently associated with a higher HTN incidence. However, evidence on the influence of youth SEP is less common.

Life course epidemiology offers an important theoretical framework for the study of the association between SEP and HTN. Theoretical models, such as the critical, sensitive, accumulation of risk, and social mobility ones, are proposed to explain how exposure to socioeconomic adversities in distinct periods of life can affect illness risk in adulthood. Individuals with downward or chronically low SEP trajectories have worse health outcomes[9,10] and higher CVD mortality.[11,12]

The accumulation of socioeconomic disadvantages and adverse social mobility are expressions of few opportunities for social ascension in any society. Brazil is one of the most unequal societies in the world and upward social mobility is a rare phenomenon. According to the World Economic Forum, it takes 9 generations, an average, for a low-income Brazilian to reach the country's median income.[13]

A recent study from the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil), showed that downward intragenerational social mobility was associated with increased blood pressure (BP) levels, but not with HTN incidence.[14] Therefore, the present study investigated if low SEP in different life periods, particularly whether the accumulation of exposures to low SEP in the life cycle and an unfavorable intergenerational social mobility, increases HTN incidence in ELSA-Brasil in about 4-year follow-up.

METHODS

Type of study and population

This longitudinal study uses ELSA-Brasil data, a cohort of 15,105 civil servants aged between 35 and 74 years, from teaching and research institutions in 6 Brazilian cities. Study design and cohort profile have been described elsewhere.[15,16] The research protocol was approved by the research ethics committees of each institution and all participants signed an informed consent.

This study included all participants who attended ELSA-Brasil visits 1 (2008–2010) and 2 (2012–2014), with valid information on HTN and SEP over the life course. Eligible population consisted of participants without HTN at visit 1 (n = 9,019), excluding prevalent cases of HTN (n = 5,427), with reported CVD (n = 738), and self-declared Indigenous (n = 157) due to small numbers for some SEP categories. Out of 9,256 eligible individuals, 502 (5.42%) were lost to follow up. Lost participants were older, had lower schooling, smoked more and drank less ($P < 0.05$) than those followed up (data not shown). Considering the overlaps, the final study sample totaled 8,754 individuals (94.6% of eligible population) (Figure 1).

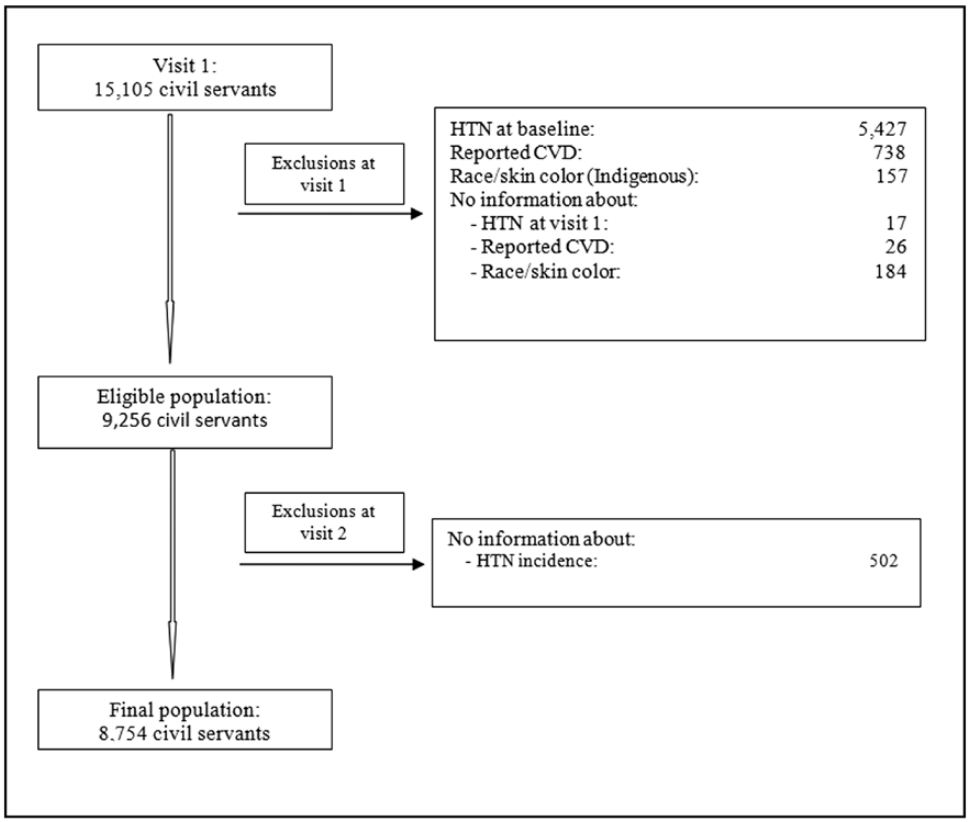

Figure 1. Flowchart of the studied population. Abbreviations: CVD, cardiovascular disease; HTN, hypertension.

Study variables

Response variable HTN was ascertained the same way at visits 1 and 2, as systolic BP ≥140 mm Hg and/or diastolic BP ≥90 mm Hg, and/or use of antihypertensive medication to treat HTN in the 2 weeks prior to the interview.

BP was measured using a digital sphygmomanometer (Omron HEM-705 CP) following a standardized protocol. Measurements were taken after 5 minutes of rest, with the participant seated, in a quiet environment and with controlled temperature. BP was the mean of the second and third measures.

The use of antihypertensive drugs was obtained by an affirmative answer to the question, "*Were any of the medications you used in the last two weeks for hypertension (high blood pressure)?*," made after the interviewers' examination of medical prescriptions and medication packages brought by participants.[17]

Explanatory variables *Childhood SEP*: assessed by maternal schooling level, obtained by the following question "What is your mother's educational level?" and classified as "never studied," "incomplete elementary school," "complete elementary school," and "high school or higher education."

Youth SEP: defined by household head's occupational social class at the time when the participant started working (mean age of participants = 17 years). The occupational social class was obtained by a detailed analysis of the description of the work activities performed, considering the relation between the income observed for a given occupation in the labor market and the expected income according to the educational level required for that occupation. This analysis resulted in the creation of 7 occupational social class categories: upper-high, upper-low, middle-high, middle-middle, middle-low, low-high, and low-low.[18] In this study, the classes were grouped into high (upper-high and upper-low), middle-high, middle (middle-middle and middle-low), and low (low-high and low-low).

Adulthood SEP: assessed by current occupational social class, categorized similar to youth SEP.

Cumulative low SEP: to indicate the accumulation of risk during the life course, a cumulative low SEP score was created, calculated by the sum of maternal schooling level (high school or higher education = 1; complete elementary school = 2; incomplete elementary school = 3; never studied = 4); the household head's occupational social class (upper class = 1; middle-high class = 2; middle-middle and middle-low class = 3; low class = 4); and the participant's current occupational social class (upper class = 1; middle-high class = 2; middle-middle and middle-low class = 3; low class = 4). The total score (ranging from 3 to 12 points) was divided into quartiles, with higher values reflecting worse SEP over the life course.

Intergenerational social mobility: for this analysis, the occupational social class was dichotomized into high (high, middle-high, middle-middle) and low (middle-low and low). Intergenerational social mobility was obtained by comparing the household head's occupational social class when the participant started to work and the participant's current occupational social class, and it was categorized as high stable, upward, downward, and low stable.

Covariables Sociodemographic characteristics—sex, age, race/skin color (white, black, brown, Asian)—were included for being potential confounding factors in the analyses, considering they precede SEP in any period of life. Health behaviors—smoking (nonsmoker, ex-smoker, smoker), alcohol consumption (moderate, none, excessive), physical activity (weak, moderate, strong)—and health indicators—body mass index (normal, overweight, obese), diabetes (no, yes), total cholesterol/High Density Lipoprotein ratio (<3.5; ≥3.5), and family history of HTN (no, yes)—were also included as covariates in fully adjusted models, although they are potential mediators of an association between SEP in different periods of life and the development of chronic diseases in the future (Figure 2).[19] All adjustment covariates were obtained at visit 1.

Data analysis

HTN incidence rate was obtained by dividing the number of new cases by total number of person-years at risk and described according to the study population's characteristics and SEP indicators. Time at risk (in years) was determined as the shortest time between visits 1 and 2 dates, after combining 3 pieces of information: date of the annual follow-up call at which HTN diagnosis was reported for the first time, BP and anti-HTN use at visit 2 date. For individuals who used anti-HTN medication at visit 2 and did not report

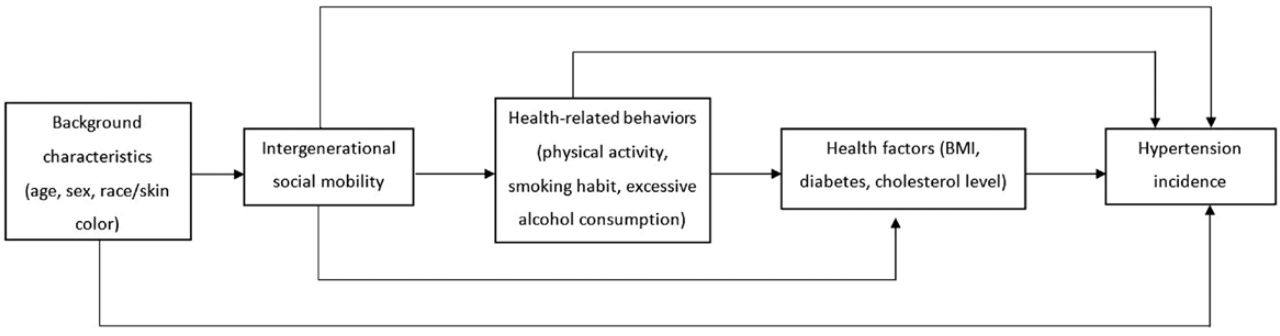

Figure 2. Theoretical model for the relationship between intergenerational social mobility and incidence of hypertension. Abbreviation: BMI, body mass index.

Table 1. Characteristics of study population at visit 1 and hypertension (HTN) incidence rate in about 4-year follow-up

Characteristics[b]	*N*[a] (%)	Person-years (PY) at risk	Cases	HTN incidence/1,000 PY
Sociodemographic variables				
Sex				
Male	3,674 (42.0)	12,695.1	655	51.6
Female	5,080 (58.0)	18,332.8	684	37.3
Age (years)				
35–39	950 (10.9)	3,532.5	70	19.8
40–44	1,670 (19.1)	6,072.7	187	30.8
45–49	2,086 (23.8)	7,416.9	310	41.8
50–54	1,634 (18.7)	5,662.2	297	52.5
55–59	1,267 (14.5)	4,404.5	236	53.6
60–64	693 (7.9)	2,386.5	134	56.1
65–69	308 (3.5)	1,068.3	62	58.0
70–74	146 (1.7)	484,3	43	88.8
Race/skin color				
White	4,952 (56.6)	17,525.8	677	38.6
Brown	2,436 (27.8)	8,638.1	409	47.3
Black	1,140 (13.0)	4,025.7	225	55.9
Asian	226 (2.6)	838.4	28	33.4
Health behavior				
Smoking habit				
Nonsmoker	5,264 (60.1)	18,827.1	705	37.4
Ex-smoker	2,331 (26.6)	8,104.9	442	54.5
Smoker	1,159 (13.2)	4,095.0	192	46.9
Alcohol consumption				
Moderate	5,714 (65.3)	20,310.1	815	40.1
No alcohol consumption	2,517 (28.8)	8,938.2	422	47.2
Excessive	518 (5.9)	1,761.5	102	57.9
Physical activity				
Weak	6,514 (75.7)	23,026.8	1,043	45.3
Moderate	1,407 (16.4)	4,958.4	200	40.3
Strong	685 (8.0)	2,484.9	71	28.6
Health characteristics				
BMI				
Normal weight	3,928 (44.9)	14,406.7	366	25.4
Overweight	3,416 (39.0)	11,926.0	600	50.3
Obesity	1,407 (16.1)	4,682.9	373	79.7
Diabetes mellitus				
No	8,045 (91.9)	28,704.1	1,126	39.2
Yes	707 (8.1)	2,318.9	212	91.4

ELSA-Brasil (2008/2010–2012/2014). Some frequencies can add up to 100.1% or 99.9%, due to rounding. Abbreviations: BMI, body mass index; ELSA-Brasil, Brazilian Longitudinal Study of Adult Health.

[a]The total *N* can vary due to lack of information on some variables.

[b]Characteristics of study population at visit 1.

diagnosis at any follow-up call, we used the midpoint between visits 1 and 2 dates. For those with raised BP at visit 2, who were not under treatment and did not report previous diagnosis, the date was obtained by linear interpolation of visits 1 and 2 dates and regarded as the first date that systolic blood pressure or diastolic blood pressure value reached diagnostic criteria (systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg), whichever occurred

first, assuming that BP levels increased at constant rates between visits. For participants who remained free from HTN, we considered the time between visits.

Incidence rate ratios (IRRs) and respective 95% confidence interval (95% CI) for each explanatory variable were obtained by generalized linear models with Poisson distribution and logarithmic link function. Participant's investigation center was entered as a cluster variable, to allow for intragroup correlation, and time at risk as offset. Following a univariable analysis (model 0), we added sociodemographic variables (model 1), and then behavioral and health factors (model 2).

The level of significance adopted was 5% and the Stata 14.0 (Stata Corporation, College Station, TX) was used to conduct the analyses.

RESULTS

At visit 1, the female gender (58.0%), the 45–49-year-old group (23.8%), and the white race/skin color (56.6%) predominated (Table 1). The mean follow-up time was 3.5 years (SD: 0.9), varying from 0.1 to 5.9 years, totaling 31,027.9 person-years at risk. We identified 1,339 new cases of HTN, corresponding to an overall incidence rate of 43.2 per 1,000 person-years.

Table 2. Distribution of study population and hypertension (HTN) incidence rate according to SEP indicators at visit 1 in about 4-year follow-up

Characteristics[b]	*N*[a] (%)	Person-years (PY) at risk	Cases	HTN incidence/1,000 PY
Childhood SEP indicator				
Maternal schooling level				
High school or higher	2,265 (26,3)	8,100.7	285	35.2
Complete elementary	1,735 (20.2)	6,176.9	247	40.0
Incomplete elementary	3,656 (42.5)	12,902.4	599	46.4
Never studied	946 (11.0)	3,322.1	181	54.5
Youth SEP indicator				
Household head's occupational social class				
High	1,943 (23.3)	6,947.2	257	37.0
Middle-high	860 (10.3)	3,051.2	118	38.7
Middle	1,552 (18.6)	5,493.6	252	45.9
Low	3,989 (47.8)	14,108.6	654	46.4
Adulthood SEP indicator				
Current occupational social class				
High	3,069 (35.6)	10,945.2	406	37.1
Middle-high	437 (5.1)	1,541.9	63	40.9
Middle	3,353 (38.9)	11,990.5	494	41.2
Low	1,757 (20.4)	6,056.9	357	58.9
Cumulative low SEP				
First quartile (lowest)	2,662 (32.9)	9,496.9	348	36.6
Second quartile	1,883 (23.3)	6,762.1	255	37.7
Third quartile	2,282 (28.2)	8,068.5	382	47.3
Fourth quartile (highest)	1,255 (15.5)	4,352.2	254	58.4
Intergenerational mobility in occupational social class				
High stable	2,699 (32.7)	9,657.0	348	36.0
Upward	2,364 (28.8)	8,444.1	336	39.8
Downward	677 (8.2)	2,382.0	116	48.6
Low stable	2,473 (30.1)	8,649.7	463	53.5

ELSA-Brasil (2008/2010–2012/2014). Some frequencies can add up to 100.1% or 99.9%, due to rounding. Abbreviations: ELSA-Brasil, Brazilian Longitudinal Study of Adult Health.

Bold values indicates statistically significant.

[a]The total *N* can vary due to lack of information on some variables.

[b]Characteristics of study population at visit 1.

The incidence was higher among male, older (70–74-year-old), self-declared black and in participants exposed to low SEP (Tables 1 and 2). Among the incident HTN cases, 60.3% were under medical treatment (data not shown).

Low childhood SEP was associated with a higher HTN incidence regardless of sociodemographic factors (model 1); however, it lost statistical significance in the fully adjusted model (model 2). In youth, both middle and low household head's occupational social class (vs. high) were associated with a higher HTN incidence, even after considering behavioral and health factors (IRR: 1.23; 95% CI: 1.03–1.47 and IRR: 1.15; 95% CI: 1.02–1.28) (model 2). The current middle and low occupational social class (vs. high) also increased the HTN rate (IRR: 1.14; 95% CI: 1.03–1.26 and IRR: 1.33; 95% CI: 1.14–1.55), respectively (model 1). After considering the behavioral and health factors (model 2), only the IRR for low class remained statistically significant (IRR: 1.25; 95% CI: 1.10–1.43) (Table 3).

Table 4 shows that HTN rates were greater for individuals in the third (IRR: 1.26; 95% CI: 1.11–1.44) and fourth quartiles (IRR: 1.29; 95% CI: 1.11–1.49) of cumulative low SEP, compared with those less exposed after adjustment for sociodemographic factors. However, only the latter group remained statistically significant in the fully adjusted model (IRR: 1.22; 95% CI: 1.07–1.40). Regarding social mobility, permanence in lower social class over generations (vs. permanence in the upper class) was associated with higher HTN incidence (IRR: 1.29; 95% CI: 1.16–1.43) in model 1. This association, although attenuated, persisted after considering health factors (IRR: 1.19; 95% CI: 1.10–1.28).

DISCUSSION

We found that low SEP in all periods of life is associated with higher HTN incidence in adult participants of the ELSA-Brasil cohort, after considering sociodemographic factors. Both socioeconomic risk accumulation and intergenerational social mobility models confirmed that more adverse socioeconomic trajectories, either due to cumulative low SEP, downward intergenerational mobility, or low stable SEP increased HTN incidence rate in a short follow-up time.

Low childhood SEP has been consistently associated with a higher HTN incidence,[3,4,20] as well as with cardiovascular and cerebrovascular diseases related to HTN.[21,22] Exposures to adversities in this period can be the trigger for changes in stress response systems, including the

Table 3. Incidence rate ratio (IRR) and 95% confidence interval (95% CI) for hypertension in about 4-year follow-up according to socioeconomic position (SEP) indicators at visit 1

	Model 0[a]	Model 1[b]	Model 2[c]
SEP Indicator	**IRR (95% CI)**	**IRR (95% CI)**	**IRR (95% CI)**
Maternal schooling level			
High school or higher	1	1	1
Complete elementary	1.06 (0.79–1.42)	1.04 (0.77–1.39)	0.96 (0.72–1.29)
Incomplete elementary	**1.22 (1.08–1.39)****	**1.19 (1.02–1.38)***	1.11 (0.97–1.27)
Never studied	**1.25 (1.05–1.48)***	**1.18 (1.03–1.36)***	1.11 (0.96–1.28)
Household head's occupational social class			
High	1	1	1
Middle-high	1.14 (0.98–1.32)	1.14 (0.99–1.30)	1.11 (0.97–1.27)
Middle	**1.32 (1.08–1.62)****	**1.30 (1.08–1.56)****	**1.23 (1.03–1.47)***
Low	**1.24 (1.09–1.42)****	**1.21 (1.09–1.34)*****	**1.15 (1.02–1.28)***
Current occupational social class			
High	1	1	1
Middle-high	1.25 (0.91–1.71)	1.24 (0.90–1.69)	1.20 (0.84–1.71)
Middle	**1.18 (1.04–1.34)***	**1.14 (1.03–1.26)***	1.09 (0.97–1.22)
Low	**1.39 (1.16–1.67)*****	**1.33 (1.14–1.55)*****	**1.25 (1.10–1.43)*****

ELSA-Brasil (2008/2010–2012/2014) (N = 8,754). Abbreviations: BMI, body mass index; ELSA-Brasil, Brazilian Longitudinal Study of Adult Health.

Bold values indicates statistically significant.

[a]Model 0: univariate analysis.

[b]Model 1: adjusted for age, sex, and race/color.

[c]Model 2: model 1 + smoking habit, excessive alcohol consumption, physical activity, BMI, cholesterol levels, diabetes, and family history of hypertension.

*$P \leq 0.05$.

**$P \leq 0.01$.

***$P \leq 0.001$.

hypothalamic–pituitary–adrenal axis, the sympathetic–adrenal–medullary axis, and inflammation, mechanisms that seem to explain the persistent socioeconomic disparities in health over the life course.[23,24] The loss of statistical significance in the present study, after adjustment for behavioral and health factors, suggests that childhood SEP induces a sequence of negative events, such as low schooling levels and unhealthy behaviors, which negatively affect health in adulthood. This theory is consistent with the chain models.[25]

Evidence of the relation between youth SEP and HTN is still scarce, possibly because most studies focus on SEP indicators in childhood and/or adulthood.[3,4,26] Berger *et al.*[27] found a strong association between low youth SEP and CVD in a study with 6 European cohorts. Adolescence is a period of important transitions, exposing and providing opportunities for the adoption and/or maintenance of behaviors that can affect health in adulthood.[25] The household head's social class, used here as indicator of SEP in this phase, is related to important milestones, such as schooling and career and, therefore, exposure to social and environmental conditions that may be protective or harmful to health.[28]

The association between adulthood SEP and health outcomes is widely known. In this study, participants with low current occupational social class had a higher incidence of HTN. These findings are in line with several studies on SEP and HTN.[29–31] Occupation enable access to better education, acquisition of material and social resources, and health-related habits, therefore it is strongly related to the illness process.[32]

Cumulative low SEP was associated with higher incidence of HTN, suggesting an upward gradient in the categories that accumulated more exposure throughout life. These findings advance ELSA-Brasil report on a relation between cumulative low SEP and higher CVD risk estimated by the Framingham score at visit 1.[33] The risk accumulation model postulates that repeated exposures to adverse conditions throughout life can anticipate the aging of several organs and systems, favoring early illness.[34]

Our results advance previous findings from ELSA-Brasil[14] by showing that participants with low stable intergeneration trajectories had higher rates of HTN. Accordingly, an American study with 379 black men reported a 7-fold increase in the odds of HTN for individuals who remained in low SEP, between generations.[26] In another study, Högberg *et al.*[35] found similar results for downward SEP trajectory. Epigenetic studies have contributed to elucidate biological mechanisms by which socioeconomic adversities in different periods are physically incorporated. Findings from the Multi-Ethnic Study of Atherosclerosis suggest that exposures to social adversity in childhood and adulthood are associated with genes related to stress and inflammation.[36] Adverse intergenerational social mobility may increase HTN incidence either directly or by prompting the adoption of unhealthy behaviors linked to more proximal HTN risk factors such as body mass index, diabetes, and cholesterol (Figure 2).

Studies on intergenerational mobility and HTN are scarce. Social mobility between generations is an important marker of social development, signaling inequalities in opportunities

Table 4. Incidence rate ratio (IRR) and 95% confidence interval (95% CI) for hypertension in about 4-year follow-up according to exposure to cumulative low socioeconomic position (SEP) and intergenerational mobility at visit 1

	Adjustment		
	Model 0[a]	Model 1[b]	Model 2[c]
Indicator	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)
Cumulative low SEP			
First quartile (lowest)	1	1	1
Second quartile	1.02 (0.71–1.46)	1.00 (0.69–1.43)	0.95 (0.66–1.35)
Third quartile	**1.31 (1.12–1.53)****	**1.26 (1.11–1.44)*****	1.15 (0.99–1.34)
Fourth quartile (highest)	**1.36 (1.15–1.62)*****	**1.29 (1.11–1.49)****	**1.22 (1.07–1.40)****
Intergenerational mobility			
High stable	1	1	1
Upward	1.12 (1.00–1.26)	1.11 (1.00–1.25)	1.07 (0.95–1.19)
Downward	1.23 (0.96–1.58)	1.19 (0.95–1.50)	1.10 (0.90–1.34)
Low stable	**1.35 (1.19–1.53)*****	**1.29 (1.16–1.43)*****	**1.19 (1.10–1.28)*****

ELSA-Brasil (2008/2010–2012/2014) (N = 8,754). Abbreviations: BMI, body mass index; ELSA-Brasil, Brazilian Longitudinal Study of Adult Health.

Bold values indicates statistically significant.

[a]Model 0: univariate analysis.

[b]Model 1: adjusted for age, sex, and race/color.

[c]Model 2: model 1 + smoking habit, alcohol consumption, physical activity, BMI, cholesterol levels, diabetes, and family history of hypertension.

*$P \leq 0.05$.

**$P \leq 0.01$.

***$P \leq 0.001$.

for social advancement over time. The gains resulting from social ascension make it possible for individuals to mitigate or even overcome the effects of adverse exposures in childhood, therefore reducing the risk of diseases, such as HTN.[4]

The strengths of this study include a longitudinal analysis with a large sample of adults from 6 major capital cities in Brazil, a middle-income country, one of the world leaders in social inequalities and low rates of upward social mobility, with high HTN prevalence and high early mortality from HTN-related causes. In addition, 3 life cycle periods (childhood, youth, and adulthood) were analyzed, allowing to capture particularities of each stage in the HTN incidence. Finally, we tested 2 important models—risk accumulation and intergeneration social mobility—which are uncommon in the literature on SEP and HTN.

As limitations, this is a cohort of civil servants from federal institutions and extremes of the social hierarchy are not represented. Thus, SEP contrasts are attenuated as compared with the country, and the magnitudes of the associations are likely reduced. However, as extensively debated recently, representativeness is not necessary to draw valid scientific inferences for associations obtained by well conducted epidemiological studies.[37] Because the information on maternal education was not overtly linked to participants' childhood, it is possible that some mothers improved their schooling level throughout their life. Hence, the number of participants with low maternal education may be underestimated, reducing the magnitude of the associations. Finally, the cumulative low SEP score considered that low SEP in any period of life has an equal effect on HTN, which may not represent the true weight of the accumulation of adversities over the life course.

Our findings reinforce previous studies and show that, in addition to biological factors, structural-level social issues play an important role in HTN incidence, emphasizing the importance of socioeconomic inequalities. Hence, promoting opportunities and reducing socioeconomic disparities at all stages of the life cycle are essential to reduce the burden of HTN, especially in highly unequal countries like Brazil.

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DISCLOSURE

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