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Life course socioeconomic adversities and 10-year risk of cardiovascular disease: cross-sectional analysis of the Brazilian Longitudinal Study of Adult Health

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Abstract

Objectives To investigate whether life course exposure to adverse socioeconomic positions (SEP) as well as maintaining a low SEP or decreasing the SEP intra- and intergeneration was associated with an increased 10-year cardiovascular disease (CVD) risk predicted by the Framingham Risk Score.

Methods This is a cross-sectional analysis of baseline data (2008–2010) of 13,544 active workers from ELSA-Brasil cohort. Maternal education, leg length, social class of first occupation and education were used to evaluate childhood, youth and adulthood SEP.

Results After considering adulthood SEP, exposure to early-life low SEP remained associated with an increased 10-year CVD risk. The 10-year CVD risk also rose as the number of exposures to low SEP throughout life increased. Compared to individuals in high-stable intragenerational trajectory, those in upward, downward, or stable low trajectory presented higher 10-year CVD risk. Increasing

individuals' SEP over generation showed no increased risk of 10-year CVD risk compared to individuals in high-stable trajectory.

Conclusions Childhood may be a critical period for exposures to social adversities. Life course low SEP may also affect the 10-year CVD risk via accumulation of risk and social mobility.

Keywords Socioeconomic position · Life course · Social mobility · Cardiovascular disease · Framingham Risk Score

Introduction

Socioeconomic adversities have a strong association with morbidity and mortality due to cardiovascular disease (CVD) (Harper et al. 2011), subclinical atherosclerotic manifestations and poor metabolic indicators (Camelo et al. 2015). Furthermore, they also promote behaviors associated with CVD risk (Murray et al. 2011). Moreover, low socioeconomic position (SEP) at various points during the life course are also associated with CVD incidence during the adult life (Galobardes et al. 2006) and with a higher prevalence of risk factors for CVD (Power et al. 2007; Camelo et al. 2015), such as hypertension (Högberg et al. 2012), smoking (Giesinger et al. 2014), low levels of high-density lipoprotein (HDL) (Benetou et al. 2000), type II diabetes (Maty et al. 2010; Stringhini et al. 2013). It is then expected that exposure to socioeconomic adversities in various stages of life also increase an individual's long-term cardiovascular risk.

A number of mechanisms have been put forward to account for this association. The critical period model postulates that exposure to socioeconomic adversity during

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a specific developmental window, such as childhood, may have irreversible effects on the organism (Barker 2003; Kuh et al. 2003). But, the evidence in support of childhood as a critical period for CVD risk remains inconsistent (Mishra et al. 2013; Kamphuis et al. 2013).

The accumulation of risk model advocates that increasing the number, duration and severity of adverse events over the life course increases the risk of disease development (Kuh et al. 2003). As exposure to adverse social conditions in a given time of life tends to increase the chances of exposure to adverse conditions at a subsequent time, and considering that social adversities during childhood, youth and adulthood are all independently associated with CVD, then an accumulation of risk is expected (Kuh et al. 2003).

The social mobility model takes into account the effects of different trajectories across categories of social structure on the risk of disease development (Hallqvist et al. 2004). Social intergenerational mobility reflects the trajectory (descending or ascending) in class position between generations. Intragenerational mobility is the stability or change in the individual's life course itself (Tiikkaja et al. 2009) and it may be defined as a change in the occupational SEP from early adulthood to later adulthood (Pollitt et al. 2005).

The 10-year CVD risk predicted by the Framingham Risk Score (FRS) has been associated with social adversity during adulthood (Karlamangla et al. 2010), but there is no evidence that an adverse SEP in childhood and youth increases the 10-year CVD risk or whether these effects can be reversed by conditions during other life stages. Therefore, the current study used data from the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil) to investigate whether exposure to adverse SEP throughout the life course, and especially in early life, is associated with the 10-year risk of CVD predicted by the FRS. In addition, we assessed whether maintaining a low SEP or undergoing a descending trajectory in life is associated with an increased CVD risk compared to individuals who maintained a stably high SEP throughout life.

Methods

We conducted a cross-sectional investigation of the baseline data from the ELSA-Brasil (2008–2010), a multicenter cohort of 15,105 civil servants aged 35–74 years from six Brazilian states. Baseline data included detailed interviews, clinical, laboratory and anthropometric evaluations (Aquino et al. 2012). The Ethics Committee of each participating institution approved the research protocol and all participants signed an informed consent form.

The present study excluded 1533 (10.1%) participants with a history of CVD (self-reported coronary artery disease, cerebrovascular disease, heart failure or peripheral arterial disease). Additionally, we excluded participants with missing data for any variables used to estimate the FRS, including total cholesterol ($n = 16$), HDL ($n = 6$), fasting blood sugar, insulin use or use of hypoglycemic drugs ($n = 7$), and use of anti-hypertensive drugs ($n = 16$), resulting in 13,544 participants.

Response variable

The response variable was the 10-year CVD risk estimated by the FRS, which refers to the incidence or death from CVD (coronary artery disease, myocardial infarction, coronary insufficiency, and angina), cerebrovascular events (ischemic or hemorrhagic cerebrovascular disease and transitory ischemic attacks), peripheral artery disease (intermittent claudication) and heart failure (D'Agostino et al. 2008). The gender-specific FRS considers age, total cholesterol, HDL cholesterol, systolic blood pressure (SBP), diabetes, smoking and use of anti-hypertensive drugs (D'Agostino et al. 2008).

Total and HDL cholesterol were obtained using standard enzyme tests (ADVIA Chemistry). Systolic blood pressure (SBP) was measured according to standard procedures, and the average between the second and third measurements was used. Diabetes was defined as: fasting blood sugar level ≥ 126 mg/dL, or use of insulin, or use of other hypoglycemic drugs. Individuals who reported having smoked at least 100 cigarettes during their lifetime and still smoking at the time of the interview were considered smokers. Use of anti-hypertensive drugs was self-reported.

Explanatory variables

Indicators of SEP

Childhood (1) Maternal educational was evaluated retrospectively and categorized into four groups: ≥ 11, 8–10, 1–7, and 0 years of study. (2) Leg length (cm) was defined as the difference between standing height and trunk length, which, in turn, was defined as the sitting height minus the height of the stool used (stool height = 46 cm). Sex-specific leg length was categorized into three groups: high (longer than average + 1 standard deviation (SD)); medium (average ± 1 SD); low (shorter than average − 1 SD).

Youth (1) Social class of the first occupation was defined based on the occupational socioeconomic status of the first job held by the participant. The occupational socioeconomic status is a score that results from the comparison between the expected and the observed educational and

income levels required by each specific job title, taking as the reference the Brazilian occupational matrix (Ministry of Labor and Employment 2010) prevailing at the time of ELSA baseline interview. Then, occupational socioeconomic status scores were grouped into seven strata to achieve a minimum intra-stratum variance for the values of the scores and a maximum variation between the strata. The resulting variable defined seven socioeconomic status categories: "high-upper, high-low, middle-upper, middle-middle, middle-low, low-high and low-low" (Camelo et al. 2016). For the current analysis, the first and last two strata were grouped, reducing the variable to the following five groups: high, middle–high, middle, middle–low, low. This indicator better represents the SEP in young adulthood because the mean age at which the participants started working was 17 years.

Adulthood Participant's educational attainment was categorized into four groups: ≥15, 11–14, 8–10, and 0–7 years of study.

Cumulative SEP index indicates the accumulation of risk during the life course, ranging between 0 and 12 (higher values reflect a lower life course SEP). It was obtained by the sum of the maternal education (≥15 years = 0; 11–14 years = 1; 8–10 years = 2; 1–7 years = 3; 0 years = 4), social class of first occupation (high = 0; average–high = 1; average = 2; average–low = 3; low = 4) and participant's education (graduate = 0; undergraduate = 1; high-school = 2; complete primary and middle school = 3; incomplete primary and middle school = 4).

Social mobility trajectory was measured within a single generation (intragenerational) and across generations (intergenerational). First, the social class of the first occupation, of the current occupation, and the social class of the occupation of the head of the family when the participant started working were dichotomized into high (high and middle) and low. The intragenerational SEP trajectory was obtained from comparison between the individual's first and current occupations and categorized as High–high (high social level of both occupations assessed), Low–high (low level of the first and high of the last occupation assessed), High–low (high level of the first and low of the last occupation assessed), and Low–low (low social level of both occupations assessed). The intergenerational social mobility trajectory was obtained from comparison between the social class of the head of the family and the social class of the participant in adulthood (current). The social class of the head of the family was based on the occupation that he/she held at the time the participant started working. Categories were defined following the same rules defined for intragenerational trajectories.

Covariates

Body mass index (BMI, kg/m^2) was continuously considered in the analysis. Alcohol consumption (g) was evaluated based on self-reports of weekly consumption and the type and amount of drink. The quantities were obtained in dosages and processed in consumer grams per week. Excessive drinking was defined as >210 g of alcohol per week for men and >140 g for women (WHO 1998). Any consumption below these levels was considered moderate. Physical activity was measured using the leisure time section of the long version of the International Physical Activity Questionnaire (IPAC), and low, moderate and high levels of physical activity was defined according to the IPAC guidelines for data processing and analysis (IPAQ 2005). The use of oral hypolipidemic drugs was determined from self-reports.

Statistical methods

The association between SEP during the life course and 10-year CVD risk was investigated using generalized linear models (GLM), which are a generalization of the classical linear model, allowing for non-normal error and non-identity link function (McCullagh and Nelder 1989). We used GLM with the gamma distribution and logarithm link function. The gamma distribution is useful for modeling positive data that have positively skewed distributions (McCullagh and Nelder 1989). The magnitude of association was estimated from the exponential of estimated coefficients, which yields the arithmetic mean ratio (AMR) of the 10-year CVD risk. Thus, the AMR indicates how much greater the 10-year CVD risk arithmetic mean is compared to the reference category established for each SEP indicator, i.e., the category with the best socioeconomic condition. The AMR with a gamma distribution and log link function has been used in previous studies (Tan et al. 2015; Araújo et al. 2015; Fehm et al. 2008).

Initially, we conducted the univariable analysis to investigate the association between SEP prevailing of each period of life and the CVD risk and the adulthood 10-year CVD risk (Model 1). Afterwards, we entered the SEP indicators for each period of life in the same model (Model 2) to assess whether the associations of exposure to adverse SEP in each period of life with the 10-year CVD risk remained statistically significant. Finally, Model 2 was adjusted for the covariates (Model 3).

The AMR of the association of the cumulative SEP index and social mobility trajectories with the 10-year CVD risk was obtained from the univariable analysis (Model 1) and was adjusted for the covariates (Model 2). The presence of multicollinearity was verified by the variance inflation factor, and we found no evidence of this.

We did not find significant differences according to sex in the stratified analysis and, for this reason, we did not report the results stratified by sex. The significance level was 5% and all analyses were conducted using Stata 12.0 (Stata Corporation, College Station, United States).

We applied the Bonferroni correction (Bender and Lange 2001; Dickhaus 2014) to the *p* values shown in the final multivariate models to take account of the multiplicity of statistical tests performed in the present analysis.

Results

The characteristics of the study population are presented in Table 1. We found that exposure to socioeconomic adversities throughout life was associated with a higher average SBP and lower average HDL in a positive graded form (Table 2). A greater prevalence of use of anti-hypertensive medication, diabetes, and smoking was also observed for those exposed to an increased number of socioeconomic adversities throughout life (Table 2).

The association between socioeconomic indicators and 10-year risk of cardiovascular disease is shown in Table 3. Exposure to adverse socioeconomic conditions in each period of life was associated with a higher 10-year CVD risk compared to individuals with a better socioeconomic standing. The univariable analysis (Model 1) indicated that participants with mothers who never went to school had an 88% greater 10-year CVD risk compared to those whose mothers had more than 11 years of study, with the indication of a dose–response gradient. Individuals with medium and low leg length had an increased 10-year CVD risk increased by 12 and 37%, respectively, compared to individuals with high leg length. Participants with fewer years of education had a higher 10-year CVD risk, and the CVD risk was twofold higher than observed for participants with more than 15 years of study. After simultaneous adjustment of all SEP indicators (Model 2), we found that adverse conditions during childhood and during the adulthood maintained an independent association with higher 10-year CVD risk, with a clear dose–response gradient. By contrast, after adjustments, the youth SEP was no longer associated with a higher 10-year CVD risk, except for a small 11% increase from the middle-high social class compared to those in the high social class. Further adjustments for the covariates did not attenuate these associations (Model 3).

In Table 4, in the univariable analysis (Model 1), the higher the exposure to unfavorable conditions throughout life, the higher the 10-year CVD risk. After adjustments for

Table 1 Study population characteristics

Characteristics	N	%
Age mean, SD	51.5	8.8
Gender		
Male	6112	45.1
Female	7432	54.8
Childhood socioeconomic indicators		
Maternal educational level (years of study)		
≥11	958	7.2
8–10	2490	18.8
1–7	8021	60.5
0	1773	13.4
Leg length[a]		
High	2034	15.0
Medium	9429	69.6
Low	2074	15.3
Youth socioeconomic indicator		
Social class of the first occupation		
High	783	6.8
Middle–high	1454	12.6
Middle	422	3.6
Middle–low	2000	17.4
Low	6812	59.3
Adult life socioeconomic indicator		
Participant's educational level (years of study)		
≥15	7295	53.8
11–14	4674	34.4
8–10	857	6.3
0–7	718	5.3
Physical activity		
High	1247	9.3
Moderate	1859	13.9
Low	10,237	76.7
Alcohol consumption		
No consumption	4074	30.1
Moderate consumption	8450	62.4
Excessive consumption	1007	7.4
Body Mass Index BMI-kg/m² mean, SD	26.8	4.6
Hypolipidemic drugs use		
No	12,020	88.7
Yes	1524	11.2

Baseline of the Brazilian Longitudinal Study of Adult Health, 2008–2010

[a] Separate evaluations conducted for men and women. High = average + 1 SD; medium = average ± 1 SD; low = average − 1 SD

Differences in the total for each variable may occur as a result of lost information

Frequencies are shown as percentages, except when otherwise specified

Table 2 Distribution of risk factors that compose the Framingham Risk Score for cardiovascular disease according to the cumulative socioeconomic position (SEP) index

	Points in the cumulative SEP index				
	0–3 ($n = 1\,623$)	4–6 ($n = 2799$)	7–9 ($n = 4983$)	10–12 $n =$ (1700)	p value for trend[1]
Risk factors					
SBP (mean, SD, mmHg)	116.7 (±14.3)	118.6 (15.5)	120.8 (16.9)	127.2 (18.9)	$p < 0.001$
Use of anti-hypertensive (%)	22.3	24.7	25.3	32.3	$p < 0.001$
Total cholesterol (mean, SD, mg/dl)	215.1 (±40.5)	215.7 (±40.6)	214.4 (±41.9)	216.3 (±44.6)	$p = 0.610$
HDL (mean, SD, mg/dl)	59.2 (±15.6)	57.1 (±14.3)	56.0 (±14.3)	55.0 (±14.1)	$p < 0.001$
Diabetes (%)	9.4	11.4	12.7	21.5	$p < 0.001$
Smoking (%)	9.6	10.8	14.5	17.1	$p < 0.001$

Baseline of the Brazilian Longitudinal Study of Adult Health, 2008–2010 ($N = 13,544$)

Total points varied from 0 to 12, higher values reflect lower socioeconomic conditions through the course of life, including maternal education, social class of the first occupation and participant's educational level

SBP systolic blood pressure, *HDL* high-density lipoprotein

[1] Chi-square test for trend

covariates (Model 2), the participants with a higher cumulative SEP index (i.e., greater exposure to adverse conditions through the course of life) had a 70% higher 10-year CVD risk compared to participants with less exposure to adversities.

The social mobility analysis is shown in Table 5. More than half (52.6%) of the study population experienced intragenerational social ascension, whereas 5.1% went the opposite way. When comparing generations, 43% of the participants had better social standing than their parents, 13% descended the social hierarchy. After univariable analysis (Model 1), in the adjustments for covariates (Model 2), Low–High, High–Low and Low–Low intragenerational SEP trajectories were associated with higher 10-year CVD risk and remaining at a stable low socioeconomic level yielded the highest AMR compared to those who remained in a higher social class.

In the intergenerational SEP trajectory, we found that the Low–High trajectory was not associated with any changes in the 10-year CVD risk compared to individuals who remained in a high class (Model 2). However, the High–Low or Low–Low intergenerational SEP trajectory resulted in, respectively, a 16 and 48% higher average 10-year CVD risk compared to individuals who remained in a higher class across generations (Model 2).

Discussion

We found that regardless of the socioeconomic advantage experienced later in life, the detrimental effect of exposure to early-life low SEP on the 10-year CVD risk cannot be reversed. This finding supports the critical period model, which postulates that exposures to low SEP at an early age

are not completely reversed by subsequent exposures to socioeconomic adversities. Moreover, the accumulation of exposures to low SEP during the life course was associated with increased risk.

Our findings also indicate that having descending inter- or intragenerational trajectories, as well as a stable low trajectory, were associated with a greater 10-year CVD risk compared to remaining in a more favored social class throughout life. Nevertheless, findings regarding intergenerational trajectories suggest that the low social class of the head of the family does not translate into a higher risk of CVD among participants who reached a better social condition in adulthood. These results suggest that exposure in the past does not provide an additional risk of cardiovascular disease among individuals who have an ascending intergenerational trajectory. Taken together with the results of the intragenerational analysis, they reinforce the importance of an individual's exposure vis-à-vis that of the head of the family and the greater impact of adulthood exposure on the final 10-year CVD risk.

The absence of reversibility in the association between exposure to SEP adversities in early-life and CVD risk that we found in the present study is consistent with other authors who investigated cardiovascular outcomes (Galobardes et al. 2006; Kittleson et al. 2006; Glymour et al. 2008) or the presence of risk factors during adulthood (Power et al. 2007; Murray et al. 2011). However, in some prospective studies, the effect of childhood exposure was not significant after adjustment for adulthood SEP, suggesting that adverse social exposure in adulthood may be more determinantal of incidence and mortality from CVD than early-life SEP (Loucks et al. 2009; Kamphuis et al. 2013; Gebreab et al. 2015). Possibly, the persistence of effects of exposures to social adversities in childhood on

Table 3 Association between life course socioeconomic indicators and 10-year risk of cardiovascular disease

	AMR (95% CI)[a]		
	Model 1	Model 2	Model 3
Childhood socioeconomic indicators			
Maternal educational level (years of study)			
≥11	Ref.	Ref.	Ref.
8–10	1.36 (1.26–1.46)***	1.27 (1.16–1.39)***	1.26 (1.15–1.37)***
1–7	1.43 (1.33–1.53)***	1.26 (1.16–1.36)***	1.29 (1.19–1.40)***
0	1.88 (1.73–2.03)***	1.40 (1.27–1.54) ***	1.48 (1.35–1.63)***
Leg length[b]			
High	Ref.	Ref.	Ref.
Medium	1.12 (1.07–1.18)***	1.10 (1.05–1.16)***	1.07 (1.02–1.13)**
Low	1.37 (1.29–1.46)***	1.31 (1.22–1.40)***	1.25 (1.17–1.33)***
Youth socioeconomic indicators			
Social class of the first occupation			
High	Ref.	Ref.	Ref.
Middle–high	1.18 (1.08–1.29)***	1.14 (1.04–1.25)**	1.11 (1.02–1.21)*
Middle	1.21 (1.07–1.37)**	1.12 (1.00–1.27)*	1.10 (0.98–1.24)
Middle–low	1.05 (0.96–1.14)	0.95 (0.88–1.04)	0.95 (0.88–1.04)
Low	1.33 (1.23–1.43)***	1.08 (0.99–1.16)	1.05 (0.97–1.14)
Adult life socioeconomic indicators			
Participant's educational level (years of study)			
≥15	Ref.	Ref.	Ref.
11–14	1.08 (1.04–1.12)***	1.01 (0.96–1.06)	1.02 (0.97–1.06)
8–10	1.70 (1.58–1.82)***	1.55 (1.43–1.68)***	1.55 (1.43–1.68)***
0–7	2.08 (1.92–2.25)***	1.78 (1.63–1.95)***	1.78 (1.63–1.95)***

Baseline of the Brazilian Longitudinal Study of Adult Health, 2008–2010 ($N = 13{,}544$)

Model 1 Univariable analysis, *Model 2* simultaneous adjustment for all SEP indicators, *Model 3* simultaneous adjustment for all SEP indicators plus co-variables (BMI, alcohol consumption, physical activity, and hypolipidemic drugs use)

* <0.05; ** <0.01; *** <0.001: statistical significance of explanatory variable categories in the generalized linear regression. Models using as response variables the Framingham Risk Score for 10-year risk of cardiovascular disease

[a] Arithmetic mean ratio obtained from the exponential of coefficients from generalized linear Models with gamma distribution, log link function, using as reference the categories corresponding to higher socioeconomic conditions

[b] Separate evaluations conducted for men and women. Longer than average = average + 1 SD; average = average ± 1 SD; shorter than average = average − 1 SD

CVD risk depends on the choice of SEP indicators and on the intensity of exposure in different contexts. In the ELSA-Brasil, the percentage of mothers who had little or no study was very high. In the 40s, Brazil had an illiteracy rate of 56%, whereas the US and England had rates of 3 and 10%, respectively (Roser 2015). This pattern suggests that ELSA-Brasil participants were exposed to worse conditions than those faced by similar birth cohorts in developed countries, which may contribute to the long-term permanence of the effects of exposure to low SEP in childhood on CVD risk.

We measured the childhood SEP based on the maternal educational level and participant leg length. Strong evidence suggests that maternal education provides a good indicator of social conditions in early life (Boyle et al. 2006), and it is highly associated with health and nutritional conditions during pregnancy and post-partum than paternal SEP indicators (Hasan et al. 2015). Adult leg length also provides a sensitive indicator of the impact of SEP on child growth (Gigante et al. 2009) and has a strong connection to the risk of CVD and the presence of risk factors during adulthood (Ferrie et al. 2006).

Table 4 Association between the adverse socioeconomic position (SEP) accumulation index and the 10-year risk of cardiovascular disease

	N (%)	AMR (95% CI)[a]	
		Model 1	Model 2
Adverse SEP accumulation index[b]			
0–3 (higher)	1626 (14.4)	Ref.	Ref.
4–6	2802 (24.9)	1.05 (0.99–1.12)	1.06 (1.00–1.13)*
7–9	4987 (44.4)	1.07 (1.01–1.13)*	1.10 (1.04–1.16)**
10–12 (lower)	1805 (16.0)	1.63 (1.52–1.74)***	1.69 (1.58–1.81)***

Baseline of the Brazilian Longitudinal Study of Adult Health, 2008–2010 (N = 13,544)

Model 1 Univariable analysis, *Model 2* adjusted for BMI, alcohol consumption, physical activity, and hypolipidemic drugs use

SEP socioeconomic position

* <0.05; ** <0.01; *** <0.001: statistical significance of explanatory variable categories in the generalized linear regression. Models using as response variables the Framingham Risk Score for 10-year risk of cardiovascular disease

[a] Arithmetic mean ratio obtained from the exponential of coefficients from generalized linear Models with gamma distribution, log link function, using as reference the categories corresponding to higher socioeconomic conditions

[b] Total points varied from 0 to 12, higher values reflect lower socioeconomic conditions throughout the course of life, including maternal education, social class of the first occupation and participant's educational level

Table 5 Association between intra- and intergenerational socioeconomic position (SEP) trajectories and 10-year risk of cardiovascular disease

	N (%)	AMR (95% CI)[a]	
		Model 1	Model 2
Intragenerational SEP trajectory[b]			
High–high	2351 (20.7)	Ref.	Ref.
Low–high	5956 (52.6)	1.26 (1.20–1.32)***	1.24 (1.18–1.30)***
High–low	582 (5.14)	1.30 (1.19–1.43)***	1.34 (1.22–1.47)***
Low–low	2427 (21.4)	1.67 (1.58–1.77)***	1.68 (1.58–1.78)***
Intergenerational SEP trajectory[c]			
High–high	3362 (26.4)	Ref.	Ref.
Low–high	5482 (43.1)	1.02 (0.98–1.07)	1.03 (0.99–1.08)
High–low	1707 (13.4)	1.13 (1.07–1.20)***	1.16 (1.09–1.23)***
Low–low	2150 (16.9)	1.43 (1.36–1.52)***	1.48 (1.40–1.57)***

Baseline of the Brazilian Longitudinal Study of Adult Health, 2008–2010 (N = 13,544)

Model 1 Univariate analysis, *Model 2* adjusted for BMI, alcohol consumption, physical activity, and hypolipidemic drugs use

SEP socioeconomic position

* <0.05; ** <0.01; *** <0.001: statistical significance of explanatory variable categories in the generalized linear regression Models using as response variables the Framingham Risk Score for the 10-year risk of cardiovascular disease

[a] Arithmetic mean ratio obtained from the exponential of coefficients from generalized linear Models with gamma distribution, log link function, using as reference the categories corresponding to higher socioeconomic conditions

[b] Comparison between first and current occupational social class

[c] Comparison between the head of the family and the participant's current occupational social classes

Different mechanisms may explain the independent effect of childhood adversities on CVD risk. The FRS may encompass risk factors that remain relevant in the adult due to latent physiological effects of exposure to socioeconomic adversity during the fetal and childhood periods (Barker 2003). This relationship was demonstrated for

dyslipidemias, type II diabetes (Maty et al. 2010), and hypertension (Högberget et al. 2012). Moreover, the direct effect of early-life SEP on behavioral risk factors such as smoking (Lawlor et al. 2005) may correspond to behavioral responses to negative environmental stimuli or other psychosocial reactions to adverse contexts during childhood (Pollitt et al. 2005; Johnson-Lawrence et al. 2015).

The association between childhood adversities and a higher 10-year CVD risk was attenuated after simultaneous adjustment for youth and adulthood SEP indicators. Exposure to social adversity in early-life increases the odds of exposure to such events later in life, suggesting that the association between childhood SEP and CVD risk may be at least partly mediated by the adulthood SEP as postulated by the "chain of risks" hypothesis (Kuh et al. 2003). This concept is supported by a study of a Scottish cohort showing that the level of education achieved in adulthood represents an important mediator of the association between childhood SEP and CVD risk (Lawlor et al. 2005). In the coronary artery risk development (CARDIA), the SEP and psychosocial symptoms in adulthood represented important mediators of the association between early-life psychosocial environment and increased 10-year risk of CVD, also assessed by the FRS (Loucks et al. 2011).

We further observed that the risk of developing a CVD within 10 years increased with increasing scores for the exposure to socioeconomic adversities throughout the life course, supporting the accumulation of risk model (Kuh et al. 2003). This result is also consistent with the allostatic load hypothesis, which states that chronic exposure to psychosocial stress through the life course triggers a subclinical atherosclerotic condition that may promote CVD (Danese and McEwen 2012). A cumulative effect of social adversities has also been detected for CVD-related deaths (Mishra et al. 2013; Johnson-Lawrence et al. 2015) and cardiovascular risk factors such as type II diabetes (Stringhini et al. 2013). Analysis of the Whitehall II study found a clear dose–response gradient connecting the socioeconomic adversities over the life course and incidence of CVD in adulthood (Singh-Manoux et al. 2004).

In the present study, descending and stable low, intra- and intergenerational trajectories resulted in a higher risk of CVD compared to a stable high trajectory, as previously observed (Pollitt et al. 2005). Prospective studies showed that even individuals with high childhood SEP face a greater chance of developing CVD if they descend in the SEP as they age (Tiikkaja and Hemstrom 2008; Tiikkaja et al. 2009). The average 10-year CVD risk was greater among individuals who experienced an ascending intragenerational trajectory than in individuals whose intragenerational trajectories were stable high. Therefore, the intragenerational upgrade on SEP may not completely reverse the effects of exposure to low SEP in early life. It

also appears that the individual's own SEP in youth is more important to CVD risk in adulthood than the SEP of the head of the family during the same period. However, the CVD risk of individuals who ascended socially compared to their parent's SEP was not different from those who maintained a stable high intergenerational trajectory, indicating that the exposure to low SEP in adulthood is more detrimental to CVD risk than in early life.

No previous study evaluated the association between life course SEP and 10-year risk of CVD assessed by the FRS. The association between SEP and CVD stems only in part from a pattern of risk factors that arises during life (Stringhini et al. 2010). For example, people in lower income classes are more prone to initiate and less likely to stop smoking (Nagelhout et al. 2012). Therefore, low SEP may predict CVD incidence independently of risk factors included in the FRS (Brindle et al. 2005). This evidence may explain why the FRS underestimates the CVD risk for populations exposed to low SEP (Brindle et al. 2005). Accordingly, Franks et al. (2010) found that the inclusion of measures of SEP in the Framingham risk prediction equation improved calibration of the equation and reduced the SEP bias involved in using the 10-year CVD risk alone (Franks et al. 2010).

This study has some limitations. First, we considered the participant educational level as an indicator of SEP during adulthood and not during youth, as preferred by other authors (Kamphuis et al. 2013). As an indicator for youth SEP, we selected the social class of the first occupation. This is because in the ELSA-Brasil, the participants began working at an average age of 17, but they finished their education much later in life. Second, the index that we created to assess the accumulation of risk assumed that exposure to low SEP in each period of life has an equal effect on the 10-year CVD risk, which is a simplification of this framework and may have led to a misclassification of the true cumulative burden of SEP life course adversities. However, if we considered our multivariate findings regarding the association of SEP in each period with CVD risk, the strength of the association is greatest with exposure in adulthood compared to exposure in childhood. Therefore, the index used to assess the accumulation of risk likely underestimates the true dose–response gradient from low to high for the life course burden of exposure to social adversities.

We must also emphasize that the ELSA-Brasil is a cohort of civil servants with a higher educational level and income than the average Brazilian. Therefore, this study may not have included the worst cases of socioeconomic adversity across the life course, which could result in an underestimation of the association between SEP and CVD risk. Finally, despite being largely used in Brazil, the associations with 10-year CVD risk assessed by the FRS are no guarantee of associations with cardiovascular

events. The applicability of FRS for the Brazilian population has not been assessed. In some populations, the score tends to overestimate risk (Rodenas et al. 2013), whereas in others, it displays a high degree of accuracy and discriminating power (Chia et al. 2015).

This study indicates that exposures to social adversities during childhood and adulthood are associated with an increased 10-year risk of CVD. Our results support the hypothesis that exposure to SEP adversities during childhood may have irreversible negative effects on CVD risk. Furthermore, our results also support the accumulation of risk and social mobility models. Together, these results, considering a life course perspective, contribute to improving our understanding of the social causes of adult health. They corroborate previous findings showing that prevention strategies to reduce CVD risk should start in childhood and that social policies directed towards improving social conditions in childhood can have long-term benefits for CVD health. Moreover, our results suggest that providing opportunities to individuals who originate from a low social background to move upward in SEP reduces the total burden of social disadvantages throughout life and may improve CVD risk.

Compliance with ethical standards

Ethical statement All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of interest The authors declare that there is no conflict of interest.

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