

# BMJ Open

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (<http://bmjopen.bmj.com>).

If you have any questions on BMJ Open's open peer review process please email [info.bmjopen@bmj.com](mailto:info.bmjopen@bmj.com)

# BMJ Open

## Progress and setbacks in socioeconomic inequalities in adolescent health-related behaviours in Brazil, 2009-2015.

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-025338
Article Type:	Research
Date Submitted by the Author:	19-Jul-2018
Complete List of Authors:	Azeredo, Catarina; Universidade Federal de Uberlandia, Faculdade de Medicina Rezende, Leandro; Departamento de Medicina Preventiva, Faculdade de Medicina FMUSP, Universidade de Sao Paulo, SP, BR, Mallinson, Poppy; London School of Hygiene and Tropical Medicine Faculty of Epidemiology and Population Health, Department of Non-Communicable Disease Epidemiology Ricardo, Camila; Universidade de Sao Paulo Faculdade de Medicina, Departamento de Medicina Preventiva Kinra, Sanjay; LSHTM, Levy, Renata; University of Sao Paulo, Medicine Barros, A; Federal University of Pelotas (UFPeL), Postgraduate Programme in Epidemiology
Keywords:	Adolescent, Health Behavior, Health Inequality, EPIDEMIOLOGY

SCHOLARONE™  
Manuscripts

1  
2  
3 **Progress and setbacks in socioeconomic inequalities in adolescent**  
4 **health-related behaviours in Brazil, 2009-2015.**  
5  
6  
7  
8

9 **Catarina Machado Azeredo<sup>1,a</sup>, Leandro Fórnias Machado de Rezende<sup>2</sup>, Poppy**  
10 **Alice Carson Mallinson<sup>3</sup>, Camila Zancheta Ricardo<sup>2</sup>, Sanjay Kinra<sup>3</sup>, Renata**  
11 **Bertazzi Levy<sup>2</sup>, Aluisio J D. Barros<sup>4</sup>**  
12  
13  
14  
15

16  
17  
18 <sup>a</sup> Corresponding Author  
19

20 1 Faculdade de Medicina da Universidade Federal de Uberlândia. Address: Av. Pará  
21 1720, Bloco 2 U, sala 20. Campus Umuarama. Uberlândia/MG - Brasil - 38.405-320  
22 Telephone: +55 (34) 32258584. E-mail: [catarina@famed.ufu.br](mailto:catarina@famed.ufu.br)  
23

24 2 Departamento de Medicina Preventiva, Faculdade de Medicina FMUSP,  
25 Universidade de Sao Paulo, Sao Paulo, SP, Brazil  
26

27 3 Institution: Department of Non-Communicable Disease Epidemiology, London  
28 School of Hygiene and Tropical Medicine (LSHTM), London, United Kingdom.  
29

30 4 Postgraduate Program in Epidemiology, Federal University of Pelotas, Pelotas, RS,  
31 Brazil.  
32

33  
34  
35  
36  
37 **Keywords:** Adolescents; Social Inequalities; Health Behaviors; Lifestyle

38 **Words count:** 2849  
39  
40

41  
42 **Authorship statement:** CMA, LFMR, RBL and AJDB conceptualized the study and  
43 were involved in the analysis and interpretation of the results. CZR was involved in data  
44 preparation, designed and prepared the tables. The initial draft of the paper was  
45 prepared by CMA following extensive discussions and inputs from the other co-authors.  
46 All authors have reviewed, revised the manuscript and approved the final version.  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## ABSTRACT

### Objectives

Despite some progress, Brazil is still one of the most unequal countries, and the extent of socioeconomic inequalities in adolescent health is unclear. We assessed trends in socioeconomic inequalities in adolescent's health-related behaviours in Brazil between 2009-2015.

**Design:** We used cross-sectional data from the Brazilian National Survey of School Health carried out in 2009, 2012 and 2015.

**Setting:** Brazilian state capitals.

**Participants:** Students attending 9<sup>th</sup> grade from public and private schools in Brazilian state capitals in 2009 (60,973 students), 2012 (74,432 students) and 2015 (60,078 students)

### Main Outcome measure:

We assessed 12 health-related behaviours under 3 broad domains (lifestyle risk behaviours, engagement in risky activities and exposure to violence). Socioeconomic status was assessed through an asset-based wealth index derived from principal components analysis. Absolute and relative inequalities in these health behaviours and inequalities trends were investigated.

### Results

From 2009 to 2015, prevalence of certain harmful health-related behaviours increased, such as unsafe sex (21.5% to 33.9%), domestic violence (9.5% to 16.2%), bullying victimization (14.2% to 21.7%) and in irregular consumption of beans (37.5% to 43.7%). Other indicators decreased: alcohol use (27.1% to 23.2%), irregular physical activity (83.0% to 75.6%) and consumption of soft drinks (37.2% to 28.8%). Over the period, we found consistent evidence of decreasing health inequalities for lifestyle behaviours (fruit, bean and soft drink consumption) and alcohol use, set against increasing inequalities in violence (domestic violence, fights using guns and bullying victimization).

### Conclusion

Socioeconomic inequality increased in the violence domain and decreased for lifestyle behaviours among Brazilian adolescents. Widening gaps in violence domain urge immediately policy measures in Brazil.

**Key-words:** Adolescent, Social inequalities, health behaviour.

### Strengths and limitations of this study

- We assessed the extent of socioeconomic inequalities in adolescent health and how it has changed over time in a middle-income country;
- We used a large representative urban samples from Brazilian adolescents attending public and private schools;
- Another strength of this study was the use of complex measures of inequality;
- Although we have used validated questionnaires, the self-report of behaviours may cause some degree of classification bias;
- The period of 6 years may be too short to expect significant changes in inequalities.

## INTRODUCTION

Adolescence is a critical period for promotion of human development. During adolescence, biological, cognitive, emotional, and social capabilities are founded and future patterns of adult health are established [1]. Despite its clear importance, adolescent's health has been generally overlooked in social policies. In order to guide surveillance, investments and policy actions, a broad concept of adolescent health has been proposed by The Lancet Commission on adolescent health. This concept includes aspects related to sexual and reproductive health, nutritional deficiencies, injury and violence, physical and mental health, and substance use disorders [2].

Socioeconomic factors strongly predict adolescent health [3]. Socioeconomic inequalities have consistently increased over the last decades in US and Europe [4], and this trend coincides with widening gaps in indicators of adolescent health [5]. For instance, a time-series analysis of 34 North American and European countries showed an increase in inequalities between socioeconomic groups in physical activity, body mass index, and psychological and physical symptoms between 2002 and 2010 [5].

Studies monitoring inequality in adolescent health in low- and middle-income countries are sparse in the literature. Brazil is still one of the most unequal countries worldwide [6], although considerable social protection efforts have been adopted in the last decades (*e.g.*, creation of a free public universal health system, expanding community-based primary care and providing a robust conditional cash transfer program) [7]. These social programs have had positive impacts on adult health, especially among the most deprived, with increased overall food quality and diversity [8], reduced racial inequalities in health [9] and cardiovascular disease mortality [10]. However, the extent of socioeconomic inequalities in adolescent health and how it has changes over time in Brazil is unclear.

1  
2  
3 In this study, we assessed levels and trends in socioeconomic inequalities in  
4 adolescent health in Brazil between 2009 and 2015. We used data from three large  
5 representative health surveys of adolescents living in Brazilian state capitals. We  
6  
7 selected 12 indicators under 3 broad domains (lifestyle risk behaviours, engagement in  
8 risky activities and exposure to violence) to provide a holistic view of adolescent health  
9 inequalities in Brazil.  
10  
11  
12  
13  
14

## 15 16 17 18 **METHODS**

19  
20 We used cross-sectional data from three Brazilian National Surveys of School Health  
21 (*Pesquisa Nacional da Saude do Escolar - PeNSE*) carried out in 2009, 2012 and 2015.  
22  
23 In order to have comparable datasets across the three surveys, we used a representative  
24 subsample of adolescents attending 9<sup>th</sup> grade (i.e., mostly aged between 14-15 years) in  
25 public and private schools from the 26 state capitals and the Federal District. Detailed  
26 information about PeNSE has been published elsewhere [11-13]. Briefly, PeNSE  
27 sampling strategy included stratification per cluster and multi-stage selection. The  
28 sampling strata were each of the 26 state capitals and Federal District. The primary  
29 sampling units (PSUs) were schools, and the secondary sampling units (SSUs) were  
30 classrooms. School selection was proportional to the total number of 9<sup>th</sup> grade classes,  
31 while the classes in each school were chosen by simple random selection. Two  
32 classrooms were selected from schools with three or more 9<sup>th</sup> grade classrooms, whereas  
33 one classroom was selected from schools with one or two 9<sup>th</sup> grade classrooms. All  
34 students enrolled in the selected classrooms were invited to participate in the study.  
35  
36 Participants were not included in the study if they did not attend school during data  
37 collection, refuse to participate, or did not report their age and sex. The total number of  
38 students included in our analysis was 60,973 (final response rate 83.8%) for 2009,  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 61,145 (final response rate 82.2%) for 2012, and 51,192 (final response rate 95.2%) for  
4  
5 2015 surveys [11-13].

6  
7 Students filled out a self-reported structured questionnaire available in a  
8  
9 Personal Digital Assistant device (2009 survey) or smartphone application (2012 and  
10  
11 2015 survey) in their school classrooms during regular school hours. The questionnaire  
12  
13 was based on the Global School-Based Student Health Survey [14] and the Youth Risk  
14  
15 Behaviour Surveillance System[15], and was adapted to the Brazilian setting. Questions  
16  
17 included socioeconomic variables and several risk and protective factors for adolescent  
18  
19 health.

20  
21  
22 We estimated a wealth index specific for each survey year through Principal  
23  
24 Component Analysis (PCA), following the steps proposed by Barros and Victora [16].  
25  
26 We ran PCA including the following variables: mother's educational level (incomplete  
27  
28 middle school, complete middle school, complete high-school, complete higher  
29  
30 education); school administrative status (public or private); self-report of having:  
31  
32 landline, mobile phone, computer, internet access, car, bathroom inside the house and  
33  
34 housemaid services. We retained the first component of the analysis and calculated  
35  
36 coefficients from the expression:  $\text{coefficient} = \text{loading} / \text{standard deviation} \times 100$ . The  
37  
38 individual scores were estimated from the  $\sum c_i v_i$ , where  $c_i$  is the coefficient and  $v_i$  is the  
39  
40 value for the  $i^{\text{th}}$  variable. The wealth index was assessed as quintiles of the total wealth  
41  
42 scores. We refer to the first quintile (Q1) as the poorest quintile (poorest 20%) and the  
43  
44 fifth quintile (Q5) as the wealthiest quintile (wealthiest 20%).

45  
46  
47  
48 The indicators of adolescent health used in this study are defined in table 1 (full  
49  
50 questionnaire items listed in appendix 1). We divided indicators in three domains:  
51  
52 lifestyle risk behaviours, engagement in risky activities and exposure to violence.  
53  
54 Alcohol and tobacco use were included as risky activities and not lifestyle behaviours,  
55  
56  
57  
58  
59

because Brazilian law forbids the sale of these substances for younger than 18 years old. We have used the concept of “irregular consumption” (<5 times in the past week) for all food indicators, following the complementary concept of “regular consumption”, which was validated using 24 hours recall[17]. We also chose to include bean consumption because of their protective health effects and importance in Brazil as an affordable traditional staple food [18]. The frequency of 2 or more times in the previous month for bullying victimization followed the concept of this type of violence, which presume repetition[19]. The unsafe sex was assessed only for those who reported had sexual relationships.

Domain	Indicator	Definition
Lifestyle risk behaviours	Irregular fruit consumption	Less than 5 times in the past week
	Irregular vegetable consumption	Less than 5 times in the past week
	Irregular bean consumption	Less than 5 times in the past week
	Regular soft drink consumption	5 or more times in the past week
	Irregular recreational physical activity	Less than 5 times in the past week
Engagement in risky activities	Alcohol use	1 or more times in previous month
	Drug use	1 or more times in previous month
	Tobacco use	1 or more times in previous month
	Unsafe sex	If not used a condom at last sexual intercourse
Exposure to violence	Involvement in gun fights	1 or more times in previous month
	Bullying victimization	2 or more times in previous month
	Domestic violence victimization	1 or more times in previous month

**Table 1:** Indicators of adolescent health used in the present study

To assess socioeconomic inequalities in adolescent health we used several measures of inequality. Firstly, we estimated simple measures of inequality (pairwise comparisons), such as differences and ratios of each health indicator between the wealthiest group (5<sup>th</sup> quintile) and the poorest group (1<sup>st</sup> quintile).



1  
2  
3 Secondly, we estimated complex measures of inequality, represented by an  
4 indicator of absolute inequality, the slope index of inequality (SII), and an indicator of  
5 relative inequality, the concentration index (CIX) [20]. Both SII and CIX take into  
6 account all quintiles of the wealth index to compare a given health indicator across all  
7 wealth subgroups.  
8  
9

10  
11  
12  
13 We estimated the SII using logistic regression to avoid predicting implausible  
14 values below zero or above one, considering that all health indicators were presented as  
15 proportions [21]. The SII estimates the absolute difference (i.e., in percentage points) in  
16 the prevalence of health indicator between individuals in the wealthiest and poorest  
17 quintiles. Negative values of SII indicate that prevalence of the health indicator is higher  
18 among the poorest adolescents than the wealthiest (values ranged from -100 to +100).  
19  
20  
21  
22  
23  
24  
25

26  
27 The CIX was also expressed on a scale ranging from -100 to +100; a value of 0  
28 represents perfect equality, whereas negative values indicate that poor individuals have  
29 higher prevalence of a given health indicator than wealthy individuals [22]. The CIX  
30 was calculated with no corrections [21].  
31  
32  
33  
34

35  
36 Linear regressions using variance-weighted least squares were performed to  
37 assess changes over time in complex measures of inequality (SII and CIX) based on the  
38 means and standard deviation for each of the three surveys.  
39  
40  
41

42  
43 Multiple imputation was performed using the chained equation technique due to  
44 the significant proportion of missing values for the mother's education level in the three  
45 datasets (19,36%, n=33,559). We also imputed other study variables with a smaller  
46 proportion of missing values, to create a complete dataset. The imputed data exhibited  
47 satisfactory statistical reproducibility according to Monte Carlo error analysis[23].  
48  
49  
50  
51

52  
53 The sample design was taken into consideration for descriptive analyses, using  
54 survey prefix command (svy) in Stata. School clustering (random effect) and sample  
55  
56  
57  
58  
59  
60

1  
2  
3 weights were considered when estimating complex measures of inequality (SII and  
4  
5 CIX). All the statistical analyses were performed using Stata 14.0.  
6  
7

### 8 9 **Ethics approval**

10  
11  
12  
13  
14 PeNSE surveys were approved by the National Commission of Research Ethics  
15  
16 (Comissão Nacional de Ética em Pesquisa – Conep), records no. 11.537 (2009), 16.805  
17  
18 (2012) and 1.006.467 (2015). The surveys were performed in accordance with the  
19  
20 Declaration of Helsinki and all participants gave their informed consent. Databases were  
21  
22 made publicly available on an IBGE website without any information that could  
23  
24 identify subjects.  
25

### 26 27 **Patient and public involvement**

28  
29  
30 No patients or public were involved in the design and conceptualisation of this  
31  
32 study.  
33

### 34 35 **Data Sharing**

36  
37 The dataset of 2009, 2012 and 2015 PeNSE are publicly available at:  
38  
39 [https://www.ibge.gov.br/estatisticas-novoportal/sociais/educacao/9134-pesquisa-](https://www.ibge.gov.br/estatisticas-novoportal/sociais/educacao/9134-pesquisa-nacional-de-saude-do-escolar.html?=&t=microdados)  
40  
41 [nacional-de-saude-do-escolar.html?=&t=microdados](https://www.ibge.gov.br/estatisticas-novoportal/sociais/educacao/9134-pesquisa-nacional-de-saude-do-escolar.html?=&t=microdados)  
42  
43  
44

## 45 **RESULTS**

46  
47  
48 In 2015, the health-related behaviours more common among Brazilian  
49  
50 adolescents were irregular consumption of fruits (67.2%) and vegetables (61.8%) and  
51  
52 irregular recreational physical activity (75.6%). Less frequent were the unsafe sex in last  
53  
54 sexual intercourse (33.9%), alcohol use (23.2%) and exposure to bullying (21.7%).  
55  
56  
57  
58  
59

1  
2  
3 Between 2009 and 2015, the prevalence of irregular vegetable consumption, irregular  
4 recreational physical activity, regular soft drink consumption, alcohol, tobacco and drug  
5 use decreased. On the other hand, trends for irregular bean consumption, unsafe sexual  
6 intercourse, and exposure to violence (domestic violence, fight using guns, and bullying  
7 victimization) increased (Table 2).  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

**Table 2** - Brazilian adolescent characteristics and health-related behaviours from PeNSE surveys 2009, 2012 and 2015.

adolescents characteristics and behaviours	PeNSE survey year					
	2009 (60,973 students)		2012 (61,145 students)		2015 (51,192 students)	
characteristics	%	CI95%	%	CI95%	%	CI95%
Sex (female)	52.5	(51.9-53.2)	50.8	(50.1-51.6)	50.8	(49.9-51.7)
Age (mean and standard error)	14.2	(0.02)	14.3	(0.02)	14.2	(0.02)
Wealth index (mean and standard error)	3.8	(0.03)	4.0	(0.06)	4.0	(0.06)
<b>behaviours</b>						
Irregular fruit consumption	68.5	(67.8-69.2)	70.2	(69.5-70.9)	67.2	(66.3-68.0)
Irregular vegetables consumption	68.8	(68.0-69.5)	64.1	(63.3-64.9)	61.7	(60.7-62.7)
Irregular beans consumption	37.4	(36.4-38.5)	40.0	(38.5-41.5)	43.7	(42.4-45.1)
Regular soft drinks consumption	37.2	(36.3-38.2)	35.4	(34.6-36.2)	28.8	(27.9-29.8)
Irregular recreational physical activity	83.0	(82.3-83.6)	74.2	(7.5-74.8)	75.6	(74.8-76.3)
Alcohol use (once in the last month)	27.1	(26.3-28.0)	26.8	(25.8-27.7)	23.2	(22.2-24.2)
Tobacco use (once in the last month)	6.2	(5.8-6.7)	6.1	(5.6-6.6)	5.3	(4.9-5.8)
Drug use (once in the last month)	3.3	(3.0-3.6)	3.8	(3.4-4.2)	2.5	(2.2-2.7)
Unsafe sex (in the last sexual intercourse)	21.5	(20.3-22.7)	22.5	(21.6-23.5)	33.9	(32.3-35.4)
Domestic violence (once in the last month)	9.5	(9.1-10.0)	11.6	(11.1-12.1)	16.2	(15.5-16.9)
Involvement in gun fights (once in the last month)	4.0	(3.7-4.3)	6.9	(6.6-7.3)	5.6	(5.2-6.1)
Bullying victimization (twice or more in the last month)	14.2	(13.6-14.7)	16.5	(15.9-17.1)	21.7	(21.1-22.4)

1  
2  
3 Figure 1 (A-C) shows the trends in health indicators by wealth quintile between  
4 2009 and 2015. The width of the bars represents the absolute inequality. For most health  
5 indicators (except bean, soft drink and alcohol use), people in the poorest group  
6 reported more adverse levels compared to the wealthiest group. In general, over the  
7 period 2009-2015, health inequalities decreased for lifestyle behaviours (fruit,  
8 vegetable, bean and soft drink consumption, and recreational physical activity), while  
9 increased for risky activities and violence (smoking, drug use, unsafe sex, domestic  
10 violence, fights using guns and bullying victimization) (Appendix 2).  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21

22 INSERT FIGURE 1 HERE  
23  
24  
25

26 Some of these trends were not statistically significant according to complex  
27 measures of inequality (table 3).  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

**Table 3** - Complex measures of inequality in health-related behaviours among Brazilian adolescents. PeNSE surveys 2009, 2012 and 2015.

Quintiles of Wealth index (1=poorest; 5=wealthiest) Indicators	Slope Index of inequality (SII)				Concentration index of inequality (CIX)			
	2009	2012	2015	<i>p</i> -value*	2009	2012	2015	<i>p</i> -value*
Irregular fruit consumption	-13.68	-9.01	-8.88	0.015	-2.82	-2.31	-2.26	0.267
Irregular vegetables consumption	-19.02	-17.59	-17.92	0.535	-4.30	-4.48	-5.18	0.165
Irregular beans consumption	9.95	11.25	7.33	0.434	6.48	3.47	2.22	0.000
Regular soft drinks consumption	16.55	10.49	3.89	0.000	6.94	5.19	2.90	0.000
Irregular recreational physical activity	-8.66	-9.47	-7.90	0.745	-1.70	-1.91	-1.71	0.837
Alcohol use (once in the last month)	9.69	0.68	0.06	0.000	4.79	1.71	1.19	0.004
Tobacco use (once in the last month)	-1.68	-2.80	-3.15	0.125	-5.68	-6.32	-8.69	0.290
Drug use (once in the last month)	0.34	0.46	-0.98	0.048	-0.08	4.47	-4.61	0.428
Unsafe sex (in the last sexual intercourse)	-9.67	-6.88	-13.28	0.498	-6.52	-5.44	-6.56	0.914
Domestic violence (once in the last month)	-1.84	-5.24	-6.92	0.000	-2.72	-7.02	-6.57	0.014
Involvement in gun fights (once in the last month)	-0.76	-1.90	-3.30	0.002	-2.82	-4.42	-8.79	0.029
Bullying victimization (twice or more in the last month)	0.83	-0.20	-6.60	0.000	0.56	0.59	-4.41	0.000

1  
2  
3 In all years, alcohol consumption was the health indicator more equally  
4 distributed between wealth quintiles both according to absolute and relative measures.  
5  
6 On the other hand, irregular vegetables consumption and unsafe sex had the highest  
7 absolute inequality and fights using guns and tobacco use the highest relative inequality.  
8  
9 Over time, the absolute (SII) and relative inequalities (CIX) between wealth index  
10 quintiles became wider for all three indicators of exposure to violence, and narrower for  
11 some indicators of lifestyle behaviour (fruit, beans and soft drinks) and alcohol  
12 consumption. There was limited evidence of change in inequalities over time for the  
13 other lifestyle behaviours, such as irregular vegetables consumption and recreational  
14 physical activity, and indicators of engagement in risky activities, such as tobacco, drug  
15 use and unsafe sex (table 3, figure 2).  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25

26  
27 INSERT FIGURE 2 HERE  
28  
29  
30

## 31 DISCUSSION

32  
33 We showed evidence of persistent socioeconomic inequalities in adolescent  
34 health in Brazil. Between 2009 and 2015, lifestyle behaviours (fruit and soft drinks  
35 consumption) and alcohol use became more equally distributed between socioeconomic  
36 groups, while inequalities in experiencing violence were exacerbated. In this period,  
37 there was little evidence of change to inequalities in risky activities (smoking, drugs,  
38 unsafe sex).  
39  
40  
41  
42  
43  
44  
45

46 In general, the direction of health inequalities we observed are similar to that  
47 reported in other settings, that is, poorer adolescents are more likely to report harmful  
48 health behaviours than richer [5]. For certain harmful behaviours (e.g. alcohol and drug  
49 use), however, differences between social groups were not significant or went in the  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 opposite direction (i.e. wealthier adolescents reported higher prevalences). These  
4 findings are consistent with results observed in other countries [24].  
5  
6

7 Looking at time-trends in these inequalities, our findings differ to existing  
8 evidence from Western Europe and North America. For some lifestyle (e.g. vegetable  
9 consumption, physical activity) and risky behaviours (drug and tobacco use),  
10 inequalities have not changed significantly between 2009 and 2015 in Brazil. Yet  
11 inequality in lifestyle and risky behaviors have increased over similar period in many  
12 other countries [5, 25]. Similarly to ours, one study found persistent inequality in  
13 vegetable consumption [26]. Despite this, comparable data for many indicators of risk  
14 behaviours are lacking. Rates of violence as well as inequalities in violence increased  
15 markedly (gun fights, domestic violence, bullying), and these trends also differ from  
16 other countries [27].  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27

28 Reasons for differential socioeconomic inequality trends between lifestyle  
29 behaviours, risk behaviours and violence-related indicators in Brazilian adolescents are  
30 unclear. Reductions in lifestyle behaviour inequalities fits with the general trend of  
31 narrowing economic and health inequalities observed for adults in Brazil in that  
32 period[28, 29]. This is often attributed to rising prosperity combined with roll-out of  
33 redistributive health and social programs such as the Bolsa Familia cash transfer  
34 program [30], as well as scaled-up health promotion efforts (especially obesity  
35 prevention) [31]. Exacerbation of violence-related inequalities have also been observed  
36 in one study of adult mortality in Salvador [32]. It has been suggested that public health  
37 interventions have focussed on reducing infectious and chronic diseases but neglect, on  
38 the other hand, external causes of ill-health such as interpersonal violence. In fact,  
39 violence-related mortality has declined slower than all other causes in Brazil, and even  
40 increased in 19 of the 27 states [33].  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



1  
2  
3 It is worth noting that we found a shift in prevalence of alcohol use and soft  
4 drinks consumption between socioeconomic in the period studied. In 2009, these  
5 indicators were higher among the wealthiest group, but in 2015 the differences were  
6 considerably attenuated. The reduction in the consumption of these products was more  
7 pronounced among the wealthiest group than in the poorest group. Conversely, for bean  
8 consumption, poorer adolescents reported higher prevalence than wealthiest  
9 adolescences. In this regard, the reduction in disparities between wealth groups should  
10 be read with caution. In high-income countries, poorer individuals consume more  
11 alcohol, relative to wealthier individuals, while in low-middle income countries  
12 wealthier individuals are more exposed than the poorer [34]. This trend could be  
13 shifting. In fact, industries of unhealthy commodities have moved to, and are growing  
14 faster in, low- and middle-income countries comparing to high-income countries [35].  
15 This phenomenon might explain, at least in part, the increase in consumption of ultra-  
16 processed products (e.g. sugary drinks) and alcohol, and the reduction of bean  
17 consumption in these settings [36]. Brazil seems to be moving towards patterns of  
18 health indicators and their inequalities currently observed in high-income countries. In  
19 these countries, the reduction in alcohol use and soft drinks consumption among those  
20 privileged is not necessarily followed by a reduction among those more socially  
21 deprived [5]. Although this trend is measured as a reduction in inequality, it is not  
22 desirable.

23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46 The main strength of this study is to explore a wide spectrum of health  
47 indicators, which provides information on prevalence and trends in key risk factors for  
48 adolescent health. Another positive aspect is the large representative urban samples  
49 from Brazilian adolescents attending public and private schools. In Brazil, the school  
50 coverage in this age is very high (88-97%) [37], which reduces significantly the risk of  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 selection bias. Despite this, it is plausible to assume that students at higher risk of harmful  
4 health behaviors have higher truancy and dropout rates. Therefore, this could have  
5 masked the true extent of the inequalities. We also report a range of simple and complex  
6 measures of inequalities to allow clear interpretation of trends as well as presenting  
7 rigorous hypothesis tests which make use of all data. Concordance between the absolute  
8 and relative measures of inequality adds strength to our conclusions.

9  
10  
11  
12  
13  
14  
15  
16 Some limitations should be acknowledged. The engagement in health-related  
17 behaviours was self-reported by adolescents, and therefore, misclassification may have  
18 occurred towards social desirable behaviors. Misclassification likely affected the  
19 prevalence of health indicators similarly over three surveys. Although, use of self-  
20 reported outcomes is a limitation, it is widely recognised as an acceptable and often the  
21 only feasible approach for monitoring adolescent health behaviours [38]. Moreover,  
22 there is evidence of validity of the dietary indicators used in the PeNSE survey [17], and  
23 a US survey on which the PeNSE survey was based demonstrated good test-retest  
24 reliability and consistency across different modes of questioning [39].

25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35 The surveys were available only for a period of 6 years, which may be too short  
36 to expect significant changes in inequalities. To continue monitoring trends in  
37 adolescent health inequality for longer periods is desirable. Also, the data analysed are  
38 representative of Brazilian state capitals, not the whole country. State Capitals are  
39 highly urbanized cities and more developed than other cities, therefore, these results  
40 may not be generalizable to small cities and rural areas. However state capitals are the  
41 most populous and unequal areas of Brazil [40], making them important settings for  
42 studying inequality trends, and meaning they can act as sentinels to the country as a  
43 whole.

1  
2  
3 Brazil is facing a huge economic recession since 2015, which deepened in 2016.  
4  
5 Unemployment and inflation have increased and people's purchasing power has been  
6  
7 reduced, with the poor especially affected. Therefore it will be vital to continue  
8  
9 monitoring the trends observed in this study and take action to prevent exacerbation of  
10  
11 existing inequalities.  
12

13  
14 Policy makers and researchers should be alert to the fact that possible reductions  
15  
16 in health risky behaviours may be unbalanced between social groups and even be  
17  
18 increasing in disadvantaged social groups while decreasing on average [22]. In this  
19  
20 study, we found that the gap between poor adolescents and wealthy adolescents is  
21  
22 reducing for lifestyle behaviours such as fruit consumption; while it is increasing for  
23  
24 violent behaviours. For alcohol, irregular bean consumption and regular soft drink  
25  
26 consumption we found that the gap between social groups is narrowing, although  
27  
28 represented by a reduction in these risk behaviours among rich and an increase among  
29  
30 poor adolescents.  
31  
32  
33  
34  
35

36  
37 **Funding:** The present research received financial support from Brazilian National  
38  
39 Council of Scientific and Technological Development (CNPq), 404905/2016-1,  
40  
41 awarded to Catarina Machado Azeredo. Sao Paulo Research Foundation (FAPESP),  
42  
43 grant #2016/21390-0 and #2014/25614-4 due to Leandro Fórnias Machado de Rezende.  
44  
45 The funders had no role in study design, data collection and analysis, decision to  
46  
47 publish, or preparation of the manuscript.  
48

49  
50 **Conflict of interest:** None.

51  
52 **Data Sharing Statement:** The dataset of 2009, 2012 and 2015 PeNSE are publicly  
53  
54 available at: [https://www.ibge.gov.br/estatisticas-novoportal/sociais/educacao/9134-  
55  
56 pesquisa-nacional-de-saude-do-escolar.html?=&t=microdados](https://www.ibge.gov.br/estatisticas-novoportal/sociais/educacao/9134-pesquisa-nacional-de-saude-do-escolar.html?=&t=microdados)  
57  
58  
59

## REFERENCES

- 1 Sawyer SM, Afifi RA, Bearinger LH, *et al.* Adolescence: a foundation for future health. *The Lancet* 2012;**379**:1630-40.
- 2 Patton GC, Sawyer SM, Santelli JS, *et al.* Our future: a *Lancet* commission on adolescent health and wellbeing. *The Lancet* 2016;**387**:2423-78.
- 3 Viner RM, Ozer EM, Denny S, *et al.* Adolescence and the social determinants of health. *The Lancet* 2012;**379**:1641-52.
- 4 Piketty T, Saez E. Inequality in the long run. *Science* 2014;**344**:838-43.
- 5 Elgar FJ, Pfortner T-K, Moor I, *et al.* Socioeconomic inequalities in adolescent health 2002–2010: a time-series analysis of 34 countries participating in the Health Behaviour in School-aged Children study. *The Lancet* 2015;**385**:2088-95.
- 6 Solt F. The Standardized World Income Inequality Database. *Social Science Quarterly* 2016;**97**:14.
- 7 Landmann-Szwarcwald C, Macinko J. A panorama of health inequalities in Brazil. *International Journal for Equity in Health* 2016;**15**:174.
- 8 Martins APB, Monteiro CA. Impact of the Bolsa Familia program on food availability of low-income Brazilian families: a quasi experimental study. *BMC Public Health* 2016;**16**:827.
- 9 Hone TA-Ohoo, Rasella D, Barreto MLA-Ohoo, *et al.* Association between expansion of primary healthcare and racial inequalities in mortality amenable to primary care in Brazil: A national longitudinal analysis. *PLoS Med* 2017;**14**.
- 10 Rasella D, Harhay MO, Pamponet ML, *et al.* Impact of primary health care on mortality from heart and cerebrovascular diseases in Brazil: a nationwide analysis of longitudinal data. *BMJ* 2014;**349**:g4014.
- 11 IBGE. Pesquisa Nacional de Saúde do Escolar 2009. In: Ministério do Planejamento OeGIDdPCdPeIS, ed. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística 2009:138.
- 12 IBGE. Pesquisa Nacional de Saúde do Escolar 2012. In: Estatística IBdGe, ed. Rio de Janeiro 2013:256.
- 13 IBGE. Pesquisa Nacional de Saúde do Escolar: 2015. In: Ministério do Planejamento OeGIDdPCdPeIS, ed. Rio de Janeiro: IBGE 2016:132.
- 14 WHO WHO. Global School-Based Student Health Surveillance (GSHS). In: Organization WH, ed 2009.
- 15 Eaton DK, Kann L, Kinchen S, *et al.* Youth Risk Behavior Surveillance -United States- 2009. In: Services DOHAH, ed. United States: Centers for Disease Control and Prevention (CDC) 2010:148.
- 16 Barros AJ, Victora CG. [A nationwide wealth score based on the 2000 Brazilian demographic census]. *Rev Saude Publica* 2005;**39**:523-9.
- 17 Tavares LF, Castro IR, Levy RB, *et al.* [Relative validity of dietary indicators from the Brazilian National School-Based Health Survey among adolescents in Rio de Janeiro, Brazil]. *Cad Saude Publica* 2014;**30**:1029-41.
- 18 Ha V, Sievenpiper JL, de Souza RJ, *et al.* Effect of dietary pulse intake on established therapeutic lipid targets for cardiovascular risk reduction: a systematic review and meta-analysis of randomized controlled trials. *CMAJ* 2014;**186**:E252-62.
- 19 Olweus D. *Bullying at School: What we know and what we can do.* . Oxford, U.K. : Blackwell 1993.
- 20 Mackenbach JP, Kunst AE. Measuring the magnitude of socio-economic inequalities in health: an overview of available measures illustrated with two examples from Europe. *Soc Sci Med* 1997;**44**:757-71.

- 1  
2  
3 21 Barros AJ, Victora CG. Measuring coverage in MNCH: determining and  
4 interpreting inequalities in coverage of maternal, newborn, and child health  
5 interventions. *PLoS Med* 2013;**10**:e1001390.
- 6 22 WHO WHO. Handbook on health inequality monitoring: with a special focus on  
7 low- and middle-income  
8  
9 countries. Geneva: World Health Organization 2013:108.
- 10 23 Royston P, White IR. Multiple Imputation by Chained Equations (MICE):  
11 Implementation in Stata *Journal of Statistical Software* 2011;**45**:1-20.
- 12 24 Liu Y, Wang M, Tynjala J, *et al.* Socioeconomic inequalities in alcohol use of  
13 adolescents: the differences between China and Finland. *Int J Public Health*  
14 2013;**58**:177-85.
- 15 25 Hargreaves DS, Djafari Marbini A, Viner RM. Inequality trends in health and  
16 future health risk among English children and young people, 1999-2009. *Arch Dis Child*  
17 2013;**98**:850-5.
- 18 26 Rasmussen M, Pedersen TP, Johnsen NF, *et al.* Persistent social inequality in  
19 low intake of vegetables among adolescents, 2002-2014. *Public Health Nutr* 2018:1-5.
- 20 27 Pickett W, Molcho M, Elgar FJ, *et al.* Trends and socioeconomic correlates of  
21 adolescent physical fighting in 30 countries. *Pediatrics* 2013;**131**:e18-26.
- 22 28 Beltrán-Sánchez H, Andrade FCD. Time trends in adult chronic disease  
23 inequalities by education in Brazil: 1998–2013. *International Journal for Equity in*  
24 *Health* 2016;**15**:139.
- 25 29 Mújica OJ, Vázquez E, Duarte EC, *et al.* Socioeconomic inequalities and  
26 mortality trends in BRICS, 1990–2010. *Bull World Health Organ* 2014;**92**:405–12.
- 27 30 Das J, Do Q-T, Özler B. Reassessing conditional cash transfer programs. *World*  
28 *Bank Res Obs* 2005;**20**:23.
- 29 31 Jaime PC, da Silva AC, Gentil PC, *et al.* Brazilian obesity prevention and  
30 control initiatives. *Obes Rev* 2013;**14 Suppl 2**:88-95.
- 31 32 Viana LAC, Costa MdcN, Paim JS, *et al.* Social inequalities and the rise in  
32 violent deaths in Salvador, Bahia State, Brazil: 2000-2006. *Cadernos de Saúde Pública*  
33 2011;**27**:s298-s308.
- 34 33 França EB, Passos VMdA, Malta DC, *et al.* Cause-specific mortality for 249  
35 causes in Brazil and states during 1990–2015: a systematic analysis for the global  
36 burden of disease study 2015. *Population Health Metrics* 2017;**15**:39.
- 37 34 Grittner U, Kuntsche S, Gmel G, *et al.* Alcohol consumption and social  
38 inequality at the individual and country levels—results from an international study. *The*  
39 *European Journal of Public Health* 2013;**23**:332-9.
- 40 35 Moodie R, Stuckler D, Monteiro C, *et al.* Profits and pandemics: prevention of  
41 harmful effects of tobacco, alcohol, and ultra-processed food and drink industries.  
42 *Lancet* 2013;**381**:670-9.
- 43 36 Monteiro CA, Moubarac JC, Cannon G, *et al.* Ultra-processed products are  
44 becoming dominant in the global food system. *Obesity Reviews* 2013;**14**:21-8.
- 45 37 IBGE. Pesquisa Nacional por Amostra de Domicílios. Rio de Janeiro: Brasil  
46 2008.
- 47 38 Brener ND, Billy JOG, Grady WR. Assessment of factors affecting the validity  
48 of self-reported health-risk behavior among adolescents: evidence from the scientific  
49 literature. *Journal of Adolescent Health* 2003;**33**:436-57.
- 50 39 Brener N, Kann L, Shanklin S, *et al.* Methodology of the Youth Risk Behavior  
51 Surveillance System – 2013. . 2013:1-18.
- 52 40 IBGE. Síntese de Indicadores Sociais, uma análise das condições de vida. Rio de  
53 Janeiro: IBGE, Coordenação de População e Indicadores Sociais 2017:147.
- 54  
55  
56  
57  
58  
59  
60

1  
2  
3 Figure 1 - Time trends in health-related behaviours by wealthy quintile among  
4 adolescent  
5  
6  
7  
8  
9

10  
11  
12  
13 Figure 2- Prevalence of health-related behaviours among adolescent in 2015 and Slope  
14 Index of Inequality (SII, absolute inequality).  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

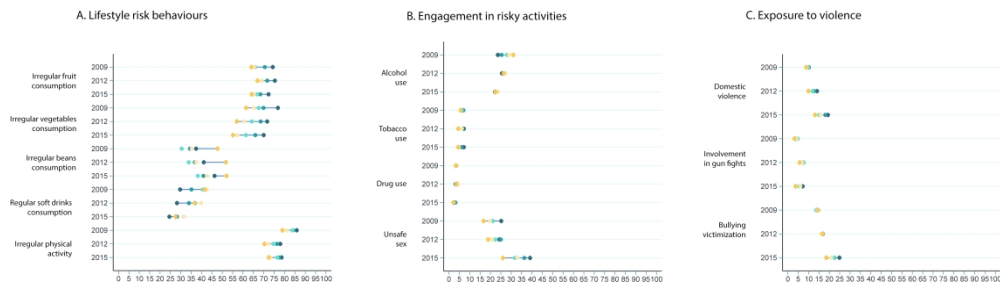


Figure 1 - Time trends in health-related behaviours by wealthy quintile among adolescent.

529x152mm (300 x 300 DPI)

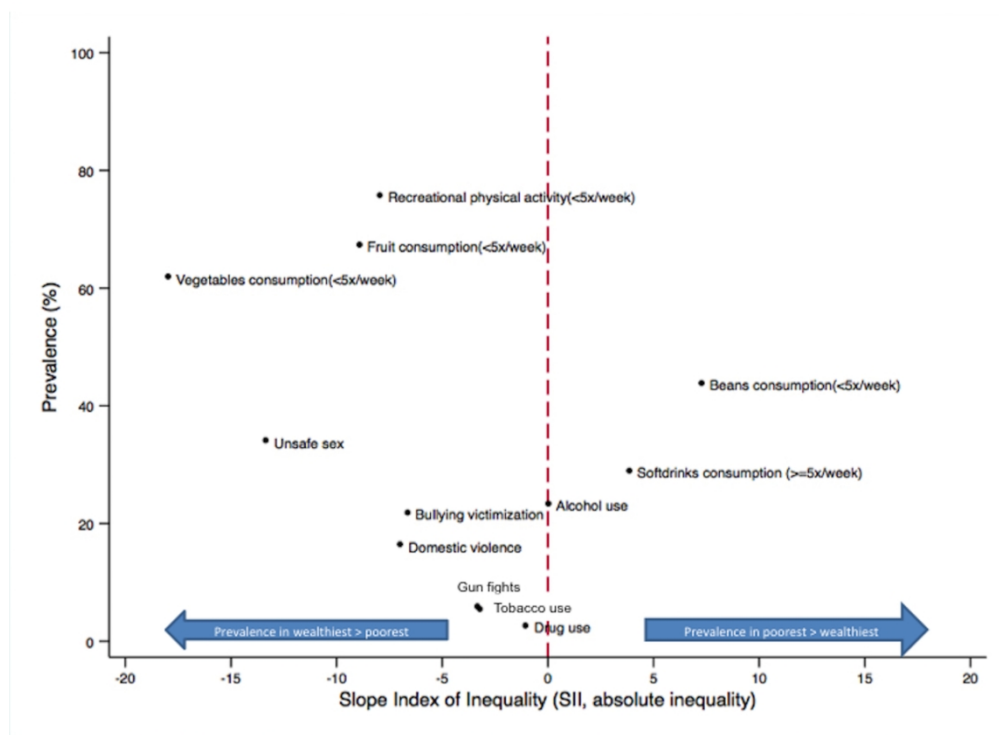


Figure 2- Prevalence of health-related behaviours among adolescent in 2015 and Slope Index of Inequality (SII, absolute inequality).

108x81mm (300 x 300 DPI)



## Appendix 1. Description of health indicators assessed.

Health indicator	Original question
Regular dietary consumption of fruits ( $\geq 5$ days) in the last week	<p>In the 7 days, on how many days did you eat fresh fruits or fruits salad?</p> <p>Options: I did not eat fresh fruits or fruits salad in the last 7 days; 1 day in the last 7 days; 2 days in the last 7 days; 3 days in the last 7 days; 4 days in the last 7 days; 5 days in the last 7 days; 6 days in the last 7 days; Every day in the last 7 days</p>
Regular dietary consumption of vegetables ( $\geq 5$ days) in the last week	<p>In the 7 days, on how many days did you eat at least one type of raw or cooked vegetable?</p> <p>Options: I did not eat vegetables in the last 7 days; 1 day in the last 7 days; 2 days in the last 7 days; 3 days in the last 7 days; 4 days in the last 7 days; 5 days in the last 7 days; 6 days in the last 7 days; Every day in the last 7 days</p>
Regular dietary consumption of beans ( $\geq 5$ days) in the last week	<p>In the 7 days, on how many days did you eat beans?</p> <p>Options: I did not eat beans in the last 7 days; 1 day in the last 7 days; 2 days in the last 7 days; 3 days in the last 7 days; 4 days in the last 7 days; 5 days in the last 7 days; 6 days in the last 7 days; Every day in the last 7 days</p>
Regular dietary consumption of soft drinks ( $\geq 5$ days) in the last week	<p>In the 7 days, on how many days did you drink soft drinks?</p> <p>Options: I did not drink soft drinks in the last 7 days; 1 day in the last 7 days; 2 days in the last 7 days; 3 days in the last 7 days; 4 days in the last 7 days; 5 days in the last 7 days; 6 days in the last 7 days; Every day in the last 7 days</p>

<p>Recreational physical activity at least 5 times in the last week</p>	<p>In the last 7 days, excluding physical education classes, on how many days did you practice any physical activity such as sports, dance, gymnastics, etc?</p> <p>Options: No day in the last 7 days; 1 day in the last 7 days; 2 days in the last 7 days; 3 days in the last 7 days; 4 days in the last 7 days; 5 days in the last 7 days; 6 days in the last 7 days; Every day in the last 7 days</p>
<p>Victim of domestic violence at least once in the previous month by some adult family member</p>	<p>In the last 30 days, how many times was you physically assaulted by some adult family member?</p> <p>Options: Not once in the last 30 days; 1 time in the last 30 days; 2 or 3 times in the last 30 days; 4 or 5 times in the last 30 days; 6 or 7 times in the last 30 days; 8 or 9 times in the last 30 days; 10 or 11 times in the last 30 days; 12 or more times in the last 30 days</p>
<p>Involvement in fights using guns at least one in the last month</p>	<p>In the last 30 days, did you get involved in any fight that someone used guns?</p> <p>Options: yes; no</p>
<p>Bullying victimization at least twice in the last month</p>	<p>“In the past 30 days, how often have you been mocked, teased, called names or intimidated by one of your schoolmates so much that you were hurt/annoyed/upset/offended/ashamed?</p> <p>Options: No day in the last 30 days; rarely in the last 30 days; sometimes in the last 30 days; most of the time in the last 30 days; always in the last 30 days</p>
<p>Alcohol use at least once in the previous month</p>	<p>In the last 30 days, on how many days did you drink at least one cup or dose of alcoholic</p>

	<p>beverage?</p> <p>Options: No day in the last 30 days; 1 or 2 days in the last 30 days; 3 to 5 days in the last 30 days; 6 to 9 days in the last 30 days; 10 to 19 days in the last 30 days; 20 to 29 days in the last 30 days; Every day in the last 30 days</p>
<p>Drug use at least once in the previous month</p>	<p>In the last 30 days, how many times did you used drugs such as marijuana, cocain, crack, glue, ecstasy, oxy, etc?</p> <p>Options: I have never used drugs; no day in the last 30 days; 1 or 2 days in the last 30 days; 3 to 5 days in the last 30 days; 6 to 9 days in the last 30 days; 10 or more days in the last 30 days</p>
<p>Smoking at least once in the previous month</p>	<p>In the last 30 days, on how many days did you smoke cigarettes?</p> <p>Options: I have never smoked; No day in the last 30 days; 1 or 2 days in the last 30 days; 3 to 5 days in the last 30 days; 6 to 9 days in the last 30 days; 10 to 19 days in the last 30 days; 20 to 29 days in the last 30 days; Every day in the last 30 days</p>
<p>Safe sexual behaviour (if have used condom in the last sexual intercourse)</p>	<p>In the last time you had sex, did you and your partner use a condom?</p> <p>Options: I have never had sex; yes; no; I don't know</p>

## Appendix 2

Simple measures of inequality in health-related behaviours among Brazilian adolescents from PeNSE surveys 2009, 2012 and 2015.

Indicator	PeNSE survey year	National	Q1 (poorest) %	Q5 (richest) %	Difference (quintile 5 - quintile 1) %	Difference (quintile 5 - quintile 1) 95% CI	Ratio (quintile 5/ quintile 1) %	Ratio (quintile 5/ quintile 1) 95% CI	Population Attributable risk (PAR)	Population Attributable risk percentage (PAR%)
Irregular fruit consumption	2009	68.49	74.34	64.00	10.34	8.06; 12.62	1.16	1.12; 1.20	-4.49	-6.56
	2012	70.24	75.35	66.96	8.39	6.03; 10.74	1.13	1.08; 1.16	-3.28	-4.67
	2015	67.17	72.29	64.15	8.14	5.28; 11.00	1.13	1.08; 1.18	-3.02	-4.50
Irregular vegetables consumption	2009	68.77	76.81	61.47	15.34	13.28; 17.41	1.25	1.21; 1.29	-7.30	-10.62
	2012	64.12	71.64	56.99	14.65	12.46; 16.83	1.26	1.21; 1.30	-7.13	-11.12
	2015	61.73	69.97	55.14	14.83	11.66; 18.01	1.27	1.20; 1.34	-6.59	-10.68
Irregular beans consumption	2009	37.45	37.38	47.74	-10.36	-12.96; -7.77	0.78	0.74; 0.83	10.29	27.48
	2012	40.00	41.09	51.74	-10.65	-13.88; -7.42	0.79	0.74; 0.85	11.74	29.35
	2015	43.74	46.27	52.07	-5.80	-9.17; -2.43	0.89	0.83; 0.95	8.33	19.04
Regular softdrinks consumption	2009	37.21	29.67	41.59	-11.92	-14.32; -9.50	0.71	0.67; 0.76	4.38	11.77
	2012	35.44	28.17	36.62	-8.45	-10.69; -6.20	0.77	0.72; 0.83	1.18	3.33
	2015	28.84	24.51	27.42	-2.91	-5.45; -0.33	0.89	0.81; 0.98	-1.42	-4.92
Irregular recreational physical activity	2009	82.96	85.88	78.96	6.92	5.30; 8.55	1.09	1.07; 1.11	-4.00	-4.66
	2012	74.15	77.97	70.27	7.70	5.82; 9.58	1.11	1.08; 1.14	-3.88	-4.98
	2015	75.58	78.58	72.36	6.22	3.93; 8.51	1.09	1.05; 1.12	-3.22	-4.10
Alcohol use (once in the last month)	2009	27.13	23.57	31.02	-7.45	-9.22; -5.67	0.76	0.71; 0.81	3.89	14.33
	2012	26.78	25.55	26.33	-0.78	-2.94; 1.37	0.97	0.89; 1.05	-0.45	-1.67
	2015	23.2	22.24	22.50	-0.26	-2.99; 2.47	0.99	0.87; 1.12	-0.70	-3.03
Tobacco use (once in the last month)	2009	6.25	6.70	5.63	1.07	0.09; 2.06	1.19	1.01; 1.40	-0.62	-9.92
	2012	6.08	7.20	4.44	2.76	1.70; 3.82	1.62	1.35; 1.95	-1.64	-26.99
	2015	5.34	7.18	4.41	2.77	1.48; 4.06	1.63	1.28; 2.08	-0.93	-17.35

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

	2009	3.32	3.01	3.52	-0.51	-1.29; 0.27	0.85	0.67; 1.08	0.20	6.02
Drug use (once in the last month)	2012	3.81	3.94	3.63	0.31	-0.70; 1.32	1.09	0.83; 1.42	-0.18	-4.72
	2015	2.45	2.55	2.20	0.35	-0.52; 1.22	1.16	0.80; 1.69	-0.25	-10.20
	2009	21.46	25.19	16.65	8.54	5.27; 11.82	1.51	1.27; 1.80	-4.81	-22.41
Unsafe sex (in the last sexual intercourse)	2012	22.5	24.29	18.83	5.46	2.10; 8.81	1.29	1.10; 1.51	-3.67	-16.31
	2015	33.86	39.11	26.00	13.11	8.21; 18.01	1.50	1.28; 1.77	-7.86	-23.21
	2009	9.54	10.13	8.79	1.34	0.06; 2.62	1.15	1.00; 1.33	-0.75	-7.86
Domestic violence (once in the last month)	2012	11.6	14.08	9.87	4.21	2.82; 5.61	1.43	1.27; 1.61	-1.73	-14.91
	2015	16.17	19.33	13.11	6.22	4.48; 7.96	1.47	1.32; 1.65	-3.06	-18.92
	2009	4.01	3.93	3.15	0.78	0.02; 1.53	1.25	1.00; 1.55	-0.86	-21.45
Involvement in gun fights (in the last month)	2012	6.94	7.50	5.65	1.85	0.82; 2.88	1.33	1.13; 1.55	-1.29	-18.59
	2015	5.61	7.19	3.70	3.49	2.41; 4.58	1.94	1.56; 2.42	-1.91	-34.05
	2009	14.16	13.71	14.54	-0.83	-2.16; 0.50	0.94	0.86; 1.04	0.38	2.68
Bullying victimization (twice or more in the last month)	2012	16.5	16.90	16.73	0.17	-1.68; 2.04	1.01	0.90; 1.13	0.23	1.39
	2015	21.74	24.88	18.51	6.37	4.28; 8.45	1.34	1.22; 1.48	-3.23	-14.86

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract <b>abstract; page 1</b> (b) Provide in the abstract an informative and balanced summary of what was done and what was found <b>page 1</b>
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported <b>Page2</b>
Objectives	3	State specific objectives, including any prespecified hypotheses <b>Page 3</b>
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper <b>Page 3</b>
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection <b>Page 3</b>
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <b>NA</b> <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <b>NA</b> <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants <b>–Page3 and first para page 4</b> (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <b>NA</b> <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case <b>NA</b>
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable <b>Page 4 and page 5</b>
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group <b>Table 1 – page 5 and Supplementary material</b>
Bias	9	Describe any efforts to address potential sources of bias <b>Page 4 (response rate – selection bias); page 5 (validation of measures – information bias)</b>
Study size	10	Explain how the study size was arrived at . <b>Page 3 and Reference: Oliveira et al. 2017</b>
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why <b>Page 6</b>
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding <b>Page 6</b> (b) Describe any methods used to examine subgroups and interactions <b>NA</b> (c) Explain how missing data were addressed <b>Pages 6-7</b>

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

(d) *Cohort study*—If applicable, explain how loss to follow-up was addressed NA  
*Case-control study*—If applicable, explain how matching of cases and controls was addressed NA  
*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy Page 7

---

(e) Describe any sensitivity analyses NA

Continued on next page

For peer review only

<b>Results</b>		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
<b>Discussion</b>		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
<b>Other information</b>		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).



# BMJ Open

## Progress and setbacks in socioeconomic inequalities in adolescent health-related behaviours in Brazil, 2009-2015.

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-025338.R1
Article Type:	Research
Date Submitted by the Author:	19-Dec-2018
Complete List of Authors:	Azeredo, Catarina; Universidade Federal de Uberlandia, Faculdade de Medicina Rezende, Leandro; Departamento de Medicina Preventiva, Faculdade de Medicina FMUSP, Universidade de Sao Paulo, SP, BR, Mallinson, Poppy; London School of Hygiene and Tropical Medicine Faculty of Epidemiology and Population Health, Department of Non-Communicable Disease Epidemiology Ricardo, Camila; Universidade de Sao Paulo Faculdade de Medicina, Departamento de Medicina Preventiva Kinra, Sanjay; LSHTM, Levy, Renata; University of Sao Paulo, Medicine Barros, A; Federal University of Pelotas (UFPeL), Postgraduate Programme in Epidemiology
<b>Primary Subject Heading</b>:	Epidemiology
Secondary Subject Heading:	Global health, Paediatrics
Keywords:	Adolescent, Health Behavior, Health Inequality, EPIDEMIOLOGY

SCHOLARONE™  
Manuscripts

1  
2  
3 **Progress and setbacks in socioeconomic inequalities in adolescent**  
4 **health-related behaviours in Brazil, 2009-2015.**  
5  
6  
7  
8  
9

10 **Catarina Machado Azeredo<sup>1,a</sup>, Leandro Fórniás Machado de Rezende<sup>2</sup>, Poppy**  
11 **Alice Carson Mallinson<sup>3</sup>, Camila Zancheta Ricardo<sup>2</sup>, Sanjay Kinra<sup>3</sup>, Renata**  
12 **Bertazzi Levy<sup>2</sup>, Aluisio J D. Barros<sup>4</sup>**  
13  
14  
15  
16  
17  
18

19 <sup>a</sup> Corresponding Author  
20

21  
22 1 Faculdade de Medicina da Universidade Federal de Uberlândia. Address: Av. Pará  
23 1720, Bloco 2 U, sala 20. Campus Umuarama. Uberlândia/MG - Brasil - 38.405-320  
24 Telephone: +55 (34) 32258584. E-mail: [catarina@famed.ufu.br](mailto:catarina@famed.ufu.br)  
25

26 2 Departamento de Medicina Preventiva, Faculdade de Medicina FMUSP,  
27 Universidade de Sao Paulo, Sao Paulo, SP, Brazil  
28

29 3 Institution: Department of Non-Communicable Disease Epidemiology, London  
30 School of Hygiene and Tropical Medicine (LSHTM), London, United Kingdom.  
31

32 4 Postgraduate Program in Epidemiology, Federal University of Pelotas, Pelotas, RS,  
33 Brazil.  
34  
35  
36  
37  
38

39 **Keywords:** Adolescents; Social Inequalities; Health Behaviors; Lifestyle  
40

41 **Words count:** 2849  
42  
43  
44

45 **Authorship statement:** CMA, LFMR, RBL and AJDB conceptualized the study and  
46 were involved in the analysis and interpretation of the results. CZR was involved in data  
47 preparation, designed and prepared the tables. SK and PACM were involved in the  
48 interpretation and discussion of results. The initial draft of the paper was prepared by  
49 CMA following extensive discussions and inputs from the other co-authors. All authors  
50 have reviewed, revised the manuscript and approved the final version.  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## ABSTRACT

### Objectives

Despite some progress, Brazil is still one of the most unequal countries, and the extent of socioeconomic inequalities in adolescent health is unclear. We assessed trends in socioeconomic inequalities in adolescent's health-related behaviours in Brazil between 2009-2015.

**Design:** We used cross-sectional data from the Brazilian National Survey of School Health carried out in 2009, 2012 and 2015.

**Setting:** Brazilian state capitals.

**Participants:** Students attending 9<sup>th</sup> grade from public and private schools in Brazilian state capitals in 2009 (60,973 students), 2012 (74,432 students) and 2015 (60,078 students)

### Main Outcome measure:

We assessed 12 health-related behaviours (irregular fruit, vegetables and bean consumption; regular soft drinks consumption; irregular physical activity; alcohol, drug and tobacco use; unsafe sex; involvement in gun fights; bullying victimization and domestic violence victimization), under the broad domains of lifestyle risk behaviours, engagement in risky activities and exposure to violence. Socioeconomic status was assessed through an asset-based wealth index derived from principal components analysis. Absolute and relative inequalities in these health behaviours and inequalities trends were investigated.

### Results

From 2009 to 2015, prevalence of certain harmful health-related behaviours increased, such as unsafe sex (21.5% to 33.9%), domestic violence (9.5% to 16.2%), bullying victimization (14.2% to 21.7%) and in irregular consumption of beans (37.5% to 43.7%). Other indicators decreased: alcohol use (27.1% to 23.2%), irregular physical activity (83.0% to 75.6%) and consumption of soft drinks (37.2% to 28.8%). Over the period, we found consistent evidence of decreasing health inequalities for lifestyle behaviours (fruit, bean and soft drink consumption) and alcohol use, set against increasing inequalities in violence (domestic violence, fights using guns and bullying victimization).

### Conclusion

Socioeconomic inequality increased in the violence domain and decreased for lifestyle behaviours among Brazilian adolescents. Widening gaps in violence domain urge immediately policy measures in Brazil.

**Key-words:** Adolescent, Social inequalities, health behaviour.

### Strengths and limitations of this study

- We assessed the extent of socioeconomic inequalities in adolescent health and how it has changed over time in a middle-income country;
- We used a large representative urban samples from Brazilian adolescents attending public and private schools;
- Another strength of this study was the use of complex measures of inequality;
- Although we have used validated questionnaires, the self-report of behaviours may cause some degree of classification bias;
- The period of 6 years may be too short to expect significant changes in inequalities.

## INTRODUCTION

Adolescence is a critical period for promotion of human development. During adolescence, biological, cognitive, emotional, and social capabilities are founded and future patterns of adult health are established [1]. Despite its clear importance, adolescent's health has been generally overlooked in social policies. In order to guide surveillance, investments and policy actions, a broad concept of adolescent health has been proposed by The Lancet Commission on adolescent health. This concept includes aspects related to sexual and reproductive health, nutritional deficiencies, injury and violence, physical and mental health, and substance use disorders [2].

Socioeconomic factors strongly predict adolescent health [3]. Socioeconomic inequalities have consistently increased over the last decades in US and Europe [4], and this trend coincides with widening gaps in indicators of adolescent health [5]. For instance, a time-series analysis of 34 North American and European countries showed an increase in inequalities between socioeconomic groups in physical activity, body mass index, and psychological and physical symptoms between 2002 and 2010 [5].

Studies monitoring inequality in adolescent health in low- and middle-income countries are sparse in the literature. Brazil is still one of the most unequal countries worldwide [6], although considerable social protection efforts have been adopted in the last decades (*e.g.*, creation of a free public universal health system, expanding community-based primary care and providing a robust conditional cash transfer program) [7]. These social programs have had positive impacts on adult health, especially among the most deprived, with increased overall food quality and diversity [8], reduced racial inequalities in health [9] and cardiovascular disease mortality [10]. However, the extent of socioeconomic inequalities in adolescent health and how it has changes over time in Brazil is unclear.

1  
2  
3 In this study, we assessed levels and trends in socioeconomic inequalities in  
4 adolescent health in Brazil between 2009 and 2015, addressing absolute and relative  
5 measures of inequality. We used data from three large representative health surveys of  
6 adolescents living in Brazilian state capitals. We selected 12 indicators under 3 broad  
7 domains (lifestyle risk behaviours, engagement in risky activities and exposure to  
8 violence) to provide a holistic view of adolescent health inequalities in Brazil.  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18

## 19 **METHODS**

20  
21 We used cross-sectional data from three Brazilian National Surveys of School Health  
22 (*Pesquisa Nacional da Saude do Escolar* - PeNSE) carried out in 2009, 2012 and 2015.  
23  
24 In order to have comparable datasets across the three surveys, we used a representative  
25 subsample of adolescents attending 9<sup>th</sup> grade (i.e., mostly aged between 14-15 years) in  
26 public and private schools from the 26 state capitals and the Federal District. Detailed  
27 information about PeNSE has been published elsewhere [11-13]. Briefly, PeNSE  
28 sampling strategy included stratification per cluster and multi-stage selection. The  
29 sampling strata were each of the 26 state capitals and Federal District. The primary  
30 sampling units (PSUs) were schools, and the secondary sampling units (SSUs) were  
31 classrooms. School selection was proportional to the total number of 9<sup>th</sup> grade classes,  
32 while the classes in each school were chosen by simple random selection. Two  
33 classrooms were selected from schools with three or more 9<sup>th</sup> grade classrooms, whereas  
34 one classroom was selected from schools with one or two 9<sup>th</sup> grade classrooms. All  
35 students enrolled in the selected classrooms were invited to participate in the study.  
36  
37 Participants were not included in the study if they did not attend school during data  
38 collection, refuse to participate, or did not report their age and sex. The total number of  
39 students included in our analysis was 60,973 (final response rate 83.8%) for 2009,  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 61,145 (final response rate 82.2%) for 2012, and 51,192 (final response rate 85.2%) for  
4  
5 2015 surveys [11-13].  
6

7  
8 Students filled out a self-reported structured questionnaire available in a  
9  
10 Personal Digital Assistant device (2009 survey) or smartphone application (2012 and  
11  
12 2015 survey) in their school classrooms during regular school hours. The questionnaire  
13  
14 was based on the Global School-Based Student Health Survey [14] and the Youth Risk  
15  
16 Behaviour Surveillance System[15], and was adapted to the Brazilian setting. Questions  
17  
18 included socioeconomic variables and several risk and protective factors for adolescent  
19  
20 health.  
21  
22

23  
24 We estimated a wealth index specific for each survey year through Principal  
25  
26 Component Analysis (PCA), following the steps proposed by Barros and Victora [16].  
27  
28 We ran PCA including the following variables: mother's educational level (incomplete  
29  
30 middle school, complete middle school, complete high-school, complete higher  
31  
32 education); school administrative status (public or private); self-report of having:  
33  
34 landline, mobile phone, computer, internet access, car, bathroom inside the house and  
35  
36 housemaid services. We retained the first component of the analysis and calculated  
37  
38 coefficients from the expression:  $\text{coefficient} = \text{loading} / \text{standard deviation} \times 100$ . The  
39  
40 individual scores were estimated from the  $\sum c_i v_i$ , where  $c_i$  is the coefficient and  $v_i$  is the  
41  
42 value for the  $i^{\text{th}}$  variable. The wealth index was assessed as quintiles of the total wealth  
43  
44 scores. We refer to the first quintile (Q1) as the poorest quintile (poorest 20%) and the  
45  
46 fifth quintile (Q5) as the wealthiest quintile (wealthiest 20%).  
47  
48  
49

50  
51 The indicators of adolescent health used in this study are defined in table 1. We  
52  
53 divided indicators in three domains: lifestyle risk behaviours, engagement in risky  
54  
55 activities and exposure to violence. Alcohol and tobacco use were included as risky  
56  
57 activities and not lifestyle behaviours, because Brazilian law forbids the sale of these  
58  
59  
60

substances for younger than 18 years old. We have used the concept of “irregular consumption” (<5 times in the past week) for all food indicators, following the complementary concept of “regular consumption”, which was validated using 24 hours recall[17]. We also chose to include bean consumption because of their protective health effects and importance in Brazil as an affordable traditional staple food [18]. The frequency of 2 or more times in the previous month for bullying victimization followed the concept of this type of violence, which presume repetition[19]. The unsafe sex was assessed only for those who reported had sexual relationships.

**Table 1:** Indicators of adolescent health used in the present study

Domain	Health indicator	Original question
<b>Lifestyle risk behaviours</b>	Regular dietary consumption of fruits ( $\geq 5$ days) in the last week	In the 7 days, on how many days did you eat fresh fruits or fruits salad? Options: I did not eat fresh fruits or fruits salad in the last 7 days; other options ranged from 1 day in the last 7 days to every day in the last 7 days.
	Regular dietary consumption of vegetables ( $\geq 5$ days) in the last week	In the 7 days, on how many days did you eat at least one type of raw or cooked vegetable? Options: I did not eat vegetables in the last 7 days; other options ranged from 1 day in the last 7 days to every day in the last 7 days.
	Regular dietary consumption of beans ( $\geq 5$ days) in the last week	In the 7 days, on how many days did you eat beans? Options: I did not eat beans in the last 7 days; other options ranged from 1 day in the last 7 days to every day in the last 7 days.
	Regular dietary consumption of soft drinks ( $\geq 5$ days) in the last week	In the 7 days, on how many days did you drink soft drinks? Options: I did not drink soft drinks in the last 7 days; other options ranged from 1 day in the last 7 days to every day in the last 7 days.
	Recreational physical activity at least 5 times in the last week	In the last 7 days, excluding physical education classes, on how many days did you practice any physical activity such as sports, dance, gymnastics, etc? Options: No day in the last 7 days; other

		options ranged from 1 day in the last 7 days to every day in the last 7 days.
<b>Exposure to violence</b>	Victim of domestic violence at least once in the previous month by some adult family member	In the last 30 days, how many times was you physically assaulted by some adult family member? Options: Not once in the last 30 days; 1 time in the last 30 days; other options ranged from 2 or 3 times in the last 30 days to 12 or more times in the last 30 days.
	Involvement in fights using guns at least one in the last month	In the last 30 days, did you get involved in any fight that someone used guns? Options: yes; no
	Bullying victimization at least sometimes in the last month	“In the past 30 days, how often have you been mocked, teased, called names or intimidated by one of your schoolmates so much that you were hurt/annoyed/upset/offended/ashamed? Options: No day in the last 30 days; rarely in the last 30 days; sometimes in the last 30 days; most of the time in the last 30 days; always in the last 30 days
<b>Engagement in risky activities</b>	Alcohol use at least once in the previous month	In the last 30 days, on how many days did you drink at least one cup or dose of alcoholic beverage? Options: No day in the last 30 days; Other options ranged from 1 or 2 days in the last 30 days to every day in the last 30 days.
	Drug use at least once in the previous month	In the last 30 days, how many times did you used drugs such as marijuana, cocaine, crack, glue, ecstasy, oxy, etc? Options: I have never used drugs; no day in the last 30 days; Other options ranged from 1 or 2 days in the last 30 days to 10 or more days in the last 30 days.
	Smoking at least once in the previous month	In the last 30 days, on how many days did you smoke cigarettes? Options: I have never smoked; No day in the last 30 days; Other options ranged from 1 or 2 days in the last 30 days to every day in the last 30 days.
	Safe sexual behaviour (have used condom in the last sexual intercourse)	In the last time you had sex, did you and your partner use a condom? Options: I have never had sex; yes; no; I don't know.



1  
2  
3 To assess socioeconomic inequalities in adolescent health we used several  
4 measures of inequality. Firstly, we estimated simple measures of inequality (pairwise  
5 comparisons), such as differences and ratios of each health indicator between the  
6 wealthiest group (5<sup>th</sup> quintile) and the poorest group (1<sup>st</sup> quintile).  
7  
8  
9

10  
11  
12 Secondly, we estimated complex measures of inequality, represented by an  
13 indicator of absolute inequality, the slope index of inequality (SII), and an indicator of  
14 relative inequality, the concentration index (CIX) [20]. Both SII and CIX take into  
15 account all quintiles of the wealth index to compare a given health indicator across all  
16 wealth subgroups.  
17  
18  
19  
20  
21  
22

23  
24 We estimated the SII using logistic regression to avoid predicting implausible  
25 values below zero or above one, considering that all health indicators were presented as  
26 proportions [21]. The SII estimates the absolute difference (i.e., in percentage points) in  
27 the prevalence of health indicator between individuals in the wealthiest and poorest  
28 quintiles. Negative values of SII indicate that prevalence of the health indicator is higher  
29 among the poorest adolescents than the wealthiest (values ranged from -100 to +100).  
30  
31  
32  
33  
34  
35  
36

37  
38 The CIX was also expressed on a scale ranging from -100 to +100; a value of 0  
39 represents perfect equality, whereas negative values indicate that poor individuals have  
40 higher prevalence of a given health indicator than wealthy individuals [22]. The CIX  
41 was calculated with no corrections [21].  
42  
43  
44  
45  
46

47  
48 Linear regressions using variance-weighted least squares were performed to  
49 assess changes over time in complex measures of inequality (SII and CIX) based on the  
50 means and standard deviation for each of the three surveys.  
51  
52

53  
54 Multiple imputation was performed using the chained equation technique due to  
55 the significant proportion of missing values for the mother's education level in the three  
56 datasets (19,36%, n=33,559). We also imputed other study variables with a smaller  
57  
58  
59  
60

1  
2  
3 proportion of missing values, to create a complete dataset. The imputed data exhibited  
4  
5 satisfactory statistical reproducibility according to Monte Carlo error analysis[23].  
6  
7

8 The sample design was taken into consideration for descriptive analyses, using  
9  
10 survey prefix command (svy) in Stata. School clustering (random effect) and sample  
11  
12 weights were considered when estimating complex measures of inequality (SII and  
13  
14 CIX). All the statistical analyses were performed using Stata 14.0.  
15  
16  
17  
18

### 19 **Ethics approval**

20  
21  
22  
23  
24 PeNSE surveys were approved by the National Commission of Research Ethics  
25  
26 (Comissão Nacional de Ética em Pesquisa – Conep), records no. 11.537 (2009), 16.805  
27  
28 (2012) and 1.006.467 (2015). The surveys were performed in accordance with the  
29  
30 Declaration of Helsinki and all participants gave their informed consent. Databases were  
31  
32 made publicly available on an IBGE website without any information that could  
33  
34 identify subjects.  
35  
36  
37  
38

### 39 **Patient and public involvement**

40  
41 No patients or public were involved in the design and conceptualisation of this  
42  
43 study.  
44  
45

### 46 **Data Sharing**

47  
48 The dataset of 2009, 2012 and 2015 PeNSE are publicly available at:  
49  
50 [https://www.ibge.gov.br/estatisticas-novoportal/sociais/educacao/9134-pesquisa-](https://www.ibge.gov.br/estatisticas-novoportal/sociais/educacao/9134-pesquisa-nacional-de-saude-do-escolar.html?=&t=microdados)  
51  
52 [nacional-de-saude-do-escolar.html?=&t=microdados](https://www.ibge.gov.br/estatisticas-novoportal/sociais/educacao/9134-pesquisa-nacional-de-saude-do-escolar.html?=&t=microdados)  
53  
54  
55  
56

## 57 **RESULTS**

58  
59  
60

1  
2  
3 In 2015, the health-related behaviours more common among Brazilian  
4 adolescents were irregular consumption of fruits (67.2%) and vegetables (61.8%) and  
5 irregular recreational physical activity (75.6%). Less frequent were the unsafe sex in last  
6 sexual intercourse (33.9%), alcohol use (23.2%) and exposure to bullying (21.7%).  
7  
8 Between 2009 and 2015, the prevalence of irregular vegetable consumption, irregular  
9 recreational physical activity, regular soft drink consumption, alcohol, tobacco and drug  
10 use decreased. On the other hand, trends for irregular bean consumption, unsafe sexual  
11 intercourse, and exposure to violence (domestic violence, fight using guns, and bullying  
12 victimization) increased (Table 2).  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

**Table 2** - Brazilian adolescent characteristics and health-related behaviours from PeNSE surveys 2009, 2012 and 2015.

adolescents characteristics and behaviours	PeNSE survey year					
	2009 (60,973 students)		2012 (61,145 students)		2015 (51,192 students)	
Characteristics	%	CI95%	%	CI95%	%	CI95%
Sex (female)	52.5	(51.9-53.2)	50.8	(50.1-51.6)	50.8	(49.9-51.7)
Age (mean and standard error)	14.2	(0.02)	14.3	(0.02)	14.2	(0.02)
Wealth index (mean and standard error)	3.8	(0.03)	4.0	(0.06)	4.0	(0.06)
<b>Behaviours</b>						
Irregular fruit consumption	68.5	(67.8-69.2)	70.2	(69.5-70.9)	67.2	(66.3-68.0)
Irregular vegetables consumption	68.8	(68.0-69.5)	64.1	(63.3-64.9)	61.7	(60.7-62.7)
Irregular beans consumption	37.4	(36.4-38.5)	40.0	(38.5-41.5)	43.7	(42.4-45.1)
Regular soft drinks consumption	37.2	(36.3-38.2)	35.4	(34.6-36.2)	28.8	(27.9-29.8)
Irregular recreational physical activity	83.0	(82.3-83.6)	74.2	(7.5-74.8)	75.6	(74.8-76.3)
Alcohol use (once in the last month)	27.1	(26.3-28.0)	26.8	(25.8-27.7)	23.2	(22.2-24.2)
Tobacco use (once in the last month)	6.2	(5.8-6.7)	6.1	(5.6-6.6)	5.3	(4.9-5.8)
Drug use (once in the last month)	3.3	(3.0-3.6)	3.8	(3.4-4.2)	2.5	(2.2-2.7)
Unsafe sex (in the last sexual intercourse)	21.5	(20.3-22.7)	22.5	(21.6-23.5)	33.9	(32.3-35.4)
Domestic violence (once in the last month)	9.5	(9.1-10.0)	11.6	(11.1-12.1)	16.2	(15.5-16.9)
Involvement in gun fights (once in the last month)	4.0	(3.7-4.3)	6.9	(6.6-7.3)	5.6	(5.2-6.1)
Bullying victimization (twice or more in the last month)	14.2	(13.6-14.7)	16.5	(15.9-17.1)	21.7	(21.1-22.4)

1  
2  
3 Figure 1 (A-C) shows the trends in health indicators by wealth quintile between  
4 2009 and 2015. The width of the bars represents the absolute inequality. For most health  
5 indicators (except bean, soft drink and alcohol use), people in the poorest group  
6 reported more adverse levels compared to the wealthiest group. In general, over the  
7 period 2009-2015, health inequalities decreased for lifestyle behaviours (fruit,  
8 vegetable, bean and soft drink consumption, and recreational physical activity), while  
9 increased for risky activities and violence (smoking, drug use, unsafe sex, domestic  
10 violence, fights using guns and bullying victimization) (Appendix 1).  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

INSERT FIGURE 1 HERE

Some of these trends were not statistically significant according to complex measures of inequality (table 3).

**Table 3** - Complex measures of inequality in health-related behaviours among Brazilian adolescents. PeNSE surveys 2009, 2012 and 2015.

Quintiles of Wealth index (1=poorest; 5=wealthiest) Indicators	Slope Index of inequality (SII)				Concentration index of inequality (CIX)			
	2009	2012	2015	<i>p</i> -value*	2009	2012	2015	<i>p</i> -value*
Irregular fruit consumption	-13.68	-9.01	-8.88	0.015	-2.82	-2.31	-2.26	0.267
Irregular vegetables consumption	-19.02	-17.59	-17.92	0.535	-4.30	-4.48	-5.18	0.165
Irregular beans consumption	9.95	11.25	7.33	0.434	6.48	3.47	2.22	<0.001
Regular soft drinks consumption	16.55	10.49	3.89	<0.001	6.94	5.19	2.90	<0.001
Irregular recreational physical activity	-8.66	-9.47	-7.90	0.745	-1.70	-1.91	-1.71	0.837
Alcohol use (once in the last month)	9.69	0.68	0.06	0.000	4.79	1.71	1.19	0.004
Tobacco use (once in the last month)	-1.68	-2.80	-3.15	0.125	-5.68	-6.32	-8.69	0.290
Drug use (once in the last month)	0.34	0.46	-0.98	0.048	-0.08	4.47	-4.61	0.428
Unsafe sex (in the last sexual intercourse)	-9.67	-6.88	-13.28	0.498	-6.52	-5.44	-6.56	0.914
Domestic violence (once in the last month)	-1.84	-5.24	-6.92	<0.001	-2.72	-7.02	-6.57	0.014
Involvement in gun fights (once in the last month)	-0.76	-1.90	-3.30	0.002	-2.82	-4.42	-8.79	0.029
Bullying victimization (twice or more in the last month)	0.83	-0.20	-6.60	<0.001	0.56	0.59	-4.41	<0.001

1  
2  
3 In all years, alcohol consumption was the health indicator more equally  
4 distributed between wealth quintiles both according to absolute and relative measures.  
5  
6 On the other hand, irregular vegetables consumption and unsafe sex had the highest  
7 absolute inequality and fights using guns and tobacco use the highest relative inequality.  
8  
9 Over time, the absolute (SII) and relative inequalities (CIX) between wealth index  
10 quintiles became wider for all three indicators of exposure to violence, and narrower for  
11 some indicators of lifestyle behaviour (fruit, beans and soft drinks) and alcohol  
12 consumption. There was limited evidence of change in inequalities over time for the  
13 other lifestyle behaviours, such as irregular vegetables consumption and recreational  
14 physical activity, and indicators of engagement in risky activities, such as tobacco, drug  
15 use and unsafe sex (table 3, figure 2).  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28

29 INSERT FIGURE 2 HERE  
30  
31  
32

## 33 DISCUSSION 34

35 We showed evidence of persistent socioeconomic inequalities in adolescent  
36 health in Brazil. Between 2009 and 2015, lifestyle behaviours (fruit and soft drinks  
37 consumption) and alcohol use became more equally distributed between socioeconomic  
38 groups, while inequalities in experiencing violence were exacerbated. In this period,  
39 there was little evidence of change to inequalities in risky activities (smoking, drugs,  
40 unsafe sex).  
41  
42  
43  
44  
45  
46  
47  
48

49 In general, the direction of health inequalities we observed are similar to that  
50 reported in other settings, that is, poorer adolescents are more likely to report harmful  
51 health behaviours than richer [5]. For certain harmful behaviours (e.g. alcohol and drug  
52 use), however, differences between social groups were not significant or went in the  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 opposite direction (i.e. wealthier adolescents reported higher prevalences). These  
4  
5 findings are consistent with results observed in other countries [24].  
6  
7

8 Looking at time-trends in these inequalities, our findings differ to existing  
9  
10 evidence from Western Europe and North America. For some lifestyle (e.g. vegetable  
11  
12 consumption, physical activity) and risky behaviours (drug and tobacco use),  
13  
14 inequalities have not changed significantly between 2009 and 2015 in Brazil. Yet  
15  
16 inequality in lifestyle and risky behaviors have increased over similar period in many  
17  
18 other countries [5, 25]. Similarly to ours, one study found persistent inequality in  
19  
20 vegetable consumption [26]. Despite this, comparable data for many indicators of risk  
21  
22 behaviours are lacking. Rates of violence as well as inequalities in violence increased  
23  
24 markedly (gun fights, domestic violence, bullying), and these trends also differ from  
25  
26 other countries [27].  
27  
28  
29

30 Reasons for differential socioeconomic inequality trends between lifestyle  
31  
32 behaviours, risk behaviours and violence-related indicators in Brazilian adolescents are  
33  
34 unclear. Reductions in lifestyle behaviour inequalities fits with the general trend of  
35  
36 narrowing economic and health inequalities observed for adults in Brazil in that  
37  
38 period[28, 29]. This is often attributed to rising prosperity combined with roll-out of  
39  
40 redistributive health and social programs such as the Bolsa Familia cash transfer  
41  
42 program [30], as well as scaled-up health promotion efforts (especially obesity  
43  
44 prevention) [31]. Exacerbation of violence-related inequalities have also been observed  
45  
46 in one study of adult mortality in Salvador [32]. It has been suggested that public health  
47  
48 interventions have focussed on reducing infectious and chronic diseases but neglect, on  
49  
50 the other hand, external causes of ill-health such as interpersonal violence. In fact,  
51  
52 violence-related mortality has declined slower than all other causes in Brazil, and even  
53  
54 increased in 19 of the 27 states [33].  
55  
56  
57  
58  
59  
60



1  
2  
3 It is worth noting that we found a shift in prevalence of alcohol use and soft  
4 drinks consumption between socioeconomic in the period studied. In 2009, these  
5 indicators were higher among the wealthiest group, but in 2015 the differences were  
6 considerably attenuated. The reduction in the consumption of these products was more  
7 pronounced among the wealthiest group than in the poorest group. Conversely, for bean  
8 consumption, poorer adolescents reported higher prevalence than wealthiest  
9 adolescences. In this regard, the reduction in disparities between wealth groups should  
10 be read with caution. In high-income countries, poorer individuals consume more  
11 alcohol, relative to wealthier individuals, while in low-middle income countries  
12 wealthier individuals are more exposed than the poorer [34]. This trend could be  
13 shifting. In fact, industries of unhealthy commodities have moved to, and are growing  
14 faster in, low- and middle-income countries comparing to high-income countries [35].  
15 This phenomenon might explain, at least in part, the increase in consumption of ultra-  
16 processed products (e.g. sugary drinks) and alcohol, and the reduction of bean  
17 consumption in these settings [36]. Brazil seems to be moving towards patterns of  
18 health indicators and their inequalities currently observed in high-income countries. In  
19 these countries, the reduction in alcohol use and soft drinks consumption among those  
20 privileged is not necessarily followed by a reduction among those more socially  
21 deprived [5]. Although this trend is measured as a reduction in inequality, it is not  
22 desirable.

23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49 The main strength of this study is to explore a wide spectrum of health  
50 indicators, which provides information on prevalence and trends in key risk factors for  
51 adolescent health. Another positive aspect is the large representative urban samples  
52 from Brazilian adolescents attending public and private schools. In Brazil, the school  
53 coverage in this age is very high (88-97%) [37], which reduces significantly the risk of  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 selection bias. Despite this, it is plausible to assume that students at higher risk of harmful  
4 health behaviors have higher truancy and dropout rates. Therefore, this could have  
5 masked the true extent of the inequalities. We also report a range of simple and complex  
6 measures of inequalities to allow clear interpretation of trends as well as presenting  
7 rigorous hypothesis tests which make use of all data. Concordance between the absolute  
8 and relative measures of inequality adds strength to our conclusions.  
9

10  
11  
12  
13  
14  
15  
16  
17 Some limitations should be acknowledged. The engagement in health-related  
18 behaviours was self-reported by adolescents, and therefore, misclassification may have  
19 occurred towards socially desirable behaviors. Misclassification likely affected the  
20 prevalence of health indicators similarly over three surveys. Although, use of self-  
21 reported outcomes is a limitation, it is widely recognised as an acceptable and often the  
22 only feasible approach for monitoring adolescent health behaviours [38]. Moreover,  
23 there is evidence of validity of the dietary indicators used in the PeNSE survey [17], and  
24 a US survey on which the PeNSE survey was based demonstrated good test-retest  
25 reliability and consistency across different modes of questioning [39].  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36

37  
38 The surveys were available only for a period of 6 years, which may be too short  
39 to expect significant changes in inequalities. To continue monitoring trends in  
40 adolescent health inequality for longer periods is desirable. Also, the data analysed are  
41 representative of Brazilian state capitals, not the whole country. State Capitals are  
42 highly urbanized cities and more developed than other cities, therefore, these results  
43 may not be generalizable to small cities and rural areas. However, state capitals are the  
44 most populous and unequal areas of Brazil [40], making them important settings for  
45 studying inequality trends, and meaning they can act as sentinels to the country as a  
46 whole.  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 Brazil is facing a huge economic recession since 2015, which deepened in 2016.  
4  
5 Unemployment and inflation have increased and people's purchasing power has been  
6  
7 reduced, with the poor especially affected. Therefore it will be vital to continue  
8  
9 monitoring the trends observed in this study and take action to prevent exacerbation of  
10  
11 existing inequalities.  
12  
13

14  
15 Policy makers and researchers should be alert to the fact that possible reductions  
16  
17 in health risky behaviours may be unbalanced between social groups and even be  
18  
19 increasing in disadvantaged social groups while decreasing on average [22]. In this  
20  
21 study, we found that the gap between poor adolescents and wealthy adolescents is  
22  
23 reducing for lifestyle behaviours such as fruit consumption; while it is increasing for  
24  
25 violent behaviours. For alcohol, irregular bean consumption and regular soft drink  
26  
27 consumption we found that the gap between social groups is narrowing, although  
28  
29 represented by a reduction in these risk behaviours among rich and an increase among  
30  
31 poor adolescents.  
32  
33  
34  
35  
36  
37  
38

39 **Funding:** The present research received financial support from Brazilian National  
40  
41 Council of Scientific and Technological Development (CNPq), 404905/2016-1,  
42  
43 awarded to Catarina Machado Azeredo. Sao Paulo Research Foundation (FAPESP),  
44  
45 grant #2016/21390-0 and #2014/25614-4 due to Leandro Fórnias Machado de Rezende.  
46  
47 The funders had no role in study design, data collection and analysis, decision to  
48  
49 publish, or preparation of the manuscript.  
50  
51

52 **Conflict of interest:** None.  
53  
54

55 **Data Sharing Statement:** The dataset of 2009, 2012 and 2015 PeNSE are publicly  
56  
57 available at: [https://www.ibge.gov.br/estatisticas-novoportal/sociais/educacao/9134-](https://www.ibge.gov.br/estatisticas-novoportal/sociais/educacao/9134-pesquisa-nacional-de-saude-do-escolar.html?=&t=microdados)  
58  
59 [pesquisa-nacional-de-saude-do-escolar.html?=&t=microdados](https://www.ibge.gov.br/estatisticas-novoportal/sociais/educacao/9134-pesquisa-nacional-de-saude-do-escolar.html?=&t=microdados)  
60

## REFERENCES

- 1 Sawyer SM, Afifi RA, Bearinger LH, *et al.* Adolescence: a foundation for future health. *The Lancet* 2012;**379**:1630-40.
- 2 Patton GC, Sawyer SM, Santelli JS, *et al.* Our future: a <em>Lancet</em> commission on adolescent health and wellbeing. *The Lancet* 2016;**387**:2423-78.
- 3 Viner RM, Ozer EM, Denny S, *et al.* Adolescence and the social determinants of health. *The Lancet* 2012;**379**:1641-52.
- 4 Piketty T, Saez E. Inequality in the long run. *Science* 2014;**344**:838-43.
- 5 Elgar FJ, Pfortner T-K, Moor I, *et al.* Socioeconomic inequalities in adolescent health 2002–2010: a time-series analysis of 34 countries participating in the Health Behaviour in School-aged Children study. *The Lancet* 2015;**385**:2088-95.
- 6 Solt F. The Standardized World Income Inequality Database. *Social Science Quarterly* 2016;**97**:14.
- 7 Landmann-Szwarcwald C, Macinko J. A panorama of health inequalities in Brazil. *International Journal for Equity in Health* 2016;**15**:174.
- 8 Martins APB, Monteiro CA. Impact of the Bolsa Familia program on food availability of low-income Brazilian families: a quasi experimental study. *BMC Public Health* 2016;**16**:827.
- 9 Hone TA-Ohoo, Rasella D, Barreto MLA-Ohoo, *et al.* Association between expansion of primary healthcare and racial inequalities in mortality amenable to primary care in Brazil: A national longitudinal analysis. *PLoS Med* 2017;**14**.
- 10 Rasella D, Harhay MO, Pamponet ML, *et al.* Impact of primary health care on mortality from heart and cerebrovascular diseases in Brazil: a nationwide analysis of longitudinal data. *BMJ* 2014;**349**:g4014.
- 11 IBGE. Pesquisa Nacional de Saúde do Escolar 2009. In: Ministério do Planejamento OeGIDdPCdPeIS, ed. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística 2009:138.
- 12 IBGE. Pesquisa Nacional de Saúde do Escolar 2012. In: Estatística IBdGe, ed. Rio de Janeiro 2013:256.
- 13 IBGE. Pesquisa Nacional de Saúde do Escolar: 2015. In: Ministério do Planejamento OeGIDdPCdPeIS, ed. Rio de Janeiro: IBGE 2016:132.
- 14 WHO WHO. Global School-Based Student Health Surveillance (GSHS). In: Organization WH, ed 2009.
- 15 Eaton DK, Kann L, Kinchen S, *et al.* Youth Risk Behavior Surveillance -United States- 2009. In: Services DOHAH, ed. United States: Centers for Disease Control and Prevention (CDC) 2010:148.
- 16 Barros AJ, Victora CG. [A nationwide wealth score based on the 2000 Brazilian demographic census]. *Rev Saude Publica* 2005;**39**:523-9.
- 17 Tavares LF, Castro IR, Levy RB, *et al.* [Relative validity of dietary indicators from the Brazilian National School-Based Health Survey among adolescents in Rio de Janeiro, Brazil]. *Cad Saude Publica* 2014;**30**:1029-41.
- 18 Ha V, Sievenpiper JL, de Souza RJ, *et al.* Effect of dietary pulse intake on established therapeutic lipid targets for cardiovascular risk reduction: a systematic review and meta-analysis of randomized controlled trials. *CMAJ* 2014;**186**:E252-62.
- 19 Olweus D. **Bullying at School: What we know and what we can do.** . Oxford, U.K. : Blackwell 1993.
- 20 Mackenbach JP, Kunst AE. Measuring the magnitude of socio-economic inequalities in health: an overview of available measures illustrated with two examples from Europe. *Soc Sci Med* 1997;**44**:757-71.

- 1  
2  
3 21 Barros AJ, Victora CG. Measuring coverage in MNCH: determining and  
4 interpreting inequalities in coverage of maternal, newborn, and child health  
5 interventions. *PLoS Med* 2013;**10**:e1001390.
- 6 22 WHO WHO. Handbook on health inequality monitoring: with a special focus on  
7 low- and middle-income  
8 countries. Geneva: World Health Organization 2013:108.
- 9  
10 23 Royston P, White IR. Multiple Imputation by Chained Equations (MICE):  
11 Implementation in Stata *Journal of Statistical Software* 2011;**45**:1-20.
- 12 24 Liu Y, Wang M, Tynjala J, *et al.* Socioeconomic inequalities in alcohol use of  
13 adolescents: the differences between China and Finland. *Int J Public Health*  
14 2013;**58**:177-85.
- 15 25 Hargreaves DS, Djafari Marbini A, Viner RM. Inequality trends in health and  
16 future health risk among English children and young people, 1999-2009. *Arch Dis Child*  
17 2013;**98**:850-5.
- 18 26 Rasmussen M, Pedersen TP, Johnsen NF, *et al.* Persistent social inequality in  
19 low intake of vegetables among adolescents, 2002-2014. *Public Health Nutr* 2018:1-5.
- 20 27 Pickett W, Molcho M, Elgar FJ, *et al.* Trends and socioeconomic correlates of  
21 adolescent physical fighting in 30 countries. *Pediatrics* 2013;**131**:e18-26.
- 22 28 Beltrán-Sánchez H, Andrade FCD. Time trends in adult chronic disease  
23 inequalities by education in Brazil: 1998–2013. *International Journal for Equity in*  
24 *Health* 2016;**15**:139.
- 25 29 Mújica OJ, Vázquez E, Duarte EC, *et al.* Socioeconomic inequalities and  
26 mortality trends in BRICS, 1990–2010. *Bull World Health Organ* 2014;**92**:405–12.
- 27 30 Das J, Do Q-T, Özler B. Reassessing conditional cash transfer programs. *World*  
28 *Bank Res Obs* 2005;**20**:23.
- 29 31 Jaime PC, da Silva AC, Gentil PC, *et al.* Brazilian obesity prevention and  
30 control initiatives. *Obes Rev* 2013;**14 Suppl 2**:88-95.
- 31 32 Viana LAC, Costa MdCN, Paim JS, *et al.* Social inequalities and the rise in  
32 violent deaths in Salvador, Bahia State, Brazil: 2000-2006. *Cadernos de Saúde Pública*  
33 2011;**27**:s298-s308.
- 34 33 França EB, Passos VMdA, Malta DC, *et al.* Cause-specific mortality for 249  
35 causes in Brazil and states during 1990–2015: a systematic analysis for the global  
36 burden of disease study 2015. *Population Health Metrics* 2017;**15**:39.
- 37 34 Grittner U, Kuntsche S, Gmel G, *et al.* Alcohol consumption and social  
38 inequality at the individual and country levels—results from an international study. *The*  
39 *European Journal of Public Health* 2013;**23**:332-9.
- 40 35 Moodie R, Stuckler D, Monteiro C, *et al.* Profits and pandemics: prevention of  
41 harmful effects of tobacco, alcohol, and ultra-processed food and drink industries.  
42 *Lancet* 2013;**381**:670-9.
- 43 36 Monteiro CA, Moubarac JC, Cannon G, *et al.* Ultra-processed products are  
44 becoming dominant in the global food system. *Obesity Reviews* 2013;**14**:21-8.
- 45 37 IBGE. Pesquisa Nacional por Amostra de Domicílios. Rio de Janeiro: Brasil  
46 2008.
- 47 38 Brener ND, Billy JOG, Grady WR. Assessment of factors affecting the validity  
48 of self-reported health-risk behavior among adolescents: evidence from the scientific  
49 literature. *Journal of Adolescent Health* 2003;**33**:436-57.
- 50 39 Brener N, Kann L, Shanklin S, *et al.* Methodology of the Youth Risk Behavior  
51 Surveillance System – 2013. . 2013:1-18.
- 52 40 IBGE. Síntese de Indicadores Sociais, uma análise das condições de vida. Rio de  
53 Janeiro: IBGE, Coordenação de População e Indicadores Sociais 2017:147.
- 54  
55  
56  
57  
58  
59  
60

1  
2  
3 Figure 1 - Time trends in health-related behaviours by wealthy quintile among  
4 adolescent  
5  
6  
7  
8  
9  
10  
11  
12  
13

14 Figure 2- Prevalence of health-related behaviours among adolescent in 2015 and Slope  
15 Index of Inequality (SII, absolute inequality).  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

For peer review only

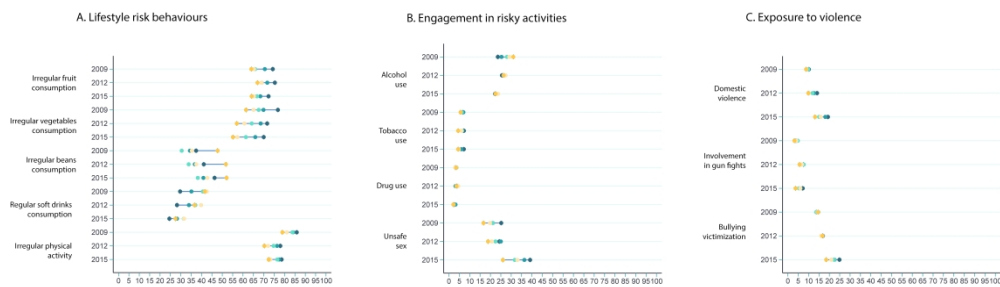


Figure 1 - Time trends in health-related behaviours by wealthy quintile among adolescent.

529x152mm (300 x 300 DPI)

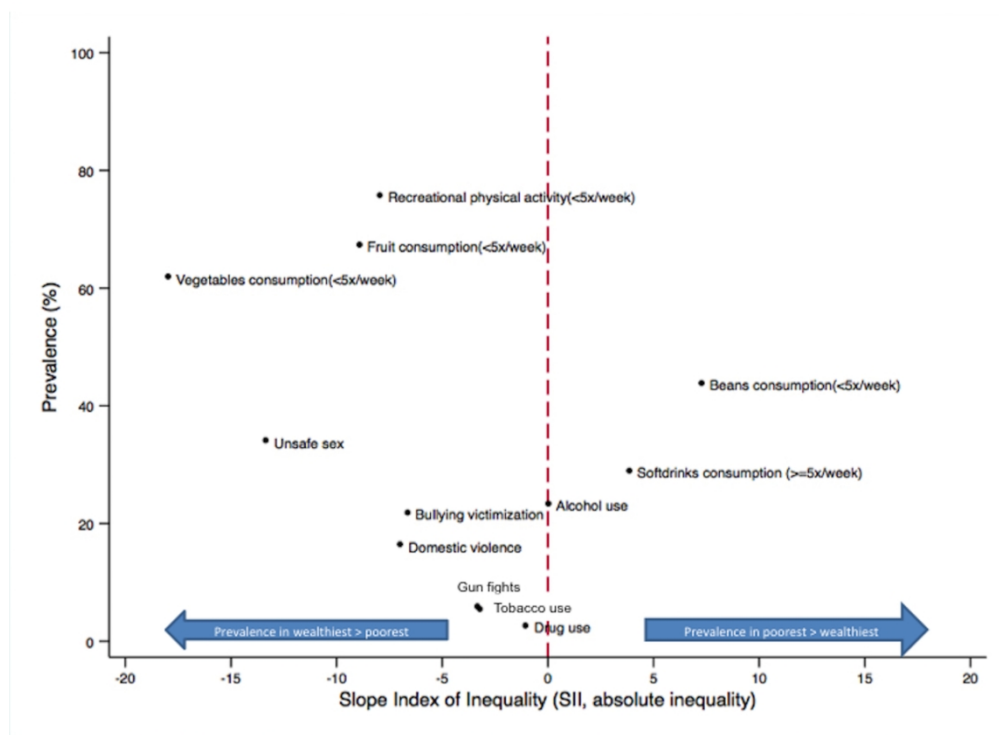


Figure 2- Prevalence of health-related behaviours among adolescent in 2015 and Slope Index of Inequality (SII, absolute inequality).

108x81mm (300 x 300 DPI)



## Appendix 1

Simple measures of inequality in health-related behaviours among Brazilian adolescents from PeNSE surveys 2009, 2012 and 2015.

Indicator	PeNSE survey year	National	Q1 (poorest) %	Q5 (richest) %	Difference (quintile 5 - quintile 1) %	Difference (quintile 5 - quintile 1) 95% CI	Ratio (quintile 5/ quintile 1) %	Ratio (quintile 5/ quintile 1) 95% CI	Population Attributable risk (PAR)	Population Attributable risk percentage (PAR%)
Irregular fruit consumption	2009	68.49	74.34	64.00	10.34	8.06; 12.62	1.16	1.12; 1.20	-4.49	-6.56
	2012	70.24	75.35	66.96	8.39	6.03; 10.74	1.13	1.08; 1.16	-3.28	-4.67
	2015	67.17	72.29	64.15	8.14	5.28; 11.00	1.13	1.08; 1.18	-3.02	-4.50
Irregular vegetables consumption	2009	68.77	76.81	61.47	15.34	13.28; 17.41	1.25	1.21; 1.29	-7.30	-10.62
	2012	64.12	71.64	56.99	14.65	12.46; 16.83	1.26	1.21; 1.30	-7.13	-11.12
	2015	61.73	69.97	55.14	14.83	11.66; 18.01	1.27	1.20; 1.34	-6.59	-10.68
Irregular beans consumption	2009	37.45	37.38	47.74	-10.36	-12.96; -7.77	0.78	0.74; 0.83	10.29	27.48
	2012	40.00	41.09	51.74	-10.65	-13.88; -7.42	0.79	0.74; 0.85	11.74	29.35
	2015	43.74	46.27	52.07	-5.80	-9.17; -2.43	0.89	0.83; 0.95	8.33	19.04
Regular softdrinks consumption	2009	37.21	29.67	41.59	-11.92	-14.32; -9.50	0.71	0.67; 0.76	4.38	11.77
	2012	35.44	28.17	36.62	-8.45	-10.69; -6.20	0.77	0.72; 0.83	1.18	3.33
	2015	28.84	24.51	27.42	-2.91	-5.45; -0.33	0.89	0.81; 0.98	-1.42	-4.92
Irregular recreational physical activity	2009	82.96	85.88	78.96	6.92	5.30; 8.55	1.09	1.07; 1.11	-4.00	-4.66
	2012	74.15	77.97	70.27	7.70	5.82; 9.58	1.11	1.08; 1.14	-3.88	-4.98
	2015	75.58	78.58	72.36	6.22	3.93; 8.51	1.09	1.05; 1.12	-3.22	-4.10
Alcohol use (once in the last month)	2009	27.13	23.57	31.02	-7.45	-9.22; -5.67	0.76	0.71; 0.81	3.89	14.33
	2012	26.78	25.55	26.33	-0.78	-2.94; 1.37	0.97	0.89; 1.05	-0.45	-1.67
	2015	23.2	22.24	22.50	-0.26	-2.99; 2.47	0.99	0.87; 1.12	-0.70	-3.03
Tobacco use (once in the last month)	2009	6.25	6.70	5.63	1.07	0.09; 2.06	1.19	1.01; 1.40	-0.62	-9.92
	2012	6.08	7.20	4.44	2.76	1.70; 3.82	1.62	1.35; 1.95	-1.64	-26.99
	2015	5.34	7.18	4.41	2.77	1.48; 4.06	1.63	1.28; 2.08	-0.93	-17.35

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

	2009	3.32	3.01	3.52	-0.51	-1.29; 0.27	0.85	0.67; 1.08	0.20	6.02
Drug use (once in the last month)	2012	3.81	3.94	3.63	0.31	-0.70; 1.32	1.09	0.83; 1.42	-0.18	-4.72
	2015	2.45	2.55	2.20	0.35	-0.52; 1.22	1.16	0.80; 1.69	-0.25	-10.20
Unsafe sex (in the last sexual intercourse)	2009	21.46	25.19	16.65	8.54	5.27; 11.82	1.51	1.27; 1.80	-4.81	-22.41
	2012	22.5	24.29	18.83	5.46	2.10; 8.81	1.29	1.10; 1.51	-3.67	-16.31
	2015	33.86	39.11	26.00	13.11	8.21; 18.01	1.50	1.28; 1.77	-7.86	-23.21
Domestic violence (once in the last month)	2009	9.54	10.13	8.79	1.34	0.06; 2.62	1.15	1.00; 1.33	-0.75	-7.86
	2012	11.6	14.08	9.87	4.21	2.82; 5.61	1.43	1.27; 1.61	-1.73	-14.91
	2015	16.17	19.33	13.11	6.22	4.48; 7.96	1.47	1.32; 1.65	-3.06	-18.92
Involvement in gun fights (in the last month)	2009	4.01	3.93	3.15	0.78	0.02; 1.53	1.25	1.00; 1.55	-0.86	-21.45
	2012	6.94	7.50	5.65	1.85	0.82; 2.88	1.33	1.13; 1.55	-1.29	-18.59
	2015	5.61	7.19	3.70	3.49	2.41; 4.58	1.94	1.56; 2.42	-1.91	-34.05
Bullying victimization (twice or more in the last month)	2009	14.16	13.71	14.54	-0.83	-2.16; 0.50	0.94	0.86; 1.04	0.38	2.68
	2012	16.5	16.90	16.73	0.17	-1.68; 2.04	1.01	0.90; 1.13	0.23	1.39
	2015	21.74	24.88	18.51	6.37	4.28; 8.45	1.34	1.22; 1.48	-3.23	-14.86

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract <b>abstract; page 2</b> (b) Provide in the abstract an informative and balanced summary of what was done and what was found <b>page 2</b>
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported <b>Page3</b>
Objectives	3	State specific objectives, including any prespecified hypotheses <b>Page 4</b>
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper <b>Page 4</b>
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection <b>Page 4 and 5</b>
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <b>NA</b> <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <b>NA</b> <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants <b>–Page4 and first para page 5</b> (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <b>NA</b> <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case <b>NA</b>
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable <b>Page 5 and 6</b>
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group <b>Table 1 – page 6</b>
Bias	9	Describe any efforts to address potential sources of bias <b>Last para Page 4 and first para page 5 (response rate – selection bias); page 5 (validation of measures – information bias)</b>
Study size	10	Explain how the study size was arrived at . <b>Page 4 and Reference: Oliveira et al. 2017</b>
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why <b>Pages 8 and 9</b>
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding <b>Pages 8 and 9</b> (b) Describe any methods used to examine subgroups and interactions <b>NA</b>

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

(c) Explain how missing data were addressed [Page 9](#)

---

(d) *Cohort study*—If applicable, explain how loss to follow-up was addressed [NA](#)  
*Case-control study*—If applicable, explain how matching of cases and controls was addressed [NA](#)

*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy [Page 9 last para](#)

---

(e) Describe any sensitivity analyses [NA](#)

Continued on next page

For peer review only

<b>Results</b>		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed <a href="#">Table 2</a> (b) Give reasons for non-participation at each stage <a href="#">Response rate page 4</a> (c) Consider use of a flow diagram <a href="#">NA</a>
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders <a href="#">Table 2</a> (b) Indicate number of participants with missing data for each variable of interest <a href="#">Page 9 (we used multiple imputation)</a> (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount) <a href="#">NA</a>
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <a href="#">NA</a> <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <a href="#">NA</a> <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures <a href="#">Table 2</a>
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included <a href="#">Table 3, figures 1 and 2.</a> (b) Report category boundaries when continuous variables were categorized <a href="#">NA</a> (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period <a href="#">NA</a>
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses <a href="#">NA</a>
<b>Discussion</b>		
Key results	18	Summarise key results with reference to study objectives <a href="#">Page 15</a>
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias <a href="#">Page 18</a>
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence <a href="#">Pages 15-18</a>
Generalisability	21	Discuss the generalisability (external validity) of the study results <a href="#">Page 17 last para</a>
<b>Other information</b>		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based <a href="#">Page 19</a>

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## Progress and setbacks in socioeconomic inequalities in adolescent health-related behaviours in Brazil: results from three cross-sectional surveys 2009-2015.

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-025338.R2
Article Type:	Research
Date Submitted by the Author:	05-Jan-2019
Complete List of Authors:	Azeredo, Catarina; Universidade Federal de Uberlandia, Faculdade de Medicina Rezende, Leandro; Departamento de Medicina Preventiva, Faculdade de Medicina FMUSP, Universidade de Sao Paulo, SP, BR, Mallinson, Poppy; London School of Hygiene and Tropical Medicine Faculty of Epidemiology and Population Health, Department of Non-Communicable Disease Epidemiology Ricardo, Camila; Universidade de Sao Paulo Faculdade de Medicina, Departamento de Medicina Preventiva Kinra, Sanjay; LSHTM, Levy, Renata; University of Sao Paulo, Medicine Barros, A; Federal University of Pelotas (UFPeL), Postgraduate Programme in Epidemiology
<b>Primary Subject Heading</b>:	Epidemiology
Secondary Subject Heading:	Global health, Paediatrics
Keywords:	Adolescent, Health Behavior, Health Inequality, EPIDEMIOLOGY

SCHOLARONE™  
Manuscripts

1  
2  
3 **Progress and setbacks in socioeconomic inequalities in adolescent**  
4 **health-related behaviours in Brazil: results from three cross-sectional**  
5 **surveys 2009-2015**  
6  
7  
8  
9

10  
11  
12 **Catarina Machado Azeredo<sup>1,a</sup>, Leandro Fórniás Machado de Rezende<sup>2</sup>, Poppy Alice**  
13 **Carson Mallinson<sup>3</sup>, Camila Zancheta Ricardo<sup>2</sup>, Sanjay Kinra<sup>3</sup>, Renata Bertazzi**  
14 **Levy<sup>2</sup>, Aluisio J D. Barros<sup>4</sup>**  
15  
16  
17  
18  
19  
20

21 <sup>a</sup> Corresponding Author  
22

23  
24 1 Faculdade de Medicina da Universidade Federal de Uberlândia. Address: Av. Pará  
25 1720, Bloco 2 U, sala 20. Campus Umuarama. Uberlândia/MG - Brasil - 38.405-320  
26 Telephone: +55 (34) 32258584. E-mail: [catarina@famed.ufu.br](mailto:catarina@famed.ufu.br)  
27

28 2 Departamento de Medicina Preventiva, Faculdade de Medicina FMUSP,  
29 Universidade de Sao Paulo, Sao Paulo, SP, Brazil  
30

31 3 Institution: Department of Non-Communicable Disease Epidemiology, London School  
32 of Hygiene and Tropical Medicine (LSHTM), London, United Kingdom.  
33

34 4 Postgraduate Program in Epidemiology, Federal University of Pelotas, Pelotas, RS,  
35 Brazil.  
36  
37  
38  
39  
40

41 **Keywords:** Adolescents; Social Inequalities; Health Behaviors; Lifestyle  
42

43 **Words count:** 2849  
44  
45  
46  
47

48 **Authorship statement:** CMA, LFMR, RBL and AJDB conceptualized the study and  
49 were involved in the analysis and interpretation of the results. CZR was involved in data  
50 preparation, designed and prepared the tables. SK and PACM were involved in the  
51 interpretation and discussion of results. The initial draft of the paper was prepared by  
52 CMA following extensive discussions and inputs from the other co-authors. All authors  
53 have reviewed, revised the manuscript and approved the final version.  
54  
55  
56  
57  
58  
59  
60

## ABSTRACT

### Objectives

Despite some progress, Brazil is still one of the most unequal countries, and the extent of socioeconomic inequalities in adolescent health is unclear. We assessed trends in socioeconomic inequalities in adolescent's health-related behaviours in Brazil between 2009-2015.

**Design:** We used cross-sectional data from the Brazilian National Survey of School Health carried out in 2009, 2012 and 2015.

**Setting:** Brazilian state capitals.

**Participants:** Students attending 9<sup>th</sup> grade from public and private schools in Brazilian state capitals in 2009 (60,973 students), 2012 (74,432 students) and 2015 (60,078 students)

### Main Outcome measure:

We assessed 12 health-related behaviours (irregular fruit, vegetables and bean consumption; regular soft drinks consumption; irregular physical activity; alcohol, drug and tobacco use; unsafe sex; involvement in gun fights; bullying victimization and domestic violence victimization), under the broad domains of lifestyle risk behaviours, engagement in risky activities and exposure to violence. Socioeconomic status was assessed through an asset-based wealth index derived from principal components analysis. Absolute and relative inequalities in these health behaviours and inequalities trends were investigated.

### Results

From 2009 to 2015, prevalence of certain harmful health-related behaviours increased, such as unsafe sex (21.5% to 33.9%), domestic violence (9.5% to 16.2%), bullying victimization (14.2% to 21.7%) and in irregular consumption of beans (37.5% to 43.7%). Other indicators decreased: alcohol use (27.1% to 23.2%), irregular physical activity (83.0% to 75.6%) and consumption of soft drinks (37.2% to 28.8%). Over the period, we found consistent evidence of decreasing health inequalities for lifestyle behaviours (fruit, bean and soft drink consumption) and alcohol use, set against increasing inequalities in violence (domestic violence, fights using guns and bullying victimization).

### Conclusion

Socioeconomic inequality increased in the violence domain and decreased for lifestyle behaviours among Brazilian adolescents. Widening gaps in violence domain urge immediately policy measures in Brazil.

**Key-words:** Adolescent, Social inequalities, health behaviour.

### Strengths and limitations of this study

- We assessed the extent of socioeconomic inequalities in adolescent health and how it has changed over time in a middle-income country;
- We used a large representative urban samples from Brazilian adolescents attending public and private schools;
- Another strength of this study was the use of complex measures of inequality;
- Although we have used validated questionnaires, the self-report of behaviours may cause some degree of classification bias;
- The period of 6 years may be too short to expect significant changes in inequalities.



## INTRODUCTION

Adolescence is a critical period for promotion of human development. During adolescence, biological, cognitive, emotional, and social capabilities are founded and future patterns of adult health are established [1]. Despite its clear importance, adolescent's health has been generally overlooked in social policies. In order to guide surveillance, investments and policy actions, a broad concept of adolescent health has been proposed by The Lancet Commission on adolescent health. This concept includes aspects related to sexual and reproductive health, nutritional deficiencies, injury and violence, physical and mental health, and substance use disorders [2].

Socioeconomic factors strongly predict adolescent health [3]. Socioeconomic inequalities have consistently increased over the last decades in US and Europe [4], and this trend coincides with widening gaps in indicators of adolescent health [5]. For instance, a time-series analysis of 34 North American and European countries showed an increase in inequalities between socioeconomic groups in physical activity, body mass index, and psychological and physical symptoms between 2002 and 2010 [5].

Studies monitoring inequality in adolescent health in low- and middle-income countries are sparse in the literature. Brazil is still one of the most unequal countries worldwide [6], although considerable social protection efforts have been adopted in the last decades (*e.g.*, creation of a free public universal health system, expanding community-based primary care and providing a robust conditional cash transfer program) [7]. These social programs have had positive impacts on adult health, especially among the most deprived, with increased overall food quality and diversity [8], reduced racial inequalities in health [9] and cardiovascular disease mortality [10]. However, the extent of socioeconomic inequalities in adolescent health and how it has changes over time in Brazil is unclear.

1  
2  
3 In this study, we assessed levels and trends in socioeconomic inequalities in  
4 adolescent health in Brazil between 2009 and 2015, addressing absolute and relative  
5 measures of inequality. We used data from three large representative health surveys of  
6 adolescents living in Brazilian state capitals. We selected 12 indicators under 3 broad  
7 domains (lifestyle risk behaviours, engagement in risky activities and exposure to  
8 violence) to provide a holistic view of adolescent health inequalities in Brazil.  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18

## 19 **METHODS**

20  
21 We used cross-sectional data from three Brazilian National Surveys of School Health  
22 (*Pesquisa Nacional da Saude do Escolar* - PeNSE) carried out in 2009, 2012 and 2015.  
23  
24 In order to have comparable datasets across the three surveys, we used a representative  
25 subsample of adolescents attending 9<sup>th</sup> grade (i.e., mostly aged between 14-15 years) in  
26 public and private schools from the 26 state capitals and the Federal District. Detailed  
27 information about PeNSE has been published elsewhere [11-13]. Briefly, PeNSE  
28 sampling strategy included stratification per cluster and multi-stage selection. The  
29 sampling strata were each of the 26 state capitals and Federal District. The primary  
30 sampling units (PSUs) were schools, and the secondary sampling units (SSUs) were  
31 classrooms. School selection was proportional to the total number of 9<sup>th</sup> grade classes,  
32 while the classes in each school were chosen by simple random selection. Two classrooms  
33 were selected from schools with three or more 9<sup>th</sup> grade classrooms, whereas one  
34 classroom was selected from schools with one or two 9<sup>th</sup> grade classrooms. All students  
35 enrolled in the selected classrooms were invited to participate in the study. Participants  
36 were not included in the study if they did not attend school during data collection, refuse  
37 to participate, or did not report their age and sex. The total number of students included  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 in our analysis was 60,973 (final response rate 83.8%) for 2009, 61,145 (final response  
4 rate 82.2%) for 2012, and 51,192 (final response rate 85.2%) for 2015 surveys [11-13].  
5  
6

7  
8 Students filled out a self-reported structured questionnaire available in a Personal  
9 Digital Assistant device (2009 survey) or smartphone application (2012 and 2015 survey)  
10 in their school classrooms during regular school hours. The questionnaire was based on  
11 the Global School-Based Student Health Survey [14] and the Youth Risk Behaviour  
12 Surveillance System[15], and was adapted to the Brazilian setting. Questions included  
13 socioeconomic variables and several risk and protective factors for adolescent health.  
14  
15  
16  
17  
18  
19  
20

21 We estimated a wealth index specific for each survey year through Principal  
22 Component Analysis (PCA), following the steps proposed by Barros and Victora [16].  
23 We ran PCA including the following variables: mother's educational level (incomplete  
24 middle school, complete middle school, complete high-school, complete higher  
25 education); school administrative status (public or private); self-report of having:  
26 landline, mobile phone, computer, internet access, car, bathroom inside the house and  
27 housemaid services. We retained the first component of the analysis and calculated  
28 coefficients from the expression:  $\text{coefficient} = \text{loading} / \text{standard deviation} \times 100$ . The  
29 individual scores were estimated from the  $\sum c_i v_i$ , where  $c_i$  is the coefficient and  $v_i$  is the  
30 value for the  $i^{\text{th}}$  variable. The wealth index was assessed as quintiles of the total wealth  
31 scores. We refer to the first quintile (Q1) as the poorest quintile (poorest 20%) and the  
32 fifth quintile (Q5) as the wealthiest quintile (wealthiest 20%).  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48

49 The indicators of adolescent health used in this study are defined in table 1. We  
50 divided indicators in three domains: lifestyle risk behaviours, engagement in risky  
51 activities and exposure to violence. Alcohol and tobacco use were included as risky  
52 activities and not lifestyle behaviours, because Brazilian law forbids the sale of these  
53 substances for younger than 18 years old. We have used the concept of "irregular  
54  
55  
56  
57  
58  
59  
60

consumption” (<5 times in the past week) for all food indicators, following the complementary concept of “regular consumption”, which was validated using 24 hours recall[17]. We also chose to include bean consumption because of their protective health effects and importance in Brazil as an affordable traditional staple food [18]. The frequency of 2 or more times in the previous month for bullying victimization followed the concept of this type of violence, which presume repetition[19]. The unsafe sex was assessed only for those who reported had sexual relationships.

**Table 1:** Indicators of adolescent health used in the present study

Domain	Health indicator	Original question
Lifestyle risk behaviours	Regular dietary consumption of fruits ( $\geq 5$ days) in the last week	In the 7 days, on how many days did you eat fresh fruits or fruits salad? Options: I did not eat fresh fruits or fruits salad in the last 7 days; other options ranged from 1 day in the last 7 days to every day in the last 7 days.
	Regular dietary consumption of vegetables ( $\geq 5$ days) in the last week	In the 7 days, on how many days did you eat at least one type of raw or cooked vegetable? Options: I did not eat vegetables in the last 7 days; other options ranged from 1 day in the last 7 days to every day in the last 7 days.
	Regular dietary consumption of beans ( $\geq 5$ days) in the last week	In the 7 days, on how many days did you eat beans? Options: I did not eat beans in the last 7 days; other options ranged from 1 day in the last 7 days to every day in the last 7 days.
	Regular dietary consumption of soft drinks ( $\geq 5$ days) in the last week	In the 7 days, on how many days did you drink soft drinks? Options: I did not drink soft drinks in the last 7 days; other options ranged from 1 day in the last 7 days to every day in the last 7 days.
	Recreational physical activity at least 5 times in the last week	In the last 7 days, excluding physical education classes, on how many days did you practice any physical activity such as sports, dance, gymnastics, etc? Options: No day in the last 7 days; other options ranged from 1 day in the last 7 days to every day in the last 7 days.

<b>Exposure to violence</b>	Victim of domestic violence at least once in the previous month by some adult family member	In the last 30 days, how many times was you physically assaulted by some adult family member? Options: Not once in the last 30 days; 1 time in the last 30 days; other options ranged from 2 or 3 times in the last 30 days to 12 or more times in the last 30 days.
	Involvement in fights using guns at least one in the last month	In the last 30 days, did you get involved in any fight that someone used guns? Options: yes; no
	Bullying victimization at least sometimes in the last month	“In the past 30 days, how often have you been mocked, teased, called names or intimidated by one of your schoolmates so much that you were hurt/annoyed/upset/offended/ashamed? Options: No day in the last 30 days; rarely in the last 30 days; sometimes in the last 30 days; most of the time in the last 30 days; always in the last 30 days
<b>Engagement in risky activities</b>	Alcohol use at least once in the previous month	In the last 30 days, on how many days did you drink at least one cup or dose of alcoholic beverage? Options: No day in the last 30 days; Other options ranged from 1 or 2 days in the last 30 days to every day in the last 30 days.
	Drug use at least once in the previous month	In the last 30 days, how many times did you used drugs such as marijuana, cocain, crack, glue, ecstasy, oxy, etc? Options: I have never used drugs; no day in the last 30 days; Other options ranged from 1 or 2 days in the last 30 days to 10 or more days in the last 30 days.
	Smoking at least once in the previous month	In the last 30 days, on how many days did you smoke cigarettes? Options: I have never smoked; No day in the last 30 days; Other options ranged from 1 or 2 days in the last 30 days to every day in the last 30 days.
	Safe sexual behaviour (have used condom in the last sexual intercourse)	In the last time you had sex, did you and your partner use a condom? Options: I have never had sex; yes; no; I don't know.

To assess socioeconomic inequalities in adolescent health we used several

1  
2  
3 measures of inequality. Firstly, we estimated simple measures of inequality (pairwise  
4 comparisons), such as differences and ratios of each health indicator between the  
5 wealthiest group (5<sup>th</sup> quintile) and the poorest group (1<sup>st</sup> quintile).  
6  
7

8  
9  
10 Secondly, we estimated complex measures of inequality, represented by an  
11 indicator of absolute inequality, the slope index of inequality (SII), and an indicator of  
12 relative inequality, the concentration index (CIX) [20]. Both SII and CIX take into  
13 account all quintiles of the wealth index to compare a given health indicator across all  
14 wealth subgroups.  
15  
16  
17  
18  
19  
20

21 We estimated the SII using logistic regression to avoid predicting implausible  
22 values below zero or above one, considering that all health indicators were presented as  
23 proportions [21]. The SII estimates the absolute difference (i.e., in percentage points) in  
24 the prevalence of health indicator between individuals in the wealthiest and poorest  
25 quintiles. Negative values of SII indicate that prevalence of the health indicator is higher  
26 among the poorest adolescents than the wealthiest (values ranged from -100 to +100).  
27  
28  
29  
30  
31  
32  
33  
34

35 The CIX was also expressed on a scale ranging from -100 to +100; a value of 0  
36 represents perfect equality, whereas negative values indicate that poor individuals have  
37 higher prevalence of a given health indicator than wealthy individuals [22]. The CIX was  
38 calculated with no corrections [21].  
39  
40  
41  
42  
43

44 Linear regressions using variance-weighted least squares were performed to  
45 assess changes over time in complex measures of inequality (SII and CIX) based on the  
46 means and standard deviation for each of the three surveys.  
47  
48  
49  
50

51 Multiple imputation was performed using the chained equation technique due to  
52 the significant proportion of missing values for the mother's education level in the three  
53 datasets (19,36%, n=33,559). We also imputed other study variables with a smaller  
54 proportion of missing values, to create a complete dataset. The imputed data exhibited  
55  
56  
57  
58  
59  
60

1  
2  
3 satisfactory statistical reproducibility according to Monte Carlo error analysis[23].  
4

5 The sample design was taken into consideration for descriptive analyses, using  
6 survey prefix command (svy) in Stata. School clustering (random effect) and sample  
7 weights were considered when estimating complex measures of inequality (SII and CIX).  
8  
9 All the statistical analyses were performed using Stata 14.0.  
10  
11  
12  
13  
14  
15  
16

### 17 **Ethics approval**

18  
19  
20  
21 PeNSE surveys were approved by the National Commission of Research Ethics  
22 (Comissão Nacional de Ética em Pesquisa – Conep), records no. 11.537 (2009), 16.805  
23 (2012) and 1.006.467 (2015). The surveys were performed in accordance with the  
24 Declaration of Helsinki and all participants gave their informed consent. Databases were  
25 made publicly available on an IBGE website without any information that could identify  
26 subjects.  
27  
28  
29  
30  
31  
32  
33  
34  
35

### 36 **Patient and public involvement**

37  
38  
39 No patients or public were involved in the design and conceptualisation of this  
40 study.  
41  
42

### 43 **Data Sharing**

44  
45 The dataset of 2009, 2012 and 2015 PeNSE are publicly available at:  
46  
47 [https://www.ibge.gov.br/estatisticas-novoportal/sociais/educacao/9134-pesquisa-  
48 nacional-de-saude-do-escolar.html?=&t=microdados](https://www.ibge.gov.br/estatisticas-novoportal/sociais/educacao/9134-pesquisa-nacional-de-saude-do-escolar.html?=&t=microdados)  
49  
50  
51  
52  
53

## 54 **RESULTS**

55  
56  
57  
58  
59  
60

1  
2  
3 In 2015, the health-related behaviours more common among Brazilian adolescents  
4 were irregular consumption of fruits (67.2%) and vegetables (61.8%) and irregular  
5 recreational physical activity (75.6%). Less frequent were the unsafe sex in last sexual  
6 intercourse (33.9%), alcohol use (23.2%) and exposure to bullying (21.7%). Between  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

peer review only

2009 and 2015, the prevalence of irregular vegetable consumption, irregular recreational physical activity, regular soft drink consumption, alcohol, tobacco and drug use decreased. On the other hand, trends for irregular bean consumption, unsafe sexual intercourse, and exposure to violence (domestic violence, fight using guns, and bullying victimization) increased (Table 2).



**Table 2** - Brazilian adolescent characteristics and health-related behaviours from PeNSE surveys 2009, 2012 and 2015.

adolescents characteristics and behaviours	PeNSE survey year					
	2009 (60,973 students)		2012 (61,145 students)		2015 (51,192 students)	
Characteristics	%	CI95%	%	CI95%	%	CI95%
Sex (female)	52.5	(51.9-53.2)	50.8	(50.1-51.6)	50.8	(49.9-51.7)
Age (mean and standard error)	14.2	(0.02)	14.3	(0.02)	14.2	(0.02)
Wealth index (mean and standard error)	3.8	(0.03)	4.0	(0.06)	4.0	(0.06)
<b>Behaviours</b>						
Irregular fruit consumption	68.5	(67.8-69.2)	70.2	(69.5-70.9)	67.2	(66.3-68.0)
Irregular vegetables consumption	68.8	(68.0-69.5)	64.1	(63.3-64.9)	61.7	(60.7-62.7)
Irregular beans consumption	37.4	(36.4-38.5)	40.0	(38.5-41.5)	43.7	(42.4-45.1)
Regular soft drinks consumption	37.2	(36.3-38.2)	35.4	(34.6-36.2)	28.8	(27.9-29.8)
Irregular recreational physical activity	83.0	(82.3-83.6)	74.2	(7.5-74.8)	75.6	(74.8-76.3)
Alcohol use (once in the last month)	27.1	(26.3-28.0)	26.8	(25.8-27.7)	23.2	(22.2-24.2)
Tobacco use (once in the last month)	6.2	(5.8-6.7)	6.1	(5.6-6.6)	5.3	(4.9-5.8)
Drug use (once in the last month)	3.3	(3.0-3.6)	3.8	(3.4-4.2)	2.5	(2.2-2.7)
Unsafe sex (in the last sexual intercourse)	21.5	(20.3-22.7)	22.5	(21.6-23.5)	33.9	(32.3-35.4)
Domestic violence (once in the last month)	9.5	(9.1-10.0)	11.6	(11.1-12.1)	16.2	(15.5-16.9)
Involvement in gun fights (once in the last month)	4.0	(3.7-4.3)	6.9	(6.6-7.3)	5.6	(5.2-6.1)
Bullying victimization (twice or more in the last month)	14.2	(13.6-14.7)	16.5	(15.9-17.1)	21.7	(21.1-22.4)

1  
2  
3 Figure 1 (A-C) shows the trends in health indicators by wealth quintile between  
4 2009 and 2015. The width of the bars represents the absolute inequality. For most health  
5 indicators (except bean, soft drink and alcohol use), people in the poorest group reported  
6 more adverse levels compared to the wealthiest group. In general, over the period 2009-  
7 2015, health inequalities decreased for lifestyle behaviours (fruit, vegetable, bean and soft  
8 drink consumption, and recreational physical activity), while increased for risky activities  
9 and violence (smoking, drug use, unsafe sex, domestic violence, fights using guns and  
10 bullying victimization) (Appendix 1).  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23

24 INSERT FIGURE 1 HERE  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

Some of these trends were not statistically significant according to complex measures of inequality (table 3).

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

**Table 3** - Complex measures of inequality in health-related behaviours among Brazilian adolescents. PeNSE surveys 2009, 2012 and 2015.

Quintiles of Wealth index (1=poorest; 5=wealthiest) Indicators	Slope Index of inequality (SII)				Concentration index of inequality (CIX)			
	2009	2012	2015	p-value*	2009	2012	2015	p-value*
Irregular fruit consumption	-13.68	-9.01	-8.88	0.015	-2.82	-2.31	-2.26	0.267
Irregular vegetables consumption	-19.02	-17.59	-17.92	0.535	-4.30	-4.48	-5.18	0.165
Irregular beans consumption	9.95	11.25	7.33	0.434	6.48	3.47	2.22	<0.001
Regular soft drinks consumption	16.55	10.49	3.89	<0.001	6.94	5.19	2.90	<0.001
Irregular recreational physical activity	-8.66	-9.47	-7.90	0.745	-1.70	-1.91	-1.71	0.837
Alcohol use (once in the last month)	9.69	0.68	0.06	0.000	4.79	1.71	1.19	0.004
Tobacco use (once in the last month)	-1.68	-2.80	-3.15	0.125	-5.68	-6.32	-8.69	0.290
Drug use (once in the last month)	0.34	0.46	-0.98	0.048	-0.08	4.47	-4.61	0.428
Unsafe sex (in the last sexual intercourse)	-9.67	-6.88	-13.28	0.498	-6.52	-5.44	-6.56	0.914
Domestic violence (once in the last month)	-1.84	-5.24	-6.92	<0.001	-2.72	-7.02	-6.57	0.014
Involvement in gun fights (once in the last month)	-0.76	-1.90	-3.30	0.002	-2.82	-4.42	-8.79	0.029
Bullying victimization (twice or more in the last month)	0.83	-0.20	-6.60	<0.001	0.56	0.59	-4.41	<0.001

1  
2  
3 In all years, alcohol consumption was the health indicator more equally distributed  
4 between wealth quintiles both according to absolute and relative measures. On the other  
5 hand, irregular vegetables consumption and unsafe sex had the highest absolute inequality  
6 and fights using guns and tobacco use the highest relative inequality. Over time, the  
7 absolute (SII) and relative inequalities (CIX) between wealth index quintiles became  
8 wider for all three indicators of exposure to violence, and narrower for some indicators  
9 of lifestyle behaviour (fruit, beans and soft drinks) and alcohol consumption. There was  
10 limited evidence of change in inequalities over time for the other lifestyle behaviours,  
11 such as irregular vegetables consumption and recreational physical activity, and  
12 indicators of engagement in risky activities, such as tobacco, drug use and unsafe sex  
13 (table 3, figure 2).  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27

28 INSERT FIGURE 2 HERE  
29  
30  
31  
32

## 33 DISCUSSION 34

35 We showed evidence of persistent socioeconomic inequalities in adolescent  
36 health in Brazil. Between 2009 and 2015, lifestyle behaviours (fruit and soft drinks  
37 consumption) and alcohol use became more equally distributed between socioeconomic  
38 groups, while inequalities in experiencing violence were exacerbated. In this period, there  
39 was little evidence of change to inequalities in risky activities (smoking, drugs, unsafe  
40 sex).  
41  
42  
43  
44  
45  
46  
47  
48

49 In general, the direction of health inequalities we observed are similar to that  
50 reported in other settings, that is, poorer adolescents are more likely to report harmful  
51 health behaviours than richer [5]. For certain harmful behaviours (e.g. alcohol and drug  
52 use), however, differences between social groups were not significant or went in the  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 opposite direction (i.e. wealthier adolescents reported higher prevalences). These findings  
4  
5 are consistent with results observed in other countries [24].  
6  
7

8 Looking at time-trends in these inequalities, our findings differ to existing  
9  
10 evidence from Western Europe and North America. For some lifestyle (e.g. vegetable  
11  
12 consumption, physical activity) and risky behaviours (drug and tobacco use), inequalities  
13  
14 have not changed significantly between 2009 and 2015 in Brazil. Yet inequality in  
15  
16 lifestyle and risky behaviors have increased over similar period in many other countries  
17  
18 [5, 25]. Similarly to ours, one study found persistent inequality in vegetable consumption  
19  
20 [26]. Despite this, comparable data for many indicators of risk behaviours are lacking.  
21  
22 Rates of violence as well as inequalities in violence increased markedly (gun fights,  
23  
24 domestic violence, bullying), and these trends also differ from other countries [27].  
25  
26  
27

28 Reasons for differential socioeconomic inequality trends between lifestyle  
29  
30 behaviours, risk behaviours and violence-related indicators in Brazilian adolescents are  
31  
32 unclear. Reductions in lifestyle behaviour inequalities fits with the general trend of  
33  
34 narrowing economic and health inequalities observed for adults in Brazil in that  
35  
36 period[28, 29]. This is often attributed to rising prosperity combined with roll-out of  
37  
38 redistributive health and social programs such as the Bolsa Familia cash transfer program  
39  
40 [30], as well as scaled-up health promotion efforts (especially obesity prevention) [31].  
41  
42 Exacerbation of violence-related inequalities have also been observed in one study of  
43  
44 adult mortality in Salvador [32]. It has been suggested that public health interventions  
45  
46 have focussed on reducing infectious and chronic diseases but neglect, on the other hand,  
47  
48 external causes of ill-health such as interpersonal violence. In fact, violence-related  
49  
50 mortality has declined slower than all other causes in Brazil, and even increased in 19 of  
51  
52 the 27 states [33].  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 It is worth noting that we found a shift in prevalence of alcohol use and soft drinks  
4 consumption between socioeconomic in the period studied. In 2009, these indicators were  
5 higher among the wealthiest group, but in 2015 the differences were considerably  
6 attenuated. The reduction in the consumption of these products was more pronounced  
7 among the wealthiest group than in the poorest group. Conversely, for bean consumption,  
8 poorer adolescents reported higher prevalence than wealthiest adolescences. In this  
9 regard, the reduction in disparities between wealth groups should be read with caution. In  
10 high-income countries, poorer individuals consume more alcohol, relative to wealthier  
11 individuals, while in low-middle income countries wealthier individuals are more  
12 exposed than the poorer [34]. This trend could be shifting. In fact, industries of unhealthy  
13 commodities have moved to, and are growing faster in, low- and middle-income countries  
14 comparing to high-income countries [35]. This phenomenon might explain, at least in  
15 part, the increase in consumption of ultra-processed products (e.g. sugary drinks) and  
16 alcohol, and the reduction of bean consumption in these settings [36]. Brazil seems to be  
17 moving towards patterns of health indicators and their inequalities currently observed in  
18 high-income countries. In these countries, the reduction in alcohol use and soft drinks  
19 consumption among those privileged is not necessarily followed by a reduction among  
20 those more socially deprived [5]. Although this trend is measured as a reduction in  
21 inequality, it is not desirable.

22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47 The main strength of this study is to explore a wide spectrum of health indicators,  
48 which provides information on prevalence and trends in key risk factors for adolescent  
49 health. Another positive aspect is the large representative urban samples from Brazilian  
50 adolescents attending public and private schools. In Brazil, the school coverage in this  
51 age is very high (88-97%) [37], which reduces significantly the risk of selection bias.  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65  
66  
67  
68  
69  
70  
71  
72  
73  
74  
75  
76  
77  
78  
79  
80  
81  
82  
83  
84  
85  
86  
87  
88  
89  
90  
91  
92  
93  
94  
95  
96  
97  
98  
99  
100  
101  
102  
103  
104  
105  
106  
107  
108  
109  
110  
111  
112  
113  
114  
115  
116  
117  
118  
119  
120  
121  
122  
123  
124  
125  
126  
127  
128  
129  
130  
131  
132  
133  
134  
135  
136  
137  
138  
139  
140  
141  
142  
143  
144  
145  
146  
147  
148  
149  
150  
151  
152  
153  
154  
155  
156  
157  
158  
159  
160  
161  
162  
163  
164  
165  
166  
167  
168  
169  
170  
171  
172  
173  
174  
175  
176  
177  
178  
179  
180  
181  
182  
183  
184  
185  
186  
187  
188  
189  
190  
191  
192  
193  
194  
195  
196  
197  
198  
199  
200  
201  
202  
203  
204  
205  
206  
207  
208  
209  
210  
211  
212  
213  
214  
215  
216  
217  
218  
219  
220  
221  
222  
223  
224  
225  
226  
227  
228  
229  
230  
231  
232  
233  
234  
235  
236  
237  
238  
239  
240  
241  
242  
243  
244  
245  
246  
247  
248  
249  
250  
251  
252  
253  
254  
255  
256  
257  
258  
259  
260  
261  
262  
263  
264  
265  
266  
267  
268  
269  
270  
271  
272  
273  
274  
275  
276  
277  
278  
279  
280  
281  
282  
283  
284  
285  
286  
287  
288  
289  
290  
291  
292  
293  
294  
295  
296  
297  
298  
299  
300  
301  
302  
303  
304  
305  
306  
307  
308  
309  
310  
311  
312  
313  
314  
315  
316  
317  
318  
319  
320  
321  
322  
323  
324  
325  
326  
327  
328  
329  
330  
331  
332  
333  
334  
335  
336  
337  
338  
339  
340  
341  
342  
343  
344  
345  
346  
347  
348  
349  
350  
351  
352  
353  
354  
355  
356  
357  
358  
359  
360  
361  
362  
363  
364  
365  
366  
367  
368  
369  
370  
371  
372  
373  
374  
375  
376  
377  
378  
379  
380  
381  
382  
383  
384  
385  
386  
387  
388  
389  
390  
391  
392  
393  
394  
395  
396  
397  
398  
399  
400  
401  
402  
403  
404  
405  
406  
407  
408  
409  
410  
411  
412  
413  
414  
415  
416  
417  
418  
419  
420  
421  
422  
423  
424  
425  
426  
427  
428  
429  
430  
431  
432  
433  
434  
435  
436  
437  
438  
439  
440  
441  
442  
443  
444  
445  
446  
447  
448  
449  
450  
451  
452  
453  
454  
455  
456  
457  
458  
459  
460  
461  
462  
463  
464  
465  
466  
467  
468  
469  
470  
471  
472  
473  
474  
475  
476  
477  
478  
479  
480  
481  
482  
483  
484  
485  
486  
487  
488  
489  
490  
491  
492  
493  
494  
495  
496  
497  
498  
499  
500  
501  
502  
503  
504  
505  
506  
507  
508  
509  
510  
511  
512  
513  
514  
515  
516  
517  
518  
519  
520  
521  
522  
523  
524  
525  
526  
527  
528  
529  
530  
531  
532  
533  
534  
535  
536  
537  
538  
539  
540  
541  
542  
543  
544  
545  
546  
547  
548  
549  
550  
551  
552  
553  
554  
555  
556  
557  
558  
559  
560  
561  
562  
563  
564  
565  
566  
567  
568  
569  
570  
571  
572  
573  
574  
575  
576  
577  
578  
579  
580  
581  
582  
583  
584  
585  
586  
587  
588  
589  
590  
591  
592  
593  
594  
595  
596  
597  
598  
599  
600  
601  
602  
603  
604  
605  
606  
607  
608  
609  
610  
611  
612  
613  
614  
615  
616  
617  
618  
619  
620  
621  
622  
623  
624  
625  
626  
627  
628  
629  
630  
631  
632  
633  
634  
635  
636  
637  
638  
639  
640  
641  
642  
643  
644  
645  
646  
647  
648  
649  
650  
651  
652  
653  
654  
655  
656  
657  
658  
659  
660  
661  
662  
663  
664  
665  
666  
667  
668  
669  
670  
671  
672  
673  
674  
675  
676  
677  
678  
679  
680  
681  
682  
683  
684  
685  
686  
687  
688  
689  
690  
691  
692  
693  
694  
695  
696  
697  
698  
699  
700  
701  
702  
703  
704  
705  
706  
707  
708  
709  
710  
711  
712  
713  
714  
715  
716  
717  
718  
719  
720  
721  
722  
723  
724  
725  
726  
727  
728  
729  
730  
731  
732  
733  
734  
735  
736  
737  
738  
739  
740  
741  
742  
743  
744  
745  
746  
747  
748  
749  
750  
751  
752  
753  
754  
755  
756  
757  
758  
759  
760  
761  
762  
763  
764  
765  
766  
767  
768  
769  
770  
771  
772  
773  
774  
775  
776  
777  
778  
779  
780  
781  
782  
783  
784  
785  
786  
787  
788  
789  
790  
791  
792  
793  
794  
795  
796  
797  
798  
799  
800  
801  
802  
803  
804  
805  
806  
807  
808  
809  
810  
811  
812  
813  
814  
815  
816  
817  
818  
819  
820  
821  
822  
823  
824  
825  
826  
827  
828  
829  
830  
831  
832  
833  
834  
835  
836  
837  
838  
839  
840  
841  
842  
843  
844  
845  
846  
847  
848  
849  
850  
851  
852  
853  
854  
855  
856  
857  
858  
859  
860  
861  
862  
863  
864  
865  
866  
867  
868  
869  
870  
871  
872  
873  
874  
875  
876  
877  
878  
879  
880  
881  
882  
883  
884  
885  
886  
887  
888  
889  
890  
891  
892  
893  
894  
895  
896  
897  
898  
899  
900  
901  
902  
903  
904  
905  
906  
907  
908  
909  
910  
911  
912  
913  
914  
915  
916  
917  
918  
919  
920  
921  
922  
923  
924  
925  
926  
927  
928  
929  
930  
931  
932  
933  
934  
935  
936  
937  
938  
939  
940  
941  
942  
943  
944  
945  
946  
947  
948  
949  
950  
951  
952  
953  
954  
955  
956  
957  
958  
959  
960  
961  
962  
963  
964  
965  
966  
967  
968  
969  
970  
971  
972  
973  
974  
975  
976  
977  
978  
979  
980  
981  
982  
983  
984  
985  
986  
987  
988  
989  
990  
991  
992  
993  
994  
995  
996  
997  
998  
999  
1000

1  
2  
3 have higher truancy and dropout rates. Therefore, this could have masked the true extent  
4 of the inequalities. We also report a range of simple and complex measures of inequalities  
5 to allow clear interpretation of trends as well as presenting rigorous hypothesis tests which  
6 make use of all data. Concordance between the absolute and relative measures of  
7 inequality adds strength to our conclusions.  
8  
9

10  
11  
12  
13  
14 Some limitations should be acknowledged. The engagement in health-related  
15 behaviours was self-reported by adolescents, and therefore, misclassification may have  
16 occurred towards social desirable behaviors. Misclassification likely affected the  
17 prevalence of health indicators similarly over three surveys. Although, use of self-  
18 reported outcomes is a limitation, it is widely recognised as an acceptable and often the  
19 only feasible approach for monitoring adolescent health behaviours [38]. Moreover, there  
20 is evidence of validity of the dietary indicators used in the PeNSE survey [17], and a US  
21 survey on which the PeNSE survey was based demonstrated good test-retest reliability  
22 and consistency across different modes of questioning [39].  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34

35  
36 The surveys were available only for a period of 6 years, which may be too short  
37 to expect significant changes in inequalities. To continue monitoring trends in adolescent  
38 health inequality for longer periods is desirable. Also, the data analysed are representative  
39 of Brazilian state capitals, not the whole country. State Capitals are highly urbanized cities  
40 and more developed than other cities, therefore, these results may not be generalizable to  
41 small cities and rural areas. However state capitals are the most populous and unequal  
42 areas of Brazil [40], making them important settings for studying inequality trends, and  
43 meaning they can act as sentinels to the country as a whole.  
44  
45  
46  
47  
48  
49  
50  
51  
52

53  
54 Brazil is facing a huge economic recession since 2015, which deepened in 2016.  
55 Unemployment and inflation have increased and people's purchasing power has been  
56 reduced, with the poor especially affected. Therefore it will be vital to continue  
57  
58  
59  
60

1  
2  
3 monitoring the trends observed in this study and take action to prevent exacerbation of  
4  
5 existing inequalities.  
6

7  
8 Policy makers and researchers should be alert to the fact that possible reductions  
9  
10 in health risky behaviours may be unbalanced between social groups and even be  
11  
12 increasing in disadvantaged social groups while decreasing on average [22]. In this study,  
13  
14 we found that the gap between poor adolescents and wealthy adolescents is reducing for  
15  
16 lifestyle behaviours such as fruit consumption; while it is increasing for violent  
17  
18 behaviours. For alcohol, irregular bean consumption and regular soft drink consumption  
19  
20 we found that the gap between social groups is narrowing, although represented by a  
21  
22 reduction in these risk behaviours among rich and an increase among poor adolescents.  
23  
24  
25  
26  
27  
28  
29

30 **Funding:** The present research received financial support from Brazilian National  
31  
32 Council of Scientific and Technological Development (CNPq), 404905/2016-1, awarded  
33  
34 to Catarina Machado Azeredo. Sao Paulo Research Foundation (FAPESP), grant  
35  
36 #2016/21390-0 and #2014/25614-4 due to Leandro Fórniás Machado de Rezende. The  
37  
38 funders had no role in study design, data collection and analysis, decision to publish, or  
39  
40 preparation of the manuscript.  
41  
42

43 **Conflict of interest:** None.  
44

45 **Data Sharing Statement:** The dataset of 2009, 2012 and 2015 PeNSE are publicly  
46  
47 available at: [https://www.ibge.gov.br/estatisticas-novoportal/sociais/educacao/9134-](https://www.ibge.gov.br/estatisticas-novoportal/sociais/educacao/9134-pesquisa-nacional-de-saude-do-escolar.html?=&t=microdados)  
48  
49 [pesquisa-nacional-de-saude-do-escolar.html?=&t=microdados](https://www.ibge.gov.br/estatisticas-novoportal/sociais/educacao/9134-pesquisa-nacional-de-saude-do-escolar.html?=&t=microdados)  
50

## 51 REFERENCES

- 52  
53  
54 1 Sawyer SM, Afifi RA, Bearinger LH, *et al.* Adolescence: a foundation for future  
55 health. *The Lancet* 2012;**379**:1630-40.  
56 2 Patton GC, Sawyer SM, Santelli JS, *et al.* Our future: a *Lancet*  
57 commission on adolescent health and wellbeing. *The Lancet* 2016;**387**:2423-78.  
58 3 Viner RM, Ozer EM, Denny S, *et al.* Adolescence and the social determinants of  
59 health. *The Lancet* 2012;**379**:1641-52.  
60



- 1  
2  
3 4 Piketty T, Saez E. Inequality in the long run. *Science* 2014;**344**:838-43.
- 4 5 Elgar FJ, Pfortner T-K, Moor I, *et al.* Socioeconomic inequalities in adolescent  
5 health 2002–2010: a time-series analysis of 34 countries participating in the Health  
6 Behaviour in School-aged Children study. *The Lancet* 2015;**385**:2088-95.
- 7 6 Solt F. The Standardized World Income Inequality Database. *Social Science  
8 Quarterly* 2016;**97**:14.
- 9 7 Landmann-Szwarcwald C, Macinko J. A panorama of health inequalities in  
10 Brazil. *International Journal for Equity in Health* 2016;**15**:174.
- 11 8 Martins APB, Monteiro CA. Impact of the Bolsa Familia program on food  
12 availability of low-income Brazilian families: a quasi experimental study. *BMC Public  
13 Health* 2016;**16**:827.
- 14 9 Hone TA-Ohoo, Rasella D, Barreto MLA-Ohoo, *et al.* Association between  
15 expansion of primary healthcare and racial inequalities in mortality amenable to primary  
16 care in Brazil: A national longitudinal analysis. *PLoS Med* 2017;**14**.
- 17 10 Rasella D, Harhay MO, Pamponet ML, *et al.* Impact of primary health care on  
18 mortality from heart and cerebrovascular diseases in Brazil: a nationwide analysis of  
19 longitudinal data. *BMJ* 2014;**349**:g4014.
- 20 11 IBGE. Pesquisa Nacional de Saúde do Escolar 2009. In: Ministério do  
21 Planejamento OeGIDdPCdPeIS, ed. Rio de Janeiro: Instituto Brasileiro de Geografia e  
22 Estatística 2009:138.
- 23 12 IBGE. Pesquisa Nacional de Saúde do Escolar 2012. In: Estatística IBdGe, ed.  
24 Rio de Janeiro 2013:256.
- 25 13 IBGE. Pesquisa Nacional de Saúde do Escolar: 2015. In: Ministério do  
26 Planejamento OeGIDdPCdPeIS, ed. Rio de Janeiro: IBGE 2016:132.
- 27 14 WHO WHO. Global School-Based Student Health Surveillance (GSHS). In:  
28 Organization WH, ed 2009.
- 29 15 Eaton DK, Kann L, Kinchen S, *et al.* Youth Risk Behavior Surveillance -United  
30 States- 2009. In: Services DOHAH, ed. United States: Centers for Disease Control and  
31 Prevention (CDC) 2010:148.
- 32 16 Barros AJ, Victora CG. [A nationwide wealth score based on the 2000 Brazilian  
33 demographic census]. *Rev Saude Publica* 2005;**39**:523-9.
- 34 17 Tavares LF, Castro IR, Levy RB, *et al.* [Relative validity of dietary indicators  
35 from the Brazilian National School-Based Health Survey among adolescents in Rio de  
36 Janeiro, Brazil]. *Cad Saude Publica* 2014;**30**:1029-41.
- 37 18 Ha V, Sievenpiper JL, de Souza RJ, *et al.* Effect of dietary pulse intake on  
38 established therapeutic lipid targets for cardiovascular risk reduction: a systematic  
39 review and meta-analysis of randomized controlled trials. *CMAJ* 2014;**186**:E252-62.
- 40 19 Olweus D. **Bullying at School: What we know and what we can do.** . Oxford,  
41 U.K. : Blackwell 1993.
- 42 20 Mackenbach JP, Kunst AE. Measuring the magnitude of socio-economic  
43 inequalities in health: an overview of available measures illustrated with two examples  
44 from Europe. *Soc Sci Med* 1997;**44**:757-71.
- 45 21 Barros AJ, Victora CG. Measuring coverage in MNCH: determining and  
46 interpreting inequalities in coverage of maternal, newborn, and child health  
47 interventions. *PLoS Med* 2013;**10**:e1001390.
- 48 22 WHO WHO. Handbook on health inequality monitoring: with a special focus on  
49 low- and middle-income  
50 countries. Geneva: World Health Organization 2013:108.
- 51 23 Royston P, White IR. Multiple Imputation by Chained Equations (MICE):  
52 Implementation in Stata *Journal of Statistical Software* 2011;**45**:1-20.
- 53  
54  
55  
56  
57  
58  
59  
60

- 1  
2  
3 24 Liu Y, Wang M, Tynjala J, *et al.* Socioeconomic inequalities in alcohol use of  
4 adolescents: the differences between China and Finland. *Int J Public Health*  
5 2013;**58**:177-85.  
6  
7 25 Hargreaves DS, Djafari Marbini A, Viner RM. Inequality trends in health and  
8 future health risk among English children and young people, 1999-2009. *Arch Dis Child*  
9 2013;**98**:850-5.  
10  
11 26 Rasmussen M, Pedersen TP, Johnsen NF, *et al.* Persistent social inequality in  
12 low intake of vegetables among adolescents, 2002-2014. *Public Health Nutr* 2018:1-5.  
13  
14 27 Pickett W, Molcho M, Elgar FJ, *et al.* Trends and socioeconomic correlates of  
15 adolescent physical fighting in 30 countries. *Pediatrics* 2013;**131**:e18-26.  
16  
17 28 Beltrán-Sánchez H, Andrade FCD. Time trends in adult chronic disease  
18 inequalities by education in Brazil: 1998–2013. *International Journal for Equity in*  
19 *Health* 2016;**15**:139.  
20  
21 29 Mújica OJ, Vázquez E, Duarte EC, *et al.* Socioeconomic inequalities and  
22 mortality trends in BRICS, 1990–2010. *Bull World Health Organ* 2014;**92**:405–12.  
23  
24 30 Das J, Do Q-T, Özler B. Reassessing conditional cash transfer programs. *World*  
25 *Bank Res Obs* 2005;**20**:23.  
26  
27 31 Jaime PC, da Silva AC, Gentil PC, *et al.* Brazilian obesity prevention and  
28 control initiatives. *Obes Rev* 2013;**14 Suppl 2**:88-95.  
29  
30 32 Viana LAC, Costa MdCN, Paim JS, *et al.* Social inequalities and the rise in  
31 violent deaths in Salvador, Bahia State, Brazil: 2000-2006. *Cadernos de Saúde Pública*  
32 2011;**27**:s298-s308.  
33  
34 33 França EB, Passos VMdA, Malta DC, *et al.* Cause-specific mortality for 249  
35 causes in Brazil and states during 1990–2015: a systematic analysis for the global  
36 burden of disease study 2015. *Population Health Metrics* 2017;**15**:39.  
37  
38 34 Grittner U, Kuntsche S, Gmel G, *et al.* Alcohol consumption and social  
39 inequality at the individual and country levels—results from an international study. *The*  
40 *European Journal of Public Health* 2013;**23**:332-9.  
41  
42 35 Moodie R, Stuckler D, Monteiro C, *et al.* Profits and pandemics: prevention of  
43 harmful effects of tobacco, alcohol, and ultra-processed food and drink industries.  
44 *Lancet* 2013;**381**:670-9.  
45  
46 36 Monteiro CA, Moubarac JC, Cannon G, *et al.* Ultra-processed products are  
47 becoming dominant in the global food system. *Obesity Reviews* 2013;**14**:21-8.  
48  
49 37 IBGE. Pesquisa Nacional por Amostra de Domicílios. Rio de Janeiro: Brasil  
50 2008.  
51  
52 38 Brener ND, Billy JOG, Grady WR. Assessment of factors affecting the validity  
53 of self-reported health-risk behavior among adolescents: evidence from the scientific  
54 literature. *Journal of Adolescent Health* 2003;**33**:436-57.  
55  
56 39 Brener N, Kann L, Shanklin S, *et al.* Methodology of the Youth Risk Behavior  
57 Surveillance System – 2013. . 2013:1-18.  
58  
59 40 IBGE. Síntese de Indicadores Sociais, uma análise das condições de vida. Rio de  
60 Janeiro: IBGE, Coordenação de População e Indicadores Sociais 2017:147.

Figure 1 - Time trends in health-related behaviours by wealthy quintile among adolescent

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

Figure 2- Prevalence of health-related behaviours among adolescent in 2015 and Slope  
Index of Inequality (SII, absolute inequality).

For peer review only

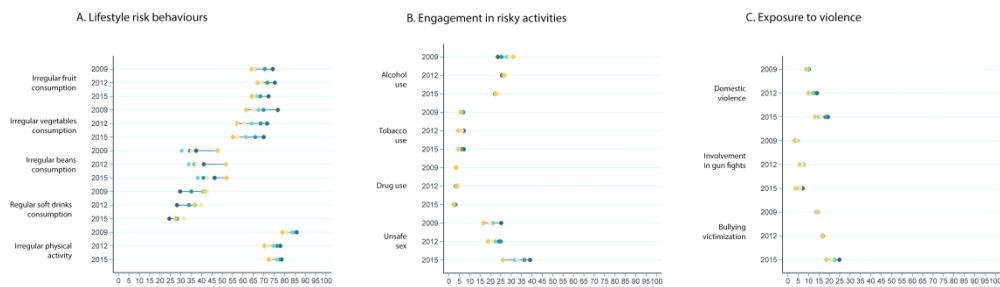


Figure 1 - Time trends in health-related behaviours by wealthy quintile among adolescent.

529x152mm (300 x 300 DPI)

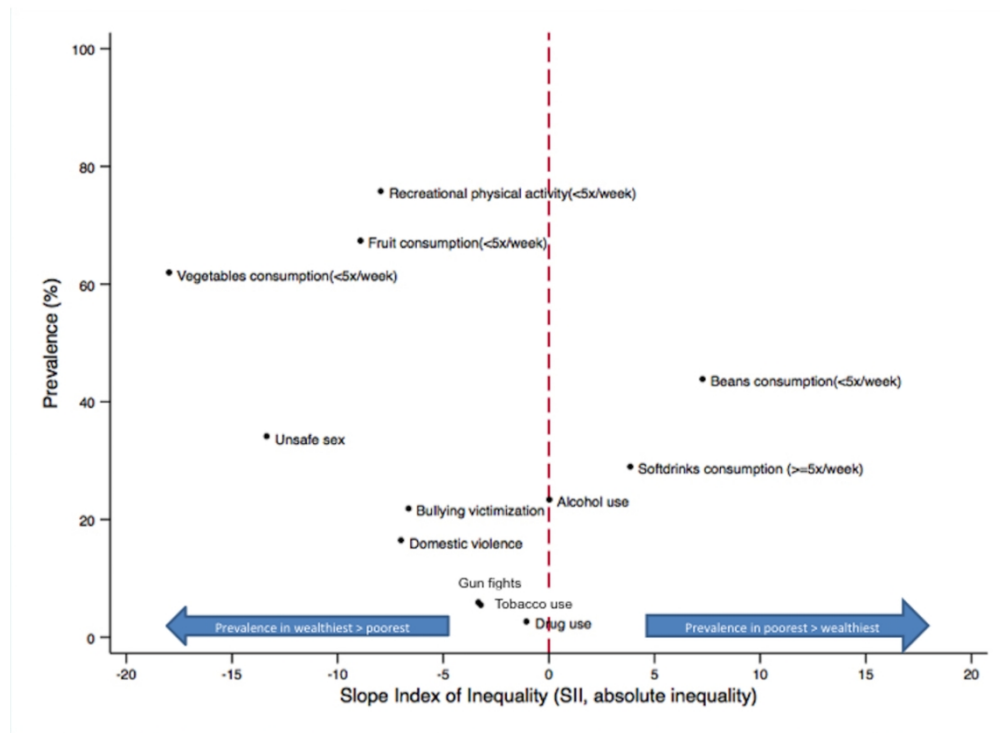


Figure 2- Prevalence of health-related behaviours among adolescent in 2015 and Slope Index of Inequality (SII, absolute inequality).

108x81mm (300 x 300 DPI)

## Appendix 1

Simple measures of inequality in health-related behaviours among Brazilian adolescents from PeNSE surveys 2009, 2012 and 2015.

Indicator	PeNSE survey year	National	Q1 (poorest) %	Q5 (richest) %	Difference (quintile 5 - quintile 1) %	Difference (quintile 5 - quintile 1) 95% CI	Ratio (quintile 5/ quintile 1) %	Ratio (quintile 5/ quintile 1) 95% CI	Population Attributable risk (PAR)	Population Attributable risk percentage (PAR%)
Irregular fruit consumption	2009	68.49	74.34	64.00	10.34	8.06; 12.62	1.16	1.12; 1.20	-4.49	-6.56
	2012	70.24	75.35	66.96	8.39	6.03; 10.74	1.13	1.08; 1.16	-3.28	-4.67
	2015	67.17	72.29	64.15	8.14	5.28; 11.00	1.13	1.08; 1.18	-3.02	-4.50
Irregular vegetables consumption	2009	68.77	76.81	61.47	15.34	13.28; 17.41	1.25	1.21; 1.29	-7.30	-10.62
	2012	64.12	71.64	56.99	14.65	12.46; 16.83	1.26	1.21; 1.30	-7.13	-11.12
	2015	61.73	69.97	55.14	14.83	11.66; 18.01	1.27	1.20; 1.34	-6.59	-10.68
Irregular beans consumption	2009	37.45	37.38	47.74	-10.36	-12.96; -7.77	0.78	0.74; 0.83	10.29	27.48
	2012	40.00	41.09	51.74	-10.65	-13.88; -7.42	0.79	0.74; 0.85	11.74	29.35
	2015	43.74	46.27	52.07	-5.80	-9.17; -2.43	0.89	0.83; 0.95	8.33	19.04
Regular softdrinks consumption	2009	37.21	29.67	41.59	-11.92	-14.32; -9.50	0.71	0.67; 0.76	4.38	11.77
	2012	35.44	28.17	36.62	-8.45	-10.69; -6.20	0.77	0.72; 0.83	1.18	3.33
	2015	28.84	24.51	27.42	-2.91	-5.45; -0.33	0.89	0.81; 0.98	-1.42	-4.92
Irregular recreational physical activity	2009	82.96	85.88	78.96	6.92	5.30; 8.55	1.09	1.07; 1.11	-4.00	-4.66
	2012	74.15	77.97	70.27	7.70	5.82; 9.58	1.11	1.08; 1.14	-3.88	-4.98
	2015	75.58	78.58	72.36	6.22	3.93; 8.51	1.09	1.05; 1.12	-3.22	-4.10
Alcohol use (once in the last month)	2009	27.13	23.57	31.02	-7.45	-9.22; -5.67	0.76	0.71; 0.81	3.89	14.33
	2012	26.78	25.55	26.33	-0.78	-2.94; 1.37	0.97	0.89; 1.05	-0.45	-1.67
	2015	23.2	22.24	22.50	-0.26	-2.99; 2.47	0.99	0.87; 1.12	-0.70	-3.03
Tobacco use (once in the last month)	2009	6.25	6.70	5.63	1.07	0.09; 2.06	1.19	1.01; 1.40	-0.62	-9.92
	2012	6.08	7.20	4.44	2.76	1.70; 3.82	1.62	1.35; 1.95	-1.64	-26.99
	2015	5.34	7.18	4.41	2.77	1.48; 4.06	1.63	1.28; 2.08	-0.93	-17.35

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

	2009	3.32	3.01	3.52	-0.51	-1.29; 0.27	0.85	0.67; 1.08	0.20	6.02
Drug use (once in the last month)	2012	3.81	3.94	3.63	0.31	-0.70; 1.32	1.09	0.83; 1.42	-0.18	-4.72
	2015	2.45	2.55	2.20	0.35	-0.52; 1.22	1.16	0.80; 1.69	-0.25	-10.20
Unsafe sex (in the last sexual intercourse)	2009	21.46	25.19	16.65	8.54	5.27; 11.82	1.51	1.27; 1.80	-4.81	-22.41
	2012	22.5	24.29	18.83	5.46	2.10; 8.81	1.29	1.10; 1.51	-3.67	-16.31
	2015	33.86	39.11	26.00	13.11	8.21; 18.01	1.50	1.28; 1.77	-7.86	-23.21
Domestic violence (once in the last month)	2009	9.54	10.13	8.79	1.34	0.06; 2.62	1.15	1.00; 1.33	-0.75	-7.86
	2012	11.6	14.08	9.87	4.21	2.82; 5.61	1.43	1.27; 1.61	-1.73	-14.91
	2015	16.17	19.33	13.11	6.22	4.48; 7.96	1.47	1.32; 1.65	-3.06	-18.92
Involvement in gun fights (in the last month)	2009	4.01	3.93	3.15	0.78	0.02; 1.53	1.25	1.00; 1.55	-0.86	-21.45
	2012	6.94	7.50	5.65	1.85	0.82; 2.88	1.33	1.13; 1.55	-1.29	-18.59
	2015	5.61	7.19	3.70	3.49	2.41; 4.58	1.94	1.56; 2.42	-1.91	-34.05
Bullying victimization (twice or more in the last month)	2009	14.16	13.71	14.54	-0.83	-2.16; 0.50	0.94	0.86; 1.04	0.38	2.68
	2012	16.5	16.90	16.73	0.17	-1.68; 2.04	1.01	0.90; 1.13	0.23	1.39
	2015	21.74	24.88	18.51	6.37	4.28; 8.45	1.34	1.22; 1.48	-3.23	-14.86

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract <b>abstract; page 2</b> (b) Provide in the abstract an informative and balanced summary of what was done and what was found <b>page 2</b>
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported <b>Page3</b>
Objectives	3	State specific objectives, including any prespecified hypotheses <b>Page 4</b>
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper <b>Page 4</b>
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection <b>Page 4 and 5</b>
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <b>NA</b> <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <b>NA</b> <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants <b>–Page4 and first para page 5</b> (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <b>NA</b> <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case <b>NA</b>
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable <b>Page 5 and 6</b>
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group <b>Table 1 – page 6</b>
Bias	9	Describe any efforts to address potential sources of bias <b>Last para Page 4 and first para page 5 (response rate – selection bias); page 5 (validation of measures – information bias)</b>
Study size	10	Explain how the study size was arrived at . <b>Page 4 and Reference: Oliveira et al. 2017</b>
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why <b>Pages 8 and 9</b>
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding <b>Pages 8 and 9</b> (b) Describe any methods used to examine subgroups and interactions <b>NA</b>



1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

(c) Explain how missing data were addressed [Page 9](#)

---

(d) *Cohort study*—If applicable, explain how loss to follow-up was addressed [NA](#)  
*Case-control study*—If applicable, explain how matching of cases and controls was addressed [NA](#)

*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy [Page 9 last para](#)

---

(e) Describe any sensitivity analyses [NA](#)

Continued on next page

For peer review only

<b>Results</b>		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed <a href="#">Table 2</a> (b) Give reasons for non-participation at each stage <a href="#">Response rate page 4</a> (c) Consider use of a flow diagram <a href="#">NA</a>
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders <a href="#">Table 2</a> (b) Indicate number of participants with missing data for each variable of interest <a href="#">Page 9 (we used multiple imputation)</a> (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount) <a href="#">NA</a>
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <a href="#">NA</a> <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <a href="#">NA</a> <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures <a href="#">Table 2</a>
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included <a href="#">Table 3, figures 1 and 2.</a> (b) Report category boundaries when continuous variables were categorized <a href="#">NA</a> (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period <a href="#">NA</a>
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses <a href="#">NA</a>
<b>Discussion</b>		
Key results	18	Summarise key results with reference to study objectives <a href="#">Page 15</a>
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias <a href="#">Page 18</a>
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence <a href="#">Pages 15-18</a>
Generalisability	21	Discuss the generalisability (external validity) of the study results <a href="#">Page 17 last para</a>
<b>Other information</b>		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based <a href="#">Page 19</a>

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).