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ORIGINAL ARTICLE

Sex-stratified socio-economic gradients in physical inactivity, obesity, and diabetes: evidence of short-term changes in Argentina

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Abstract
Objectives To evaluate how socio-economic gradients in NCDs and NCD-related risk factors change over time.
Methods Secondary analysis of cross-sectional data from the 2005 and 2009 Argentine National Risk Factor Surveys ($N = 41{,}392$ and $N = 34{,}732$) was conducted. We analyzed inequalities in three risk factors (low physical activity, obesity, and diabetes) according to income and educational attainment. The analysis was based on sex-stratified and age-adjusted logistic regression.
Results The overall prevalence of low physical activity, obesity, and diabetes increased from 2005 to 2009. Increases occurred in most of the income and education groups, but females with the lowest socio-economic status generally showed the highest increases. In 2005, differences in physical inactivity among women with different levels of education were not statistically significant. By 2009, women with low education (OR = 1.57, 95 % CI = 1.34–1.84) and medium education (OR = 1.18, 95 % CI = 1.06–1.32) were more likely than women with high education to be physically inactive.
Conclusion Inequalities in physical inactivity, obesity, and diabetes have grown in Argentina over a short period of time.

Keywords Risk factors · Population surveillance · Socio-economic factors · Argentina

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Introduction

Non-communicable diseases (NCDs) are the main cause of death in most regions of the world, including Latin America (De Maio 2011; Perel et al. 2006; World Health Organization 2005). Contrary to the widely held belief that NCDs are diseases of affluence, the World Health Statistics (2010) most recent data suggests that these diseases cause profound premature mortality and avoidable morbidity in low- and middle-income countries. Diabetes alone is now estimated to afflict 285–350 million people worldwide, with significant increases in its prevalence in low- and middle-income countries over the past few decades (Danaei et al. 2011).

Most of the burden of disease attributable to NCDs is usually attributed to a few risk factors, that include, among others, modifiable risk factors such as physical inactivity, unhealthy diet, and tobacco use, along with intermediate risk factors, including raised blood pressure and overweight/obesity (World Health Organization 2005). However, traditional risk-factor epidemiology has been limited in its ability to generate an adequate understanding for the prevention of these risk factors, due to a tendency to see them primarily as individual-level attributes stripped of social context (De Maio et al. 2008). In the past 10 years, recognition of the social patterning of risk factors has increased, and attention has increasingly been given to the 'causes of the causes' (Marmot and Wilkinson 2006)—the social factors that shape an individual's likelihood of experiencing any given risk factor or set of risk factors (Muntaner et al. 2009; WHO 2008).

There is strong evidence that most NCD risk factors are patterned along the socio-economic gradient. Not only there is a difference in risk factor profiles between the poor and the non-poor, but also there are fine differences throughout the socio-economic spectrum. These gradients have long been established in developed countries, and they are also now beginning to be detected in the developing world (Monteiro et al. 2004). In Argentina, data from the 2005 National Risk Factor Survey has shown this gradient pattern with obesity, unhealthy diet, and diabetes (De Maio et al. 2009; Fleischer et al. 2011; MSAL 2006). Understanding how these inequalities change over time is a critical goal in public health. There is a need to monitor the evolution of inequalities to evaluate possible actions to tackle them. Indeed, the WHO Commission on the Social Determinants of Health concluded with a strong call to action for the routine monitoring of health inequalities (CSDH 2008). Until recently, this has not been possible at the national-level of analysis in many Latin American countries. However, recent developments in surveillance systems for chronic diseases in the region—and in Argentina in particular, the availability of data from nationally representative risk factors surveys from 2005 and 2009—have now enabled analyses of changing gradients in health.

Research in other areas of the world has shown that socio-economic gradients change over time (Pampel et al. 2012). Mackenbach et al. (2003), in a landmark study, showed how inequalities in mortality rates widened in many parts of Europe during the 1980s and the 1990s as a result of relatively faster drops in mortality among high socio-economic groups. Other European studies have also documented steepening gradients with tobacco consumption (Harper and Lynch 2007; Iribarren et al. 1997; Kanjilal et al. 2006). Studies of other NCD risk factors have shown mixed results. For example, some work on physical inactivity has shown diminishing gradients (Iribarren et al. 1997), while other studies have shown stable patterns (Bartley et al. 2000; Galobardes et al. 2003) and others have found steepening gradients (Harper and Lynch 2007). As well, conflicting results have been published with respect to changes in the socio-economic gradient in obesity in the US (Harper and Lynch 2007), Canada (Lee et al. 2009), England (Bartley et al. 2000), and Brazil (Moura and Claro 2011). Empirical work on socio-economic gradients in diabetes has shown either stable patterns (Bartley et al. 2000) or steepening gradients (Kanjilal et al. 2006; Lee et al. 2009). All of this suggests that changes in gradients are very likely to be context specific, and will vary from country to country over time and may be influenced by public policy. At the same time, country-specific gradients are also influenced by decidedly global processes—including among others, economic trade flows, urbanization, migration, and the global production and distribution of food (Inglis and Gimlin 2009).

Previous work in Argentina and in other developing countries indicates that socio-economic gradients for NCDs and risk factors for NCDs vary by gender, to the extent that the magnitude and direction of the gradient may differ between men and women (Fleischer et al. 2011; Monteiro et al. 2004; Moura and Claro 2011). Our study therefore examines the extent to which sex-stratified gradients in low physical activity, obesity, and diabetes have changed in Argentina between 2005 and 2009.

Methods

The analysis is based on the 2005 and 2009 Argentine National Risk Factor Surveys (*Encuesta Nacional de Factores de Riesgo*; ENFR). The surveys are both nationally and provincially representative cross-sectional samples. In 2005, the ENFR had a sample size of 41,392 adults and a response rate of 86.7 %, whereas the 2009 survey had a sample size of 34,732 and a response rate of 79.8 % (Ferrante and Virgolini 2007; MSAL 2011). Both surveys were carried out by Argentina's Ministry of Health in cooperation with the National Institute of Statistics and Census (*Instituto Nacional de Estadística y Censos*; INDEC) and provincial authorities. Methodological characteristics of the ENFR have been published elsewhere (Ferrante et al. 2011; Ferrante and Virgolini 2007; MSAL 2006).

Low physical activity, obesity, and diabetes are the three dichotomous outcome variables used in these analyses. Low physical activity is classified by the WHO as a "modifiable risk factor", and was measured in the ENFR using the International Physical Activity Questionnaire (IPAQ), a widely used and validated instrument for measuring levels of physical activity in healthy adult populations (Craig et al. 2003). We contrast respondents with low physical activity versus those with moderate and high physical activity. Obesity was operationalized as a body mass index of 30 kg/m^2 or higher, based on self-reported height and weight, and diabetes was defined as having been told by a health professional that one had diabetes or high blood sugar.

Our analysis used two indicators of socio-economic status as exposure variables. Following INDEC protocol, total family income was categorized into three categories: low (the four lowest deciles), medium (the next four deciles) and high income (the two upper deciles). There was a modest non-response to the income question in the survey; the pooled dataset contains 70,199 out of a possible 76,124 respondents. Educational attainment was used to generate a secondary measure of socio-economic status. Three categories of educational attainment were generated: primary school incomplete (11.8 % of the total sample); primary school completed and/or high school incomplete (41.4 % of the total sample); and secondary school completed or more (46.8 % of the total sample). Educational attainment was available for all respondents.

The analysis took into account the complex survey design. The prevalence of each risk factor across the categories of each socio-economic variable was described using weighted percentages. Sex-stratified logistic regression models were developed to analyze the relationship between each socio-economic indicator (explanatory variable) and each risk factor (dependent variable), adjusting for age (entered into the models as a continuous variable). An interaction term between year and socio-economic indicator was used to assess the statistical significance of changes from 2005 to 2009, following standard practice (Kautiainen et al. 2009; Monteiro et al. 2010). A three-step modeling strategy was used: first, income (adjusting for age) was considered as the sole predictor. This was followed by a second model, where education (again adjusting for age) was considered as the sole predictor. The third model addressed possible confounding of income and education by including both in the model. Wald tests were used to compare the combined income and education models with the income-only models. Only cases with non-missing data for all variables were included in the models, leaving sample sizes of $N = 28{,}812$ for males and $N = 36{,}120$ for females. All analyses were performed with STATA version 11.0 (STATA Corp; College Station, TX, USA).

Results

Descriptive characteristics of the two surveys are presented in Table 1. The surveys have comparable proportions of

Table 1 Description of study samples, National Risk Factor Surveys, Argentina (2005 and 2009)

	2005			2009		
	N	Weighted	Missing *N* (% of total)	*N*	Weighted	Missing *N* (% of total)
Dependent variables						
Obese						
Yes	6,018	14.6 %		6,018	18.0 %	
No	31,937	85.3 %		26,430	82.0 %	
Total	37,955	100 %	3,397 (8.2)	32,448	100 %	2,284 (6.6)
Diabetes						
Yes	3,675	8.4 %		3,638	9.6 %	
No	37,717	91.6 %		31,094	90.4 %	
Total	41,392	100 %	0	34,732	100 %	0
Low physical activity						
Yes	19,388	46.2 %		19,445	54.9 %	
No	22,004	53.8 %		15,072	45.1 %	
Total	41,392	100 %	0	34,517	100 %	0
Independent variables						
Sex						
Male	17,827	47.5 %		15,028	46.7 %	
Female	23,565	52.5 %		19,704	53.3 %	
Total	41,392	100 %	0	34,732	100 %	0
Income						
Low	18,903	43.5 %		15,885	42.1 %	
Medium	13,854	39.7 %		11,915	42.4 %	
High	5,466	16.8 %		4,176	15.5 %	
Total	38,223	100 %	3,169 (7.7)	31,976	100.0 %	2,756 (7.9)
Education						
Low	5,819	12.7 %		4,585	10.8 %	
Medium	16,576	43.0 %		13,767	40.0 %	
High	18,997	44.3 %		16,380	49.3 %	
Total	41,392	100 %	0	34,732	100 %	0
		Mean (SD)			Mean (SD)	
Age	41,392	43.3 (17.9)	0	34,732	43.6 (18.0)	0
Total	41,392			34,732		

Unweighted, *SD* standard deviation

Table 2 Sex-stratified descriptive gradients in obesity, diabetes, and low physical activity, Argentina (2005 and 2009)

	Low physical activity			Obesity			Diabetes		
	2005 (%)	2009 (%)	Change (%)	2005 (%)	2009 (%)	Change (%)	2005 (%)	2009 (%)	Change (%)
Male									
Income									
High	44.9	47.9	3.0	14.6	18.5	3.9	8.5	6.8	−1.7
Medium	44.7	50.4	5.7	16.1	20.0	3.9	7.4	9.6	2.2
Low	42.0	51.4	9.4	14.9	18.3	3.4	8.9	8.9	0.0
Education									
High	47.1	47.3	0.2	12.8	16.9	4.1	6.0	7.9	1.9
Medium	43.5	52.5	9.0	17.2	20.8	3.6	9.2	9.2	0.0
Low	42.8	56.0	13.2	17.5	21.9	4.4	13.1	11.4	−1.7
Total	45.0	50.4	5.4	15.4	19.1	3.7	8.2	8.8	0.6
Female									
Income									
High	50.4	55.3	4.9	11.3	10.5	−0.8	5.0	7.5	2.5
Medium	45.5	57.0	11.5	12.8	16.4	3.6	8.0	8.8	0.8
Low	45.5	58.4	12.9	17.4	21.6	4.2	10.2	12.4	2.2
Education									
High	45.8	53.3	7.5	10.1	11.8	1.7	5.5	6.5	1.0
Medium	45.0	59.5	14.5	17.2	22.0	4.8	9.8	12.5	2.7
Low	52.9	69.3	16.4	23.6	31.1	7.5	16.0	19.2	3.2
Total	46.3	57.4	11.1	14.6	17.7	3.1	8.5	10.1	1.6
Overall	45.7	54.0	8.3	15.0	18.4	3.4	8.3	9.5	1.2

Percentages based on respondent with no missing data. For females, $N = 19{,}495$ in 2005 and $N = 16{,}625$ in 2009. For males, $N = 15{,}629$ in 2005 and $N = 13{,}183$ in 2009

males to females, and similar central tendency and dispersion with respect to age. A higher percentage of respondents in the 2009 survey have a high level of education.

Sex-stratified descriptive gradients by income and educational attainment for the three health measures are presented in Table 2. The overall prevalence of low physical activity, obesity, and diabetes increased from 2005 to 2009. Increases occurred in most of the income and education groups, and females with the lowest socio-economic status generally showed the highest increases, particularly with low physical activity.

Age-adjusted logistic regression models suggest that socio-economic gradients in physical inactivity switched directions between 2005 and 2009, as shown in Table 3. For males, this is seen in the education-only model as well as in the mutually adjusted income and education model. In 2005, males with low education (OR = 0.65, 95 % CI = 0.50–0.85) and medium education (OR = 0.79, 95 % CI = 0.67–0.93) were less likely than males with high education to be physically inactive (adjusting for age and income). In 2009, the direction of the gradient switched direction with statistically significant interaction effects between education and year. A similar effect is seen among females, with emerging gradients in the income-only model and in education (in both models). In the full model, the gradient steepened and attained statistical significance. By 2009, women with low education (OR = 1.57, 95 % CI = 1.34–1.84) and medium education (OR = 1.18, 95 % CI = 1.06–1.32) were more likely than women with high education to be physically inactive.

In contrast, socio-economic gradients in obesity appear more stable, as shown in Table 4. Gradients by education or income show little change for men over the study period. There are signs of increasing inequalities for women, with increases in ORs by income (in the income-only model as well as the full model), although the changes are statistically marginal.

Socio-economic gradients in diabetes show mixed patterns (see Table 5). For males, there are signs of an emerging gradient by income, with a statistically significant increase for the medium income group (OR = 0.83, 95 % CI = 0.57–1.22 in 2005 and OR = 1.46, 95 % CI = 1.17–1.81 in 2009; interaction term $p < 0.05$ in the full model). However, the gradient by education is not significant in either year. For females, income- and education-based gradients are statistically significant and remain more stable.

Discussion

These analyses indicate that between 2005 and 2009 important changes occurred in the socio-economic

Table 3 Sex-stratified logistic regression analysis predicting low physical activity, Argentina (2005 and 2009)

	Income and education model					Combined income and education model				
	2005		2009		*p* for interaction	2005		2009		*p* for interaction
	OR	95% CI	OR	95% CI		OR	95 % CI	OR	95 % CI	
Males										
Income										
High	1.00	–	1.00	–		1.00	–	1.00	–	
Medium	1.15	0.94–1.41	1.10	0.88–1.38	0.78	1.24	1.01–1.53	1.06	0.88–1.28	0.28
Low	0.88	0.72–1.07	1.10	0.91–1.34	0.10	1.02	0.82–1.27	1.03	0.89–1.19	0.95
Education										
High	1.00	–	1.00	–		1.00	–	1.00	–	
Medium	0.79	0.68–0.92	1.16	0.90–1.48	<0.05	0.79	0.67–0.93	1.15	0.90–1.47	<0.05
Low	0.64	0.50–0.81	1.12	0.94–1.34	<0.01	0.65	0.50–0.85	1.12	0.93–1.34	<0.01
N	28,812									
Female										
Income										
High	1.00	–	1.00	–		1.00	–	1.00	–	
Medium	0.81	0. 67–0.98	1.07	0.89–1.29	<0.05	0.82	0.68–0.99	1.02	0.84–1.23	0.13
Low	0.80	0.66–0.96	1.10	0.89–1.36	<0.05	0.82	0.67–0.99	0.97	0.79–1.20	0.23
Education										
High	1.00	–	1.00	–		1.00	–	1.00	–	
Medium	0.87	0.75–1.01	1.17	1.04–1.31	<0.01	0.92	0.79–1.07	1.18	1.06–1.32	<0.01
Low	1.04	0.84–1.28	1.54	1.32–1.80	<0.01	1.10	0.88–1.37	1.57	1.34–1.84	<0.01
N	36,120									

All models include age as a covariate. Wald tests indicate that the combined income and education model is significantly better than the income model for both males and females ($p < 0.01$)

OR odds ratio, *CI* confidence interval

gradients that underlie obesity, diabetes, and physical inactivity. The direction of the gradient in physical inactivity—as measured either by income or education—shifted, and lower socio-economic status groups now experience a higher likelihood of this important risk factor. In contrast, socio-economic gradients for obesity show signs of increasing for women but not for men. Gradients for diabetes show signs of increase for men and have remained significant for women over the study period.

The income and education variables, while both indicators of socio-economic status, show a certain degree of independence in these analyses. This is likely attributable to the different cut-off points used in the categorization of income and education. It also reflects the notions that income and education map onto health status in different ways (Backlund et al. 1999; Fernald and Adler 2008) and that they are not interchangeable indicators, particularly in developing countries (Koch et al. 2010). Dissonance between the income and education variables may also derive from the fact that income in this study was measured at the level of the household, while educational attainment reflects the characteristics of an individual man or woman.

These findings suggest that important changes are underway in the social gradient in Argentina. Underlying these changes is the notion of the "nutrition transition" thought to be occurring throughout the Latin America and which is particularly associated with an increased consumption of fat and refined sugars (Amuna and Zotor 2008; Hawkes 2006). When considered along with lifestyle changes associated with urbanization, increases in the prevalence of low physical activity, obesity, and diabetes are to be expected in middle-income countries like Argentina (Fleischer et al. 2011). However, what these analyses show is that not only the overall prevalence of these risk factors changing over a relatively short period of time, but also their distribution across the socio-economic spectrum, with increasing signs of inequalities, particularly among women. The results echo recently published analyses of the significance of NCDs in the region, and they contribute new insight into how social gradients vary not only by indicator of socio-economic status, but also

Table 4 Sex-stratified logistic regression analysis predicting obesity, Argentina (2005 and 2009)

	Income and education model					Combined income and education model				
	2005		2009		*p* for interaction	2005		2009		*p* for interaction
	OR	95 % CI	OR	95 % CI		OR	95 % CI	OR	95 % CI	
Males										
Income										
High	1.00	–	1.00	–		1.00	–	1.00	–	
Medium	1.16	0.91–1.48	1.09	0.91–1.30	0.67	1.07	0.84–1.38	1.03	0.86–1.23	0.79
Low	1.01	0.78–1.30	0.92	0.77–1.10	0.56	0.89	0.67–1.18	0.83	0.69–1.00	0.68
Education										
High	1.00	–	1.00	–		1.00	–	1.00	–	
Medium	1.28	1.05–1.57	1.19	1.06–1.33	0.51	1.32	1.07–1.65	1.25	1.11–1.41	0.65
Low	1.06	0.77–1.45	1.04	0.88–1.24	0.94	1.13	0.81–1.58	1.14	0.97–1.35	0.95
N	28,812									
Females										
Income										
High	1.00	–	1.00	–		1.00	–	1.00		
Medium	1.12	0.84–1.50	1.65	1.29–2.11	<0.05	0.98	0.73–1.32	1.42	1.10–1.82	0.06
Low	1.57	1.22–2.02	2.21	1.66–2.96	0.08	1.20	0.91–1.57	1.64	1.22–2.19	0.13
Education										
High	1.00	–	1.00	–		1.00	–	1.00	–	
Medium	1.65	1.35–2.00	1.88	1.68–2.11	0.24	1.54	1.25–1.91	1.70	1.52–1.89	0.42
Low	2.07	1.59–2.71	2.54	1.96–3.30	0.24	1.88	1.41–2.50	2.23	1.77–2.80	0.32
N	36,120									

All models include age as a covariate. Wald tests indicate that the combined income and education model is significantly better than the income model for both males and females ($p < 0.01$)

OR odds ratio, *CI* confidence interval

between men and women (De Maio et al. 2008; Perel et al. 2006; World Health Organization 2005). Understanding the dynamics of health inequalities is important for developing effective prevention and control policies.

There are several limitations to this analysis. Firstly, it is limited to a 4-year window. This is a relatively short period over which to see major changes in social gradients; future research should incorporate new data from the ENFR as they become available. Secondly, our models are restricted to only two alternating measures of socio-economic status. Future analyses could attempt to generate more nuanced measures, perhaps incorporating features of class analysis (Muntaner et al. 2002) as well as measures of absolute poverty such as unmet basic needs (De Maio et al. 2009; Marín et al. 2008), or a capabilities approach drawing from the work of Sen (1999). Thirdly, the models are limited to analysis of individual characteristics. Future analyses could incorporate insights from multilevel techniques to explore how the social gradients identified in this work may be influenced by contextual effects as well as the interaction between contextual effects and compositional characteristics (Diez-Roux 2002). The models presented in this paper are also descriptive in nature; future research should develop these findings by developing explanatory models that explore factors that influence socio-economic gradients.

Lastly, the study is limited by its reliance on self-reported data. Granted, the ENFR instrument has been validated in Argentina, and is based on a robust and widely accepted instrument originally developed by the World Health Organization (Ferrante and Virgolini 2007; PAHO 2008). However, despite validation of the survey instrument, the ENFR, like any other household survey, will suffer from social desirability and under/over reporting of some data (De Vaus 2002). In particular, we may expect an under-reporting of income among higher income groups. Previous research from Argentina suggests that this may be a problem, and this could result in an artificially shallow social gradients (Gasparini and Escudero 2001; Javier et al. 1995). At the same time,

Table 5 Sex-stratified logistic regression analysis predicting diabetes, Argentina (2005 and 2009)

	Income and education model					Combined income and education model				
	2005		2009		*p* for interaction	2005		2009		*p* for interaction
	OR	95% CI	OR	95% CI		OR	95 % CI	OR	95 % CI	
Males										
Income										
High	1.00	–	1.00	–		1.00	–	1.00	–	
Medium	0.90	0.62–1.30	1.40	1.14–1.72	<0.05	0.83	0.57–1.22	1.46	1.17–1.81	<0.05
Low	0.96	0.67–1.37	1.06	0.87–1.31	0.62	0.85	0.56–1.31	1.16	0.93–1.44	0.21
Education										
High	1.00	–	1.00	–		1.00	–	1.00	–	
Medium	1.24	0.94–1.64	0.93	0.79–1.10	<0.01	1.30	0.95–1.77	0.92	0.78–1.08	<0.05
Low	1.12	0.75–1.67	0.75	0.61–0.92	<0.01	1.17	0.73–1.86	0.76	0.59–0.97	0.10
N	28,812									
Females										
Income										
High	1.00	–	1.00	–		1.00	–	1.00		
Medium	1.56	1.09–2.26	1.16	0.93–1.45	0.17	1.41	0.98–2.03	1.01	0.82–1.25	0.12
Low	1.99	1.40–2.82	1.57	1.25–1.97	0.27	1.58	1.09–2.29	1.20	0.96–1.49	0.21
Education										
High	1.00	–	1.00	–		1.00	–	1.00	–	
Medium	1.54	1.22–1.95	1.69	1.40–2.05	0.53	1.38	1.07–1.79	1.61	1.34–1.93	0.34
Low	2.11	1.50–2.96	2.18	1.84–2.58	0.85	1.83	1.27–2.66	2.02	1.70–2.40	0.63
N	36,120									

All models include age as a covariate. Wald tests indicate that the combined income and education model is significantly better than the income model for women ($p < 0.01$) and marginally better for men ($p = 0.08$)

OR odds ratio, *CI* confidence interval

error can also be expected in the income reporting of individuals involved in the informal economy. This may lead to an underestimate of the income of the poor and lower middle class. Moreover, the ENFR's measure of diabetes may well underestimate the prevalence of diabetes among the poor, as it is based on respondent's recollection of their experience with a health care professional. This experience is structured by access to health care services and may lend less validity to our diabetes variable, compared to our data on physical activity. Given existing research that suggests diabetes is under-diagnosed in Latin America (Chacra et al. 2005), future studies should investigate additional methodological approaches to measure social gradients with respect to diabetes.

This study shows how a surveillance system, of which surveys like the ENFR form an integral component, can be used to track changes in socio-economic inequalities in health over time. Understanding the dynamics of health inequalities is critical—and the full value of social surveys like the ENFR is realized when the data can be used to identify areas of public health success and failure. Future research can build on the present study by analyzing how social gradients vary over time in different countries.

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