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The role of city income inequality, sex ratio and youth mortality rates in the effect of violent victimization on health-risk behaviors in Brazilian adolescents

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ABSTRACT

This study integrates insights from evolutionary psychology and social epidemiology to present a novel approach to contextual effects on health-risk behaviors (unprotected sex, drunkenness episodes, drugs and tobacco experimentation) among adolescents. Using data from the 2012 Brazilian National Survey of Adolescent Health (PeNSE), we first analyzed the effects of self-reported violent victimization on health-risk behaviors of 47,371 adolescents aged 10–19 nested in the 26 Brazilian state capitals and the Federal District. We then explored whether the magnitude of these associations was correlated with cues of environmental harshness and unpredictability (youth external mortality and income inequality) and mating competition (sex ratio) from the city level. Results indicated that self-reported violent victimization is associated with an increased chance of engagement in health-risk behaviors in all Brazilian state capitals, for both males and females, but the magnitude of these associations varies in relation to broader environmental factors, such as the cities' age-specific mortality rates, and specifically for females, income inequality and sex ratio. In addition to introducing a novel theoretical and empirical approach to contextual effects on adolescent health-risk behaviors, our findings reinforce the need to consider synergies between people's life experiences and the conditions where they live, when studying health-risk behaviors in adolescence.

1. Introduction

Underage drinking and drunkenness, drug use, unprotected sex, and other forms of risky behavior in adolescence have been studied by epidemiologists because they are closely related to increased morbidity and mortality for young people, and therefore represent major public health challenges (Hale et al., 2014). These risk-taking behaviors typically emerge and rise rapidly in adolescence (WHO, 2015; Steinberg et al., 2008), and there is a variety of models dedicated to the investigation of their underlying causal mechanisms (Boyer, 2006).

One model that has been increasingly applied to explain population and individual differences in risk behavior is evolutionary Life History Theory (Del Giudice et al., 2015). According to one influential version of the theory, the diversity of life history "strategies" between and within species can be arranged on a continuum from *fast*—early maturation and reproduction, fast growth, small body size, high fertility, short lifespan, and low investment in offspring quality—to *slow*—late maturation and reproduction, slow growth, large body size, low fertility, long lifespan, and high investment in offspring (Brumbach et al., 2009; Del Giudice et al., 2015; Ellis et al., 2012; Wang et al., 2009). According to this framework, risky behavior should be affected by cues predictive of life expectancy and other aspects of the environment, specifically, cues of environmental harshness (the rates at which extrinsic

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factors cause disability and death at each age in a population) and unpredictability (stochastic variation in salient environmental conditions) (Rogers, 1994).

When environments are unpredictable and life expectancies are short, risk taking may be more adaptive than risk avoidance, leading to "future discounting" in behavioral choices (Daly and Wilson, 2001, 2005; Ramos et al., 2013; Wang et al., 2009; Wilson and Daly, 1997). There is substantial empirical evidence that exposure to harsh (high mortality–morbidity) environments is indeed associated with the development of *fast* life history strategies and can explain variability in risky behavior, especially in adolescence (Brumbach et al., 2009; Ellis and Del Giudice, 2014; Ellis et al., 2012; Ellis et al., 2009). However, studies of the effects of attributes of the environment at different levels of proximity (e.g. one's neighborhood, city, state, etc.) are still a novelty in the risk behavior literature.

Recently, Copping and Campbell's study was one of the first to demonstrate such effects through a multilevel perspective. They found that neighborhood circumstances in 2001 predicted criminal violence and teenage pregnancy ten years later, and that individuals' perceptions of these neighborhood circumstances were associated with aggression and risky sexual behavior (Copping and Campbell, 2015). Furthermore, there was a clear similarity between neighborhood and individual level associations in both their direction and causal pathways, analyzed through structural modeling. This conceptual convergence between group and individual level measures presents a compelling argument for studies addressing how risky behavioral expression is influenced by environmental circumstances at different spatial levels.

As proposed by Diez Roux and Mair (2010), different spatial levels may contribute synergistically to the relationship between one's immediate environmental experiences and behaviors. Features of a city, for example, may serve to buffer or enhance the consequences of other sources of stress, as well as reinforce the environment–behavior associations happening at a lower level. Diez-Roux & Mair propose that these effects are often synergistic, such that whether certain variables affect one's behavior is itself influenced by broader ecological conditions. Exploring this hypothesis from a Life History Theory perspective, we believe that cities characterized by safety and better resource distribution may have stress reducing properties, whereas those characterized by danger, i.e., high mortality and resource uncertainty, may enhance the salience and hence the impact of other sources of risk-taking, ultimately increasing the rates of adolescent risk behaviors. This is especially relevant for the situation in Brazil, where rates of violence exhibit great variability across cities.

1.1. The Brazilian scenario

Over the last three decades, violence has emerged as one of the most significant problems in Brazil (Dahlberg and Krug, 2006; Minayo, 1990, 2004). While recent trends have been encouraging, with the rates decreasing within the past five years, homicide remains the leading cause of death among adolescents (Waiselfisz, 2013). During this period, an increasing number of studies have sought to characterize youth violence and the contexts in which it occurs, and to pinpoint risk and protective factors (Cardia, 2003; Castro and Abramovay, 2002; Cocco and Lopes, 2010; Formiga and Sintra, 2011; Jorge, 2002).

Recent data indicate that a significant proportion of Brazilian youth is exposed to violence in the form of direct and indirect victimization. Mortality by violent causes is maximal in young adulthood, as is the percentage of deaths that are due to external causes (Waiselfisz, 2013). However, violence does not affect the young population uniformly: the risk of death by violent causes varies greatly across Brazil's five regions and 27 state capitals.

Analyzing 2013's youth homicides, Waiselfisz (2014) observed that the rates varied between 17 per 100 thousand inhabitants in Campo Grande (Center-West) and 268 per 100 thousand inhabitants in Fortaleza (Northeast). The greatest variability was found among the four state capitals in the Southeast region where there was a standard deviation of 84 in the youth homicide rates between these cities (from 28.5 in São Paulo to 209 in Vitória) and the lowest variability in homicide rates was found in the Northeast region ($SD = 25$), with Belém having the highest rate (107) and Recife the lowest (92.1).

This variability within regions suggests the need for research to examine how the associations between exposure to violence during adolescence and risk behavior might be affected by such different environments. Being victimized in a city where youth mortality is low could be more impactful than being victimized in a city where the rates are high, but the reverse is also possible.

Despite the abundant literature on adolescent risk behavior and contextual risk factors, we know relatively little about the relative contribution of direct violent victimization and other, evolutionarily relevant, city level variables. Accordingly, our study used data from a nationally representative sample of 9th graders (ages 10 to 19) to investigate the effects of self-reported individual violent victimization and of relevant city level factors (i.e. youth mortality rates, income inequality and sex ratio) on adolescent health-risk behaviors (i.e. self-reported unprotected sexual activity, drunkenness, drug and tobacco use), and to assess whether the city level variables might influence the magnitude of the effects of the individual level variables.

Cues of competitive disadvantage also play a role in risk taking, arguably because each individual not only needs to do well, but also to beat its competitors for evolutionarily relevant resources (e.g., Daly and Wilson, 2001; Frank, 2000; Luttmer, 2005). Risk-sensitivity theory predicts that those who are competitively disadvantaged are less likely to succeed in social competition and should therefore exhibit elevated risk taking (Mishra et al., 2014). The theory applies equally to both sexes (Mishra and Lalumière, 2010), but the domains that matter for each may differ (Buss, 1989; Campbell, 1995; Ermer et al., 2008; Hill and Buss, 2010). Therefore, we also tested whether city sex ratio (males per 100 females), an indicator of mating competition, is associated with the effect of violence on adolescent health-risk behavior. In sexually reproducing animals, individuals of one sex may have to compete for access to mating partners of the opposite sex. Thus, sex ratio is central in predicting the intensity of mating competition and which sex is competing for which (Kvarnemo and Ahnesjo, 1996). One rationale for looking into sex ratio is to ask whether health-risk behavior is more affected by violence within the sex that is more strongly in competition for the other rarer sex.

The goals of our study were threefold. First, we sought to analyze the effect of self-reported violent victimization on four different types of health-risk behaviors among Brazilian students. Second, we sought to determine whether the associations between self-report of violent victimization and health-risk behaviors differ among the 27 state capitals, using effect size measures. Finally, we examined the associations between city level factors (youth mortality rates, income inequality and sex ratio) and these effect sizes, to determine what local factors modulate the effects of violent victimization. Because males and females are known to have not only distinct risk taking strategies (Daly and Wilson, 2001), but also different levels of risk sensitivity by domain (Buss, 1989; Campbell, 1995; Ermer et al., 2008; Hill and Buss, 2010), all our results are presented first for the whole sample and are then stratified by sex.

2. Methods

2.1. Design and survey population

The PeNSE (*Pesquisa Nacional de Saúde do Escolar*) survey is an ongoing school-based survey, conducted by the Brazilian Ministry of Health, together with the Brazilian Institute of Geography and Statistics (IBGE – Instituto Brasileiro de Geografia e Estatística), designed to monitor the health of children and adolescents enrolled in the 9th grade in public and private schools.

The sample was designed to be representative (in terms of race, sex and age) of the Brazilian population of 9th grade students. 2842 schools were selected across the country's five regions, (including rural and urban areas of the South, Southeast, North, Northeast, Center-West), the 26 state capitals and the Federal District, comprising a total of 110,873 students. Out of this total, 1651 refused to participate (1.5%), leaving a sample of 109,104 students (IBGE, 2012).

Due to this sampling strategy and our focus on city characteristics, we had to limit analysis to the 26 state capitals and the Federal District, constituting 56% of the original sample (N = 61,098). The PeNSE sample was not designed to be representative of all Brazilian cities; it allows us to analyze the regions (subdivided as urban and rural areas) or the state capitals. All cases with inconsistent responses concerning health-risk behaviors (e.g. if a respondent said he/she had never drunk alcohol but also provided an age at which she first drank alcohol) were removed from the analysis, leaving a final sample of 47,371 students - see (Ramos et al., 2017), regarding inconsistency and its correlates in the PeNSE survey.

In the PeNSE data, as in the Brazilian population of 9th grade students, 52% of the participants were girls and 79% were from public schools. In terms of race 42% of the students identified themselves as *pardos* (mixed race), 37% as Caucasians, 13% as "black", 4% as yellow (of East Asian descent), and 4% as indigenous. The age range of the sample was 10–19 years ($M = 14.3$, $SD = 0.08$), with 67% of the participants below the age of 15.

The PeNSE survey was approved by the Ethics Research Council of the Brazilian Ministry of Health (report n. 192/2012, referring to registration n. 16805 of CONEP/MS on 27/03/2012).

3. Measures

Using a digital device (similar to a palmtop), the students answered 127 questions covering socioeconomic status, social support, bullying, nutritional habits, body image perception, asthma, hygiene habits, mental health, work activity, use of health services, oral health, physical activity, substance use (alcohol, drugs and cigarettes), sexual activity, safety, accidents, and exposure to violence. For this paper, we focus on questions related to health-risk behaviors and self-reports of violent victimization.

3.1. Health-risk behaviors

Our measures of health-risk behaviors were the participants' answers to a set of 'yes or no' questions. In total, four health-risk behaviors were assessed: unprotected sex ("In the last time you had sex, did you or your partner use any kind of protection?"), drug experimentation ("Have you ever tried drugs [marijuana, cocaine, crack, ether inhalants, ecstasy, oxy, etc.]?"), drunkenness ("In your life, have you ever drank so much that you got really drunk?") and tobacco experimentation ("Have you ever smoked a cigarette?").

3.2. Self-reported experience of violent victimization

As a measure of direct exposure to violence, self-reported experience of violent victimization was assessed by the question "How many times have you been physically assaulted in the last year?" which was categorized as "never" or "at least once".

3.3. City level variables

The following city level variables were selected to represent cues of environmental harshness and unpredictability, the most salient contextual factors in the Life History Theory model to explain adolescent risk behavior (Brumbach et al., 2009). As a representative of environmental harshness (the rates at which extrinsic factors cause disability and death at each age in a population), we used the Municipal Youth Mortality Rate from External Causes per 100,000 (henceforth 'external mortality') in 2011, for ages 10 to 19 (the same age range of the PeNSE survey participants): the number of 10-19-year-olds who died from external causes-, divided by the same-age population at the mid-point of 2011 times 100,000. These data were provided by the Brazilian Ministry of Health through the online database DATASUS. Additionally, to explore whether the effect of cues of harshness were gender specific, we also used the sex-specific Municipal Youth Mortality Rate from External Causes (per 100,000) in 2011, for ages 10 to 19. Environmental unpredictability (stochastic variation in salient environmental conditions for growth and human development) was represented by the Cities' Gini index (household income inequality) in 2011, provided by the Brazilian Institute of Geography and Statistics (IBGE).

Sex ratio (males per 100 females) in 2011, also for population between ages 10 and 19, was used as an indicator of the level of mating competition in each city.

4. Analysis

First, the proportions of respondents who said they had been assaulted in the last year, and the proportions engaging in each of the health-risk behaviors were computed. Next, logistic regressions were used to analyze bivariate relationships between self-reported violent victimization and engagement in each of the four health-risk behaviors (unprotected sex, drug experimentation, drunkenness and tobacco experimentation) in each of the 27 cities, generating an Odds Ratio for such associations in each city. All the regression models were first conducted for the whole sample and then stratified by sex.

The regression analysis was adjusted for age, socioeconomic status (SES) and co-residence with mother and father, because these variables have previously been shown to be potential confounders of the violent victimization – risk behavior association (Brumbach et al., 2009). Socioeconomic status was defined using the ABEP index criteria (ABEP- *Associação Brasileira de Empresas de Pesquisa*/Brazilian Association of Research Agencies), which determines a person's socioeconomic status according to the educational level of the head of the household, possession of various types of household goods (e.g., television sets, desktop or laptop computer), vehicle and number of housekeepers. This scale sorts participants into standardized subgroups labeled from A to E (A1, A2, B1, B2, C1, C2, D, E; where A1 represents the highest economic level).

Based on these Odds Ratios, we calculated Cohen's d, a measure of effect size that is more meaningful than the odds ratio when dealing with large sample sizes (Chen et al., 2010). Cohen's d is usually interpreted following rule of thumb criteria set out by Cohen: $d = 0.2$–0.4 is a "small" effect, $d = 0.5$–0.7 is a "medium" effect, and $d \geq 0.8$ is a "large" effect (Cohen, 1988, 1992). Sex differences in these effect size measures were analyzed by Kruskal Wallis rank tests.

The final step of analysis was an examination of the association of city level variables with the effect size of self-reported violent victimization on each of the four types of health-risk behaviors. Because of the limited number of 'observations' (27 cities), we used nonparametric Spearman correlations to assess the relationships among city-level risk-behavior-specific effect sizes and the corresponding local external mortality, sex ratio and Gini index.

All statistical analyses were completed in Stata (version 12.0; StataCorp LP, College Station, TX, USA) and weighted data analyses were conducted using the *'svy'* family of commands to adjust prevalence and variance estimates to account for the sample design and clustering.

5. Results

5.1. Prevalence of self-reported violent victimization and health-risk behaviors

Descriptive statistics are provided in Table 1. We found that 17.30% of the participants reported having been physically assaulted at least once in the previous year, with self-reported incidence ranging from 13.48% in Porto Velho to 20.10% in Curitiba. The sexes differed little on this measure: 15.77% of the female respondents (13.02%–19.92%) and 16.44% of the male respondents (13.93%–21.54%) reported having been victimized at least once in the previous year.

Among those who reported that they had already had sexual intercourse, the prevalence of reporting not having used any kind of protection in the last sexual intercourse was 19.30%, ranging from 14.75% in Belo Horizonte to 25.99% in João Pessoa. Among the female participants, the prevalence was 18.96%, (18.17%–19.77%) as compared to 19.50% (18.88%–20.14%) for the male participants. Drug experimentation was reported by 6.21% of the participants, ranging from 2.92% in Macapá to 16.19% in Florianópolis. For the female sample, the prevalence of drug experimentation was 4.91% (1.93%–17.94%), in contrast to 6.04% for the male sample (3.77%–16.22%). With respect to drunkenness, 22.93% of the students reported having had a drunkenness episode at least once, varying from 18.93% in Belém to 34.34% in Florianópolis. Among the female respondents, the prevalence of drunkenness was 22.47% (17.31%–35.61%) against 23.46% (17.86%–33.89%) for the male respondents. Lastly, 20% of the participants reported having smoked a cigarette, ranging from 15.12% in Natal to 36.98% Campo Grande, with a prevalence of 19.50% for females (14.99%–33.98%) and 20.56% for males (14.44%–35.44%).

5.2. Effect of self-reported violent victimization on engagement in health-risk behaviors

Violent victimization was positively associated with all four types of health-risk behaviors. Among those who reported violent victimization within the past year, there were higher chances of also reporting unprotected sex (OR = 2.04; 95% CI = 1.78–2.33; Cohen's d = 0.40), drug experimentation (OR = 2.58; 95% CI = 2.29–2.91; Cohen's d = 0.43), drunkenness (OR = 2.05; 95% CI = 1.97–2.14; Cohen's d = 0.37) and tobacco experimentation (OR = 2.11; 95% CI = 1.94–2.30; Cohen's d = 0.37).

Moreover, as we anticipated, there was significant heterogeneity in the effect sizes of these associations across the 27 state capitals (Table 2). For unprotected sex, there was no significant effect of violent victimization in 11 of the 27 state capitals and a small effect (d = 0.20 to 0.50) in the remaining 16. Regarding drug experimentation, a significant effect of violent victimization was found in every city except Natal, with 16 cities presenting a small effect size, nine a medium effect size, and a large effect size (>0.80) only in João Pessoa. Self-reported violent victimization had a small effect on drunkenness in all the 27 state capitals. Finally, regarding tobacco experimentation, a small effect of violent victimization was found in 22 of the cities, with medium effect sizes in the other five.

Table 1
Prevalence (%), with respective confidence intervals, for self-reported violent victimization within the past 12 months, unprotected sex, drug experimentation, drunkenness and tobacco experimentation according to state capital city, Brazil, PeNSE 2012 (N = 47,371).

City	Self-reported violent victimization (%)	Unprotected Sex (%)	Drug Experimentation (%)	Drunkenness (%)	Tobacco Experimentation (%)
Porto Velho	13.48 (11.86–15.29)	18.27 (15.15–21.87)	7.86 (6.61–9.33)	24.2 (22.11–26.41)	21.48 (19.49–23.61)
Rio Branco	16.11 (14.26–18.15)	17.66 (14.36–21.53)	4.66 (3.67–5.92)	19.33 (17.32–21.51)	27.19 (24.90–29.60)
Manaus	17.74 (15.96–19.67)	15.82 (13.14–18.93)	7.93 (6.72–9.35)	21.57 (19.64–23.64)	21.56 (19.63–23.63)
Boa Vista	18.63 (16.77–20.64)	20.07 (17.08–23.43)	7.92 (6.68–9.37)	28.63 (26.43–30.93)	29.13 (26.93–31.44)
Belém	18.15 (16.32–20.13)	22.33 (18.94–26.14)	4.63 (3.70–5.79)	18.67 (16.82–20.67)	19.86 (17.96–21.90)
Macapá	19.31 (17.60–21.54)	18.97 (16.26–22.01)	2.92 (2.25–3.78)	20.82 (19.04–22.72)	22.19 (20.37–24.12)
Palmas	15.21 (13.38–17.25)	21.79 (17.97–26.17)	3.25 (2.42–3.78)	22.81 (19.04–25.15)	19.2 (17.16–21.41)
São Luís	14.52 (13.08–16.08)	22.95 (19.62–26.66)	5.37 (4.49–6.41)	19.68 (18.03–21.43)	17.15 (15.60–18.82)
Teresina	14.09 (12.60–15.72)	20.51 (16.95–24.60)	4.25 (3.42–5.25)	20.08 (18.35–21.94)	16.95 (15.34–18.70)
Fortaleza	19.55 (17.74–21.49)	23.68 (20.00–27.81)	5.70 (4.70–6.90)	19.71 (17.90–21.66)	17.5 (15.78–19.37)
Natal	17.77 (16.09–19.59)	20.30 (16.88–24.22)	6.20 (5.18–7.40)	20.50 (18.72–22.41)	15.12 (13.55–16.82)
João Pessoa	16.55 (14.99–18.25)	25.99 (22.16–30.23)	6.64 (5.64–7.82)	20.62 (18.91–22.45)	19.08 (17.42–20.85)
Recife	19.24 (17.69–20.90)	22.22 (19.10–25.69)	8.79 (7.70–10.07)	24.87 (23.15–26.67)	19.28 (17.72–20.93)
Maceió	16.08 (14.27–18.08)	22.90 (19.01–27.32)	7.71 (6.44–9.22)	22.51 (20.42–24.75)	18.43 (16.50–20.53)
Aracaju	15.09 (13.61–16.71)	22.43 (19.11–26.13)	5.17 (4.30–6.22)	23.32 (21.54–25.20)	15.17 (13.68–16.79)
Salvador	18.74 (16.91–20.73)	20.46 (17.33–23.98)	4.30 (3.41–5.41)	26.46 (24.36–28.68)	15.32 (13.64–17.16)
Belo Horizonte	17.40 (15.84–19.07)	14.75 (12.03–17.95)	8.71 (7.58–9.99)	29.09 (27.19–31.07)	19.93 (18.28–21.69)
Vitória	18.19 (16.40–20.13)	21.41 (17.82–25.50)	12.58 (11.07–14.28)	28.09 (25.96–30.31)	20.73 (18.84–22.76)
Rio de Janeiro	18.41 (16.72–20.23)	18.36 (15.39–21.75)	5.06 (4.15–6.15)	25.73 (23.80–27.76)	17.19 (15.55–18.96)
São Paulo	19.30 (17.56–21.72)	17.19 (14.15–20.74)	9.88 (8.59–11.33)	27.28 (25.29–29.37)	22.04 (20.20–24.00)
Curitiba	20.10 (18.22–22.12)	15.00 (11.96–18.65)	14.30 (12.68–16.09)	31.81 (29.58–34.12)	32.18 (29.95–34.50)
Florianópolis	16.97 (15.38–18.73)	18.08 (15.00–21.63)	16.19 (14.59–17.93)	32.87 (30.78–35.03)	28.06 (26.07–30.14)
Porto Alegre	16.62 (14.57–18.91)	15.22 (11.89–21.63)	11.18 (9.47–13.15)	30.84 (28.22–33.59)	26.94 (24.43–29.59)
Campo Grande	16.70 (14.91–18.90)	15.23 (12.41–18.54)	10.21 (8.78–11.84)	33.40 (31.07–35.81)	36.98 (34.59–39.44)
Cuiabá	16.56 (14.56–18.77)	17.35 (13.68–21.76)	4.44 (3.41–5.77)	23.97 (21.63–26.48)	21.07 (18.85–23.48)
Goiània	17.06 (15.60–18.64)	19.07 (16.17–22.35)	8.15 (7.11–9.33)	27.52 (25.75–29.37)	20.28 (18.70–23.48)
Brasília	18.40 (16.85–20.05)	21.45 (18.26–25.04)	13.18 (11.84–14.64)	28.89 (27.05–30.80)	23.73 (22.02–25.54)

Table 2
Odds ratios, with respective 95% confidence intervals, and effect size measures (Cohen's *d*) for self-reported violent victimization's effects on engagement on health-risk behaviors (unprotected sex, drug experimentation, alcohol experimentation, tobacco experimentation), Brazil, PeNSE 2012 ($N = 47{,}371$)*.

City	Unprotected sex		Drug Experimentation		Drunkenness		Tobacco Experimentation	
	OR (95%CI)	Effect size	OR (95%CI)	Effect size	OR (95%CI)	Effect size	OR (95%CI)	Effect size
Porto Velho	2.28 (1.31–3.97)	0.37	2.06 (1.27–3.33)	0.35	2.56 (1.84–3.57)	0.49	2.14 (1.50–3.05)	0.37
Rio Branco	1.81 (0.99–3.28)	0.31	2.52 (1.44–4.42)	0.32	2.10 (1.49–2.96)	0.37	2.41 (1.74–3.34)	0.37
Manaus	1.96 (1.21–3.18)	0.35	3.03 (2.02–4.52)	0.56	2.42 (1.81–3.24)	0.37	2.59 (1.92–3.49)	0.37
Boa Vista	1.14 (0.72–1.80)	0.05	2.37 (1.47–3.81)	0.35	2.30 (1.73–3.05)	0.37	2.63 (1.94–3.57)	0.61
Belém	2.08 (1.31–3.30)	0.37	2.50 (1.44–4.34)	0.53	2.47 (1.80–3.37)	0.37	2.63 (1.91–3.62)	0.61
Macapá	1.22 (0.79–1.90)	0.09	1.71 (0.88–3.33)	0.29	1.84 (1.40–2.42)	0.31	1.90 (1.44–2.51)	0.34
Palmas	1.64 (0.90–2.99)	0.20	3.11 (1.54–6.32)	0.62	1.99 (1.41–2.82)	0.37	1.93 (1.30–2.85)	0.34
São Luís	1.33 (0.80–2.20)	0.14	2.04 (1.28–3.22)	0.34	1.77 (1.33–2.34)	0.31	2.32 (1.73–3.10)	0.37
Teresina	1.87 (1.03–3.40)	0.34	2.87 (1.65–4.98)	0.53	2.37 (1.75–3.22)	0.37	2.48 (1.79–3.43)	0.37
Fortaleza	1.16 (1.04–2.59)	0.06	2.57 (1.63–4.04)	0.53	2.28 (1.72–3.01)	0.37	2.47 (1.83–3.34)	0.37
Natal	1.35 (0.80–2.30)	0.14	1.76 (1.10–2.86)	0.05	1.61 (1.21–2.16)	0.25	2.15 (1.55–2.99)	0.37
João Pessoa	1.81 (1.13–2.90)	0.31	4.96 (3.31–7.44)	0.81	2.67 (2.04–3.49)	0.49	3.15 (2.37–4.17)	0.61
Recife	1.76 (1.16–2.67)	0.31	2.79 (2.00–3.88)	0.58	2.18 (1.73–2.75)	0.37	2.50 (1.94–3.22)	0.37
Maceió	1.19 (0.65–2.17)	0.09	1.97 (1.20–3.24)	0.35	1.88 (1.36–2.60)	0.34	2.21 (1.55–3.17)	0.37
Aracaju	2.34 (1.46–3.76)	0.37	2.57 (1.62–4.09)	0.32	1.88 (1.43–2.48)	0.34	2.36 (1.71–3.25)	0.37
Salvador	1.24 (0.78–1.97)	0.09	3.92 (2.92–6.70)	0.65	2.75 (2.08–3.64)	0.49	2.87 (2.04–4.02)	0.61
Belo Horizonte	2.13 (1.25–3.62)	0.37	2.01 (1.39–2.93)	0.36	1.34 (1.05–1.72)	0.14	1.71 (1.29–2.26)	0.28
Vitória	1.87 (1.12–3.13)	0.34	1.91 (1.32–2.78)	0.37	1.71 (1.30–2.26)	0.28	2.59 (1.91–3.51)	0.61
Rio de Janeiro	1.46 (0.89–2.39)	0.18	2.25 (1.37–3.69)	0.32	2.01 (1.55–2.59)	0.37	2.35 (1.71–2.97)	0.37
São Paulo	1.89 (1.13–3.15)	0.34	2.28 (1.60–3.24)	0.36	2.13 (1.65–2.79)	0.37	2.25 (1.71–2.97)	0.37
Curitiba	1.65 (0.93–2.92)	0.28	2.03 (1.46–2.82)	0.37	1.88 (1.45–2.45)	0.34	2.25 (1.73–2.94)	0.37
Florianópolis	1.89 (1.12–3.18)	0.34	3.01 (2.14–4.23)	0.61	2.25 (1.73–2.92)	0.37	2.71 (2.02–3.62)	0.61
Porto Alegre	1.22 (0.61–2.46)	0.09	2.22 (1.38–3.58)	0.37	1.71 (1.21–2.42)	0.28	2.37 (1.66–3.39)	0.37
Campo Grande	1.54 (0.90–2.65)	0.21	1.65 (1.08–2.55)	0.37	2.19 (1.63–2.95)	0.37	2.37 (1.76–3.19)	0.37
Cuiabá	1.63 (0.85–3.13)	0.25	3.41 (1.93–6.02)	0.65	2.52 (1.80–3.53)	0.49	1.93 (1.34–2.78)	0.34
Goiânia	1.24 (0.78–2.00)	0.09	1.79 (1.25–2.57)	0.35	2.09 (1.65–2.65)	0.37	2.06 (1.60–2.66)	0.37
Brasília	1.09 (0.67–1.78)	0.05	1.89 (1.39–2.56)	0.37	1.79 (1.41–2.26)	0.31	1.89 (1.46–2.43)	0.34

*All models adjusted for control variables: age, lived with both parents (father and mother), socioeconomic status.

Analyzing boys and girls separately, there was no change in the direction of the associations; self-reported violent victimization remained positively associated with all four types of health-risk behavior for both sexes. However, the effect sizes for tobacco experimentation were larger for females than for males ($x^2_1 = 3.82$; $p < 0.05$).

Effects of city level variables on the association between self-reported violent victimization and health-risk behaviors.

Across the 27 cities, we found a significant correlation between the Municipal external mortality and Cohen's *d* for drug experimentation ($\rho = 0.42$; $p < 0.05$) and unprotected sex ($\rho = 0.37$; $p < 0.05$). Neither sex ratio nor income inequality were significantly associated with the variability in effect sizes across cities for any of the health-risk behaviors. However, stratified analysis showed that these correlations differed for the male and female samples.

Table 3 presents the findings of the correlation analysis, stratified by sex, on the associations between the city level variables and the effect sizes of violent victimization on health-risk behaviors. For the male sample we found that the effect sizes of violent victimization on drug experimentation ($\rho = 0.50$; $p < 0.05$), drunkenness ($\rho = 0.37$; $p < 0.05$) and tobacco experimentation ($\rho = 0.40$; $p < 0.05$) were larger in cities where youth mortality was high. Similar results were found when using sex specific external mortality, with larger effects for male drug experimentation ($\rho = 0.47$; $p < 0.05$) and tobacco experimentation ($\rho = 0.44$; $p < 0.05$) in cities where male mortality was high. Interestingly, female health-risk behavior did not show an association with overall youth external mortality, only with the sex specific rates and in the opposite direction: violent victimization had a stronger effect on females' drunkenness ($\rho = -0.39$; $p < 0.05$) and tobacco experimentation ($\rho = -0.51$; $p < 0.05$) in cities where female external mortality was low.

Table 3
Spearman correlations between city level variables (Gini index, municipal youth external mortality rates, sex specific municipal youth external mortality and sex ratio) and effect size measures (Cohen's *d*) of self-reported violent victimization on self-reports of drug experimentation, drunkenness, tobacco experimentation and unprotected sex for males and females, Brazil, PeNSE 2012 ($N = 47{,}371$).

	Gini	Youth Mortality from external causes (overall)	Youth Mortality from external causes (sex specific)	Sex Ratio
Effect sizes for males':				
Drug experimentation	−0.04	**0.50***	**0.47***	0.02
Drunkenness	−0.05	**0.37***	0.27	0.08
Tobacco experimentation	−0.06	**0.40***	**0.44***	0.05
Unprotected sex	−0.09	0.11	0.04	0.18
Effect sizes for females':				
Drug experimentation	0.24	−0.08	−0.24	−0.07
Drunkenness	**0.60***	−0.01	**−0.39***	−0.05
Tobacco experimentation	0.11	−0.20	**−0.51***	−0.08
Unprotected sex	0.02	0.20	−0.01	**−0.36***

* $p < 0.05$.

Finally, city sex ratio and income inequality showed association only with the size of the effect of violence on female health-risk behaviors; in cities with relatively few males, the effect of violent victimization on girls' chances of reporting unprotected sex was larger ($\rho = -0.36$; $p < 0.05$). Finally, the effect of violent victimization on self-reports of drunkenness was larger in cities with relatively high levels of income inequality ($\rho = 0.60$; $p < 0.05$).

6. Discussion

In this study, we investigated exposures at different levels (individual and city levels) in order to more accurately identify developmental stressors that could potentially modulate the impact of personal victimization on the expression of adolescents' health-risk behaviors in the context of Life History Theory.

We found that self-reported violent victimization is associated with an increased chance of engagement in health-risk behaviors in all 27 Brazilian state capitals, for both males and females, corroborating the Life History Theory hypothesis in these different subsamples. Our results are consistent with previous investigations that found positive associations between adolescent health-risk behavior and self-reported violent victimization (Boynton-Jarrett et al., 2013; Browning et al., 2005; Brumbach et al., 2009; Fick and Thomas, 1995). We also found that the magnitude of these associations is related to broader environmental factors, such as the cities' external mortality, and specifically for females, income inequality and sex ratio. To our knowledge, this is the first study that has explored multilevel interactions of Life History Theory relevant variables to explain health-risk behavior in adolescents. And certainly, this is the first time that these interactions have been explored in a large sample, representative of all state capitals in Brazil.

These results may illustrate what Diez Roux and Mair (2010) call a 'synergistic effect': effects of individual level exposures that can be enhanced by factors from other levels of immediacy (e.g. neighborhoods or cities). We believe that the synergistic effect of individual victimization and city level exposure to violence on health-risk behavior reflects psychological adaptation to the fact that, in high mortality environments, the costs of engaging in short-term planning and risk taking are reduced because it is less likely that one will survive into late adulthood. This interpretation is consistent with the results for the male samples. However, the negative associations between sex-specific mortality rates and the effects of violence on females' risk behaviors were unexpected. In this case, an alternative interpretation is that males and females are affected differently by violent victimization in environments where the actual risk of mortality is low, such that for the girls, being exposed to violence might be perceived as a rare event, and therefore, more salient.

Variation in risk behavior by exposure to city violence indicators is of public health interest as it shows which groups may benefit the most from changes in the city environment. It is also a test of specificity about the presumed causal association between individual violent victimization and risk taking behaviors in adolescence.

Our study also found that, for females' risk behaviors in specific domains, the effects of violence exposure were related to cities' income inequality and sex ratio. In cities with relatively few males and thus more competition for mating opportunities, being exposed to violence had a stronger effect on the females' chances of reporting having unprotected sex, and the effect of violence exposure on self-reports of drunkenness episodes was also larger in cities where income inequality was higher. These results seem to be in line with the rationale of previous studies of how competitive disadvantage can affect risk taking (Mishra et al., 2014; Mishra and Lalumière, 2010). The magnitude of the effects of violence exposure on females' risk behavior was increased in contexts characterized by competition for material resources (higher income inequality) and mating opportunities (lower male to female ratio).

Lastly, it is noteworthy that although evolutionary psychology generally proposes that males should engage in risky activities more intensely than females (Wilson and Daly, 2006) that was not the case in the PeNSE sample, as sex differences in the prevalence of health-risk behaviors were very small. We believe that the PeNSE sample of males is probably biased toward more risk-averse individuals, since those are the ones who are still in school and have not evaded.

7. Limitations

Possibly, the most important limitation of our study derives from having to rely on self-report: it remains plausible that associations between self-reported participation in risky (including illegal) behavior and self-reported experience of assault are partly an artifact of some respondents 'bragging' in both domains. There is also the possibility of converse scenarios whereby the real associations are artificially diminished by self-report.

Another limitation is that, due to the sampling strategy of the survey, the study of city level variables was restricted to the state capitals, leaving only 27 'observations' to be used in the analysis when there are in fact more than five thousand cities in Brazil. Future research should not only expand the sample of cities but also explore other levels of disaggregation (states, neighborhoods, etc.) in order to obtain more robust estimates of the true associations between individual and group measures of exposure to violence.

Violence is a complex phenomenon, and the literature suggests that multiple forms of exposure tend to co-occur. In fact, testing if our victimization variable was mixing information from other sources of violence, we found a 0.32 correlation ($p < 0.05$) with being beaten by an adult family member. This could indicate either a measurement problem or something that is intrinsic to the phenomena of reporting violent exposure itself. Nevertheless, to avoid the risk of confounded associations, future research should work with more clear definitions of violent victimization in order to further advance our understanding of the effects of different sources of exposure.

Finally, drunkenness episodes, drug and tobacco experimentation and unprotected sex, i.e., the risky behaviors that we are interpreting as consequences of exposure to violence might in reality be causes of it. Although our hypotheses were all theory-based and such associations have been shown elsewhere with longitudinal data (Brumbach et al., 2009), it is important to remark that causality cannot be truly established in correlational data; therefore, our results are not sufficient to demonstrate causal links among the variables studied.

8. Conclusions

Our results add support to the wider evidence base of a true association between exposure to environmental cues of harshness and the development of fast life histories strategies. In general, self-reported violent victimization was related to engagement in health-risk behaviors for all the population groups observed. However, the extent to which individual violent victimization can affect risk taking in adolescence may vary between the sexes according to cues of mortality risk, income inequality and mating competition from a broader level of exposure, such as age-specific external mortality, Gini index and sex ratio in the city. From a public health perspective, such findings point to the benefits of intervening not only in adolescent populations directly, but also in their city environments. Our findings reinforce the need to consider synergies between people's life experiences and the conditions where they live, when studying health-risk behaviors in adolescence.

Future research should identify different levels of environmental stressors that could potentially modulate the expression of health-risk behavior in adolescence, using longitudinal data. This could be accomplished by exploring the effects of other indicators of harshness and unpredictability such as socioeconomic mobility and age-specific crime rates within and between neighborhoods, cities, states, etc.

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