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Temporal trends in BMI in Argentina by socio-economic position and province-level economic development, 2005–2009

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Abstract

Objective: We investigated temporal trends in BMI, and assessed hypothesized predictors of trends including socio-economic position (SEP) and province-level economic development, in Argentina.

Design: Using multivariable linear regression, we evaluated cross-sectional patterning and temporal trends in BMI and examined heterogeneity in these associations by SEP and province-level economic development with nationally representative samples from Argentina in 2005 and 2009. We calculated mean annual changes in BMI for men and women to assess secular trends.

Results: Women, but not men, exhibited a strong cross-sectional inverse association between SEP and BMI, with the lowest-SEP women having an average BMI 2·55 kg/m^2 greater than the highest-SEP women. Analysis of trends revealed a mean annual increase in BMI of 0·19 kg/m^2 and 0·15 kg/m^2 for women and men, respectively, with slightly greater increases occurring in provinces with greater economic growth. No significant heterogeneity in trends existed by individual SEP.

Conclusions: BMI is increasing rapidly over time in Argentina irrespective of various sociodemographic characteristics. Higher BMI remains more common in women of lower SEP compared with those of higher SEP.

Keywords
BMI
Obesity
Socio-economic position
Representative survey
Argentina
Adults

The body weight of individuals in low- and middle-income countries (LMIC) is increasing, resulting in rapid growth in the prevalence of overweight and obesity[1–3]. These trends are alarming because obesity is linked to increases in CVD, type 2 diabetes and certain types of cancer, among other diseases[4]. In addition, increasing body weight in LMIC is likely to exacerbate health disparities between so-called developed and developing countries[5]. Approximately 80 % of the deaths due to non-communicable diseases now occur in LMIC[5] and the rise in overweight and obesity may further contribute to the non-communicable disease burden in these countries[6].

While the greatest proportion of obesity and its concomitant co-morbidities has historically fallen upon those of higher socio-economic position (SEP) in LMIC[7], recent research has highlighted that the burden is shifting to lower-SEP populations[6,8,9]. Studies comparing the association of SEP and BMI across countries have found that the relationship is dependent upon a country's level of economic development, with positive associations at lower levels of development transitioning to inverse associations at higher levels[2,9,10]. However, this pattern has not been uniform and appears to differ according to gender[11,12], urbanicity[13] and the level of social and economic inequality[14].

Despite general recognition that the prevalence of obesity is increasing across the globe, there have been few studies examining temporal trends in BMI by SEP[1,15]. Several studies of LMIC have demonstrated that the greatest temporal increases in body weight are occurring among low-SEP groups[8,16,17]. Other studies in predominantly low-income settings have revealed just the opposite: those in high-SEP groups experience greater secular increases in body weight[18,19]. Given the heterogeneity in the literature, additional studies are warranted to further understand how various factors are related to temporal trends in BMI within countries, as such knowledge may help to predict and mitigate obesity-related diseases.

Argentina is a middle-income country that has experienced rapid economic change over the past two decades, making it an important context in which to investigate the

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social patterning of BMI over time. Economic policies implemented in the 1990s resulted in a broad political and institutional crisis in 2001 accompanied by drastic social and economic changes that increased unemployment, poverty and marginalization, especially in women and young people. Starting in 2003, neo-Keynesian policies strengthened national production and increased income, allowing greater access to food products, especially in populations with fewer resources[20]. Large macroeconomic changes such as these have been shown to influence body weight in other countries[21], but their effects in Argentina remain unclear.

Using large, nationally representative samples of Argentine adults at two different time points, we explored temporal trends in body weight during a period of economic expansion. In particular, we investigated the extent to which trends over time varied by SEP and regional economic indicators. We also examined whether trends and predictors of trends were different in men and women.

Methods

Study populations and data collection

The data came from two national surveys undertaken in Argentina in 2005 and 2009 (Encuesta Nacional de Factores de Riesgo (ENFR); National Survey of Risk Factors for Noncommunicable Diseases)[22]. The ENFR was designed to ascertain the prevalence and distribution of chronic disease risk factors in the Argentine adult population. The survey employed a similar four-stage probabilistic sampling design in 2005 and 2009. Cities/towns of at least 5000 inhabitants were sampled during the first stage; censal radios (areas with an average of 300 housing units) or aggregates of censal radios were sampled during the second stage; housing units were sampled during the third stage; and an individual aged 18 years or older was randomly sampled from each household during the fourth stage. In 2005 and 2009, 41 392 individuals and 34 732 individuals participated in the survey, with response rates for the sampled residences of 89·6 % and 79·8 %, respectively. Individuals with missing information for any of the variables of interest were excluded from the analysis, resulting in the exclusion of 3482 individuals in 2005 and 2318 in 2009. A total of nineteen extreme (and likely erroneous) BMI observations (>99th percentile) were eliminated based upon visual inspection of the BMI distribution. This gave a final analytic sample of 70 305, constituting 92 % of the original participants.

Trained interviewers carried out the survey at different times throughout the day. Participants reported their weight, height, chronic disease diagnoses and various behaviours, in addition to demographic and socio-economic information. The validity of self-reported measures was evaluated in a pilot sample; Spearman correlation coefficients comparing self-reported and measured height and weight were $r = 0{\cdot}88$ and $r = 0{\cdot}89$, respectively, suggesting good measurement validity[23]. The correlation between self-reported and measured weight did not differ by sex or education level.

Analytic variables

BMI was the outcome of interest and was calculated by dividing a participant's weight by the square of their height (kg/m^2). We treated BMI as a continuous variable in our models to examine the effects of SEP and time across the spectrum of body weight. For descriptive purposes, BMI was treated as a categorical variable classifying people as overweight (BMI ≥25·0 kg/m^2) and obese (BMI ≥30·0 kg/m^2) according to WHO guidelines[24].

Age, gender, educational attainment, survey year and provincial per capita Gross Domestic Product (GDP) were the independent variables of interest. SEP was measured by the highest level of education completed. Educational attainment was grouped into four categories based upon the distribution of participants and the hypothesized effects on body weight: (i) incomplete primary education (<8 years); (ii) complete primary education/incomplete secondary education (<12 years); (iii) complete secondary education/incomplete university or tertiary education; and (iv) complete university or tertiary education. Survey year was included to assess temporal trends in BMI according to SEP. Per capita GDP was used as a marker of economic development at the province level and was calculated by dividing the each province's annual GDP in Argentine pesos by the provincial population. Information on annual GDP was derived from official government estimates[25] and estimates of the provincial populations in 2005 and 2009 were derived from the Argentine National Institute of Statistics and Censuses[26]. For analyses, change in per capita GDP was calculated by subtracting the 2005 value from the 2009 value and then dividing by the 2005 value, and was categorized as high increase (113–247 %), medium increase (101–113 %) and low increase (3–101 %) based upon tertiles of the province-level distribution.

Data analysis

All analyses were stratified by gender due to previous evidence of variations in socio-economic patterning of BMI by gender[27,28] and differential effects of economic development on women's *v.* men's health[1,13,29]. Appropriate unconditional analyses were utilized for each gender stratum, in accordance with recommendations for complex survey data[30]. To evaluate the association between each predictor variable and BMI, we utilized survey-weighted multivariable linear regression models with BMI as the dependent variable. All models included age, survey year, education, per capita GDP (at the time of the survey, time-varying) and an interaction between education and per capita GDP, based upon prior research suggesting heterogeneity in the SEP–BMI relationship by level of

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economic development[10,14]. Bivariate analyses revealed a non-linear relationship between age and BMI that was accounted for with a linear spline with a knot at age 60 years. Differences in time trends by age and education were investigated by adding interactions of these variables with survey year. In order to explore whether secular trends varied as a function of per capita GDP at the time of the first survey (baseline) or as a function of change in per capita GDP between 2005 and 2009, regression models also included categories of baseline per capita GDP and change in per capita GDP and their interactions with time. Interaction terms to explore heterogeneity in the temporal trends in BMI by individual and province-level characteristics were evaluated in separate models and their significance was tested using Wald test statistics. To avoid collinearity, the main effect of survey year-specific per capita GDP was not included in models that included baseline per capita GDP. While continuous BMI was of primary interest, sensitivity analyses using categorical obesity *v*. non-obesity as the outcome were also evaluated using Poisson regression. In addition, because not all 18-year-olds have attained their highest level of education, we performed sensitivity analyses by restricting the sample to only those 25 years of age and older. All analyses took into account the complex sample design and were conducted using the statistical software packages SAS version 9·2 and STATA version 13·1.

Results

Sample characteristics for the 2005 and 2009 surveys are displayed by gender in Table 1. A minority of men had completed secondary school or more in both 2005 and 2009 (44·2 % and 48·9 %, respectively). Women were slightly more educated than men, with 48·1 % and 52·3 % completing secondary school or more in 2005 and 2009, respectively. Province per capita GDP increased substantially between the two surveys, with the median more than doubling for both men and women. In 2005, 15·4 % of men were obese, increasing to 19·1 % in 2009. For women, the proportion of obesity increased from 13·9 % to 17·1 % from 2005 to 2009. Obesity was unequally distributed by education level in both men and women. For men, the proportion of those in the lowest education category who were obese (20·1 % and 22·5 % in 2005 and 2009, respectively) was greater than those in the highest education category (12·0 % and 17·3 % in 2005 and 2009, respectively; data not shown). Women demonstrated even greater differences in the proportion of obesity by education level, with 22·5 % and 30·3 % of women in the lowest educational category being obese in 2005 and 2009, compared with 8·6 % and 10·0 % of women in the highest education category (data not shown).

In models adjusted for age, survey year, education, per capita GDP and an interaction between education and per capita GDP, BMI was positively associated with age for those up to 60 years old and inversely associated for those greater than 60 years old (Table 2). The average BMI for both men and women increased between the two survey periods. For women, the average BMI increased by 0·19 (95 % CI 0·14, 0·24) kg/m^2 annually between 2005 and 2009. This was slightly greater than the 0·15 (95 % CI 0·11, 0·20) kg/m^2 annual increase in average BMI for men.

In women, higher education was associated with lower BMI in a graded fashion, but there was evidence of additive interaction between education and per capita

Table 1 Selected characteristics of the study sample by gender: National Survey of Risk Factors for Noncommunicable Diseases, Argentina, 2005 and 2009*

	Men				Women			
	2005		2009		2005		2009	
	n, mean or median	%, SE or IQR	*n*, mean or median	%, SE or IQR	*n*, mean or median	%, SE or IQR	*n*, mean or median	%, SE or IQR
Total number	16 886	–	14 331	–	21 008	–	18 080	–
Age (years), mean and SE	42·8	0·31	42·8	0·25	43·6	0·28	44·1	0·21
Education, *n* (%)								
Primary incomplete	2110	10·7	1719	9·4	2586	11·2	2103	10·3
Primary complete/secondary incomplete	7135	45·1	6023	41·7	7866	40·7	6706	37·3
Secondary complete/university or tertiary incomplete	5655	33·4	4837	36·2	7098	33·3	6100	34·9
University or tertiary complete	1986	10·8	1752	12·7	3458	14·8	3171	17·4
Per capita GDP (Argentine pesos)								
Mean and SE	14 201	119·3	29 173	307·9	14 619	116·2	29 584	285·5
Median and IQR	11 494	2494	23 523	3752	11 542	2404	23 531	3597
BMI (kg/m^2), mean and SE	26·1	0·1	26·7	0·1	24·8	0·1	25·4	0·1
Overweight, *n* (%)†	7195	41·9	6308	43·2	5851	26·9	5374	28·1
Obesity, *n* (%)†	2874	15·4	2859	19·1	3119	13·9	3153	17·1

IQR, interquartile range.
*Percentages, means and medians were survey weighted.
†Overweight classified as BMI = 25·0–29·9 kg/m^2 and obesity classified as BMI ≥30·0 kg/m^2.

Table 2 Mutually adjusted mean differences in BMI by age, education at the 25th and 75th percentiles of province-level per capita Gross Domestic Product (GDP), province-level per capita GDP at different education levels, and time, for men and women: National Survey of Risk Factors for Noncommunicable Diseases, Argentina, 2005 and 2009*

	Men (*n* 31 217)		Women (*n* 39 088)	
	Mean difference	95 % CI	Mean difference	95 % CI
Age (years)†				
≤60	1·03	0·95, 1·10	1·19	1·11, 1·27
>60	– 1·27	– 1·44, – 1·10	– 1·18	– 1·36, – 1·00
Education at 25th percentile of per capita GDP				
Primary incomplete	– 0·11	– 0·47, 0·26‖	2·37	1·98, 2·77¶
Primary complete/secondary incomplete	0·10	– 0·18, 0·39	1·85	1·58, 2·13
Secondary complete/university or tertiary incomplete	0·11	– 0·17, 0·40	0·77	0·51, 1·04
University or tertiary complete	Reference		Reference	
Education at 75th percentile of per capita GDP				
Primary incomplete	– 0·03	– 0·38, 0·32	2·66	2·27, 3·05
Primary complete/secondary incomplete	0·26	0·01, 0·50	2·05	1·81, 2·29
Secondary complete/university or tertiary incomplete	0·16	– 0·09, 0·41	0·91	0·68, 1·13
University or tertiary complete	Reference		Reference	
Per capita GDP‡				
Primary incomplete	– 0·00	– 0·05, 0·05	0·02	– 0·05, 0·08
Primary complete/secondary incomplete	0·02	– 0·01, 0·04	– 0·01	– 0·04, 0·03
Secondary complete/university or tertiary incomplete	– 0·01	– 0·03, 0·02	– 0·02	– 0·05, 0·00
University or tertiary complete	– 0·02	– 0·05, 0·01	– 0·06	– 0·08, – 0·03
Year§	0·15	0·11, 0·20	0·19	0·14, 0·24

*Model includes age, education, per capita GDP, year and an interaction term between education and per capita GDP.
†Mean difference for a 10-year increase in age.
‡Per capita GDP was mean-centred. Mean differences in BMI are for a 1-IQR increase (3058 Argentine pesos).
§Annualized mean difference in BMI.
‖Test for linear trend across education category at mean per capita GDP: $P=0·53$.
¶Test for linear trend across education category at mean per capita GDP: $P<0·0001$.

GDP ($P=0·02$) such that the inverse association between education and BMI was stronger at higher levels of per capita GDP and weaker at lower levels (mean differences compared with complete university were 2·37 (95 % CI 1·98, 2·77) kg/m^2 for incomplete primary school, 1·85 (95 % CI 1·58, 2·13) kg/m^2 for incomplete secondary school and 0·77 (95 % CI 0·51, 1·04) kg/m^2 for complete secondary school at the 25th percentile of per capita GDP; and 2·66 (95 % CI 2·27, 3·05) kg/m^2, 2·05 (95 % CI 1·81, 2·29) kg/m^2 and 0·91 (95 % CI 0·68, 1·13) kg/m^2, respectively, at the 75th percentile of per capita GDP). In contrast, there was no clear relationship between education and BMI in men and limited evidence that per capita GDP modified the association of education with BMI (*P* for additive interaction = 0·23). No significant differences in mean BMI between educational groups existed at the 25th percentile of province per capita GDP. At the 75th percentile, men at the lowest education level had mean BMI similar to those with a university education (mean difference = – 0·03 (95 % CI – 0·38, 0·32) kg/m^2). However, men with incomplete secondary education or complete secondary education had average BMI that was 0·26 (95 % CI 0·01, 0·50) kg/m^2 and 0·16 (95 % CI – 0·09, 0·41) kg/m^2 higher than those with the highest education level, suggesting a possible non-linear relationship between education and BMI.

As expected from the presence of additive interaction between per capita GDP and education in women, the association between per capita GDP and BMI differed across educational categories: per capita GDP was inversely associated with BMI in women with complete university/tertiary education (mean difference per interquartile range increase in per capita GDP: – 0·06 (95 % CI – 0·08, – 0·03) kg/m^2), but this association became progressively weaker and eventually reversed as education level decreased (e.g. mean difference per interquartile range increase in per capita GDP: 0·02 (95 % CI – 0·05, 0·08) kg/m^2 for women with incomplete primary education; Table 2). Weaker and less consistent associations between per capita GDP and BMI were observed in men. Figure 1 displays the predicted BMI according to per capita GDP for different education categories.

Table 3 shows time trends in BMI for various socio-demographic groups. Mean annual changes in BMI showed some heterogeneity by age. Women in the youngest age quintile (18–25 years) demonstrated the greatest mean annual increase in BMI (0·27, 95 % CI 0·16, 0·37 kg/m^2), while those in the fourth quintile (47–59 years) demonstrated the least (0·11, 95 % CI – 0·00, 0·22 kg/m^2; *P* for linear trend across age categories = 0·01). Men exhibited a different pattern, with those in the fourth quintile experiencing the greatest mean annual increase in BMI (0·23, 95 % CI 0·12, 0·34 kg/m^2) and those in the oldest quintile (60–98 years) experiencing the least (0·06, 95 % CI – 0·03, 0·14 kg/m^2; *P* for linear trend = 0·15). Temporal trends in BMI did not appear to differ by education level (*P* for interaction = 0·99 and 0·49 for women and men, respectively) or baseline province per

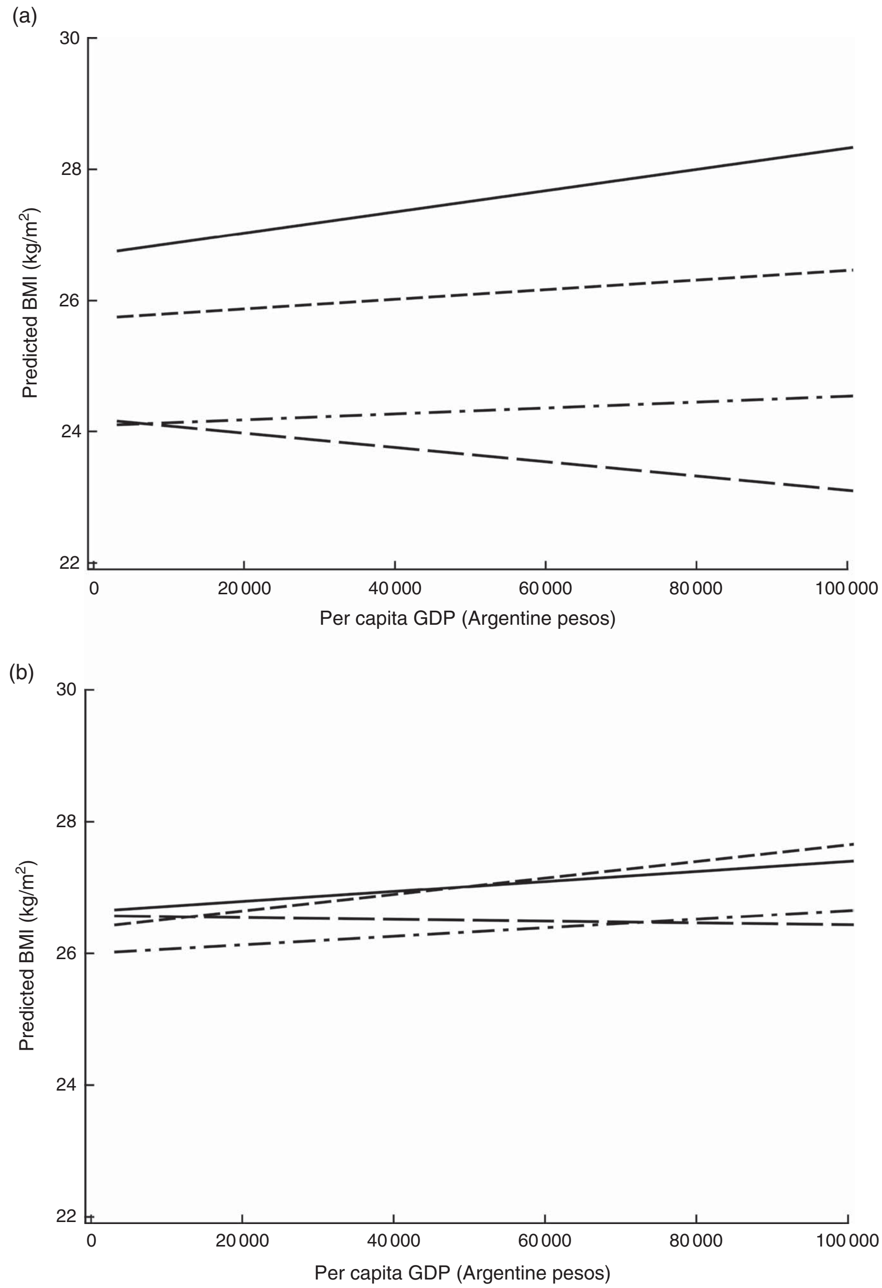

Fig. 1 Association between BMI and per capita Gross Domestic Product (GDP) by level of education (———, incomplete primary education; – – – – –, complete primary education/incomplete secondary education; - - - - -, complete secondary education/incomplete university or tertiary education; — — —, complete university or tertiary education) for (a) women and (b) men: National Survey of Risk Factors for Noncommunicable Diseases, Argentina, 2005 and 2009. Predicted values are based upon a model that includes age, education, per capita GDP, year and an interaction term between education and per capita GDP. *P* values testing the interaction between education level and time-varying per capita GDP were 0·02 for women and 0·23 for men

capita GDP (*P* for interaction = 0·51 and 0·66 for women and men, respectively). However, there was limited evidence that temporal trends differed according to the annual change in province per capita GDP between 2005 and 2009. For both men and women, residence in provinces experiencing greater annual increases in per capita GDP was associated with greater mean annual increases in BMI (increase of 0·21, 0·18 and 0·12 kg/m^2 in high, medium and low provinces for men; increase of 0·21, 0·22 and 0·15 kg/m^2 in high, medium and low provinces for women), although the differences were not statistically significant.

Sensitivity analyses using obesity *v.* non-obesity as the outcome revealed patterns that were qualitatively similar to analyses of continuous BMI. The one notable difference was an educational gradient in obesity for men such that

Table 3 Mean annual changes in BMI between 2005 and 2009 by age, education level, baseline per capita Gross Domestic Product (GDP), and change in per capita GDP, for men and women: National Survey of Risk Factors for Noncommunicable Diseases, Argentina*

	Men (*n* 31 217)		Women (*n* 39 088)	
Interaction terms	Mean annual change	95 % CI	Mean annual change	95 % CI
Model 1: Age quintile (years) × time†				
1 (18–25)	0·21	0·12, 0·30	0·27	0·16, 0·37
2 (26–34)	0·11	0·01, 0·21	0·21	0·12, 0·31
3 (35–46)	0·15	0·06, 0·23	0·25	0·15, 0·35
4 (47–59)	0·23	0·12, 0·34	0·11	− 0·00, 0·22
5 (60–98)	0·06	− 0·03, 0·14	0·13	0·03, 0·22
Model 2: Education × time‡				
Primary incomplete	0·06	− 0·08, 0·19	0·21	0·05, 0·37
Primary complete/secondary incomplete	0·16	0·08, 0·23	0·18	0·10, 0·27
Secondary complete/university or tertiary incomplete	0·17	0·11, 0·24	0·19	0·12, 0·26
University or tertiary complete	0·16	0·05, 0·27	0·19	0·10, 0·28
Model 3: Baseline per capita GDP × time§				
Low	0·15	0·10, 0·20	0·17	0·12, 0·22
Medium	0·18	0·11, 0·25	0·22	0·14, 0·29
High	0·15	0·08, 0·21	0·21	0·13, 0·28
Model 4: Annual change in per capita GDP × time‖				
Low	0·12	0·07, 0·18	0·15	0·10, 0·20
Medium	0·18	0·12, 0·24	0·22	0·16, 0·29
High	0·21	0·12, 0·29	0·21	0·12, 0·30

*Time interactions were added to each model separately. All models were adjusted for age, time, education level, time-varying per capita GDP and time-varying per capita GDP × education interaction, except for the baseline per capita GDP model, which used baseline per capita GDP instead of time-varying per capita GDP.
†*P* for age × time interaction = 0·07 and 0·10 for men and women, respectively. *P* for linear trend across age quintiles = 0·15 and 0·01 for men and women, respectively. Age was categorized for this model only.
‡*P* for education × time interaction = 0·49 and 0·99 for men and women, respectively.
§*P* for baseline per capita GDP × time interaction = 0·66 and 0·51 for men and women, respectively.
‖*P* for change in per capita GDP × time interaction = 0·19 and 0·18 for men and women, respectively.

those with incomplete primary, secondary and tertiary school were more likely to be obese compared with those with a university education (prevalence ratio = 1·40 (95 % CI 1·14, 1·73), 1·40 (95 % CI 1·17, 1·67) and 1·20 (95 % CI 1·00, 1·44), respectively). Analyses of temporal trends revealed that the prevalence of obesity increased annually for men and women alike (prevalence ratio = 1·06 (95 % CI 1·04, 1·09) and 1·07 (95 % CI 1·04, 1·09), respectively). There was no significant heterogeneity in these temporal trends by age, education level and province-level per capita GDP (data not shown). Sensitivity analyses excluding individuals younger than 25 years of age produced results that were qualitatively the same as those using the full age range of the sample, although educational gradients in BMI did become slightly more pronounced, particularly in women (data not shown).

Discussion

Using large, nationally representative samples of Argentine adults in 2005 and 2009, we found evidence of persistent social patterning of BMI over time for women and, to a much lesser extent, for men. A strong inverse relationship between SEP and BMI was evident in women, while men demonstrated a more complex relationship, with those in the middle education categories having slightly higher BMI than those in either the highest or the lowest education category. The SEP–BMI relationship was modified by province per capita GDP in women, but not men, with the inverse gradient between education and BMI in women being more pronounced in provinces with higher per capita GDP.

Despite the relatively short time period separating the two surveys, we also observed an increase in average BMI for both men and women over time, with the change being slightly greater for women. If this trend continues for 10 years, the average BMI will increase by 1·9 kg/m^2 for females and 1·5 kg/m^2 for males. To put this into perspective, a 1 kg/m^2 increase in BMI for an individual of height 6 ft (~1·8 m) corresponds to a 3·3 kg increase in weight. The temporal trend observed did not differ by education level or baseline per capita GDP, although there was limited evidence of temporal differences by age and by annual change in per capita GDP, with the average BMI increasing more in provinces with high or medium gains in per capita GDP relative to low gains.

The social patterning of BMI observed in our study is consistent with recent research in middle-income countries. An inverse association between SEP and BMI for women has been well established in the literature, in regions ranging from Europe[31], to Africa[32], to Latin America[11,12]. For men, however, the associations have been far less consistent, with several studies finding no social patterning of overweight and obesity[27] and others finding positive or U-shaped relationships[9,33,34]. The mechanisms linking

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SEP and BMI in Argentina are not fully understood, although several explanations likely exist. As in many developing countries, rapid economic development, urbanization and shifting occupational patterns have contributed to a so-called 'obesogenic environment', in which energy-dense food and drinks are increasingly available, marketed and consumed, and physical activity is often diminished[8,35–37]. High-SEP individuals may be better positioned than their low-SEP counterparts to counteract these obesogenic environments due to greater flexibility in dietary and physical activity choices, including jobs with more accommodating schedules, as well as increased health knowledge[24]. In Argentina, education is an important determinant of both occupation and health knowledge, and with over 20 % of 15–19-year-olds not enrolled in any form of education, there is a possibility of increasing educational differences in BMI that could affect a large segment of the population[38]. Social and cultural forces may also reinforce the patterns observed through the social patterning of ideal body types, which has been demonstrated in other Latin American contexts[39].

Previous research in Argentina utilizing the 2005 ENFR survey demonstrated that high-SEP women were more likely to consume fruits and vegetables than low-SEP women, but high-SEP men were more likely to have low physical activity than their low-SEP counterparts[13]. Such associations could explain some of the social patterning observed in our study, and are consistent with observations from neighbouring Brazil where low-SEP individuals are less likely to report leisure-time physical exercise than high-SEP individuals[40]. Studies with more comprehensive measures of food intake and physical activity over time for people in different socio-economic groups are needed to further understand the causes of the social patterning of BMI.

We found that for women, but not men, the inverse association between education and BMI became stronger at higher levels of province per capita GDP. Such heterogeneity is consistent with previous work demonstrating stronger inverse relationships between obesity and SEP with increasing economic development[9,41,42] and our results represent an important within-country supplement to several recent cross-national studies that included only women[14,16]. More pronounced social patterning at higher per capita GDP may reflect the disproportionate effect of increasingly obesogenic environments on low-SEP women. Why men do not exhibit similar heterogeneity is unknown, but some hypothesize that men may experience delayed transitions in nutrition and physical activity during the development process relative to women[9]. In Argentina, low-SEP men often work in physically demanding occupations which may help explain the absence of heterogeneity by per capita GDP. That such heterogeneity in the SEP–BMI relationship exists confirms the importance of focusing on obesity prevention during the development process.

Our results also demonstrate a marked increase in BMI over time for both sexes. These secular trends are similar, though stronger, than those observed in other middle-income countries, including Brazil[8] and China[34]. However, the temporal trends in Argentina did not appear to differ by SEP or province level of economic development. This is in contrast to several studies where temporal trends in BMI differed by SEP[8,17,34]. For example, a longitudinal study in China witnessed the emergence and growth of social disparities in BMI over time, with low-SEP women and high-SEP men experiencing more rapid increases in BMI than their respective counterparts[34]. The similar increase in BMI observed across social and demographic groups in Argentina points to the importance of large-scale changes that are affecting the whole population.

We found some evidence that temporal trends may differ by both age and the magnitude of annual change in province per capita GDP (although these results should be interpreted with caution as the differences were not statistically significant at the $P<0{\cdot}05$ level). Younger women appear to be gaining weight more rapidly than older women, while both young and late-middle-aged men are gaining weight fastest among men. Whether these differences represent a cohort effect, or some combination of nutritional and physical activity changes operating differently at different ages, is not known.

Provinces experiencing greater annual increases in per capita GDP tended to have higher annual increases in BMI. These preliminary results suggest that rapid GDP growth may have adverse effects on population distributions of BMI. For example, regions undergoing rapid economic development may experience rapid changes in cheap, energy-dense food availability and marketing, which likely contribute to greater temporal increases in BMI relative to regions undergoing slower development[43]. An increase in purchasing power of the population during the mid-2000s may have also allowed greater access to energy-dense foods[20]. Prior research supports the notion that increasing economic resources is related to the prevalence of overweight and obesity, although important heterogeneity may exist both between and within countries[44]. Understanding these processes may help identify effective strategies to prevent increases in BMI in these contexts.

Study limitations

Our study has several limitations. Height and weight were self-reported rather than objectively measured, undoubtedly introducing measurement error[45]. Studies comparing measured and self-reported anthropometric data have suggested that weight is often underestimated in women and height overestimated in men[46]. There can also be differential reporting error by BMI status, with studies from Brazil suggesting that underweight individuals tend to overestimate their BMI while overweight individuals underestimate theirs[47,48]. To the extent that this pattern exists in our study, overweight and obesity prevalence would be underestimated and normal weight prevalence overestimated. Notwithstanding this possibility, the pilot study demonstrated a high correlation between measured and self-reported height and weight that was non-differential by sex or education level, although differences by BMI status were not reported[23]. Furthermore, our analysis was largely focused upon temporal trends in BMI, with particular interest in trends by education level. In order for our temporal trend results to be biased due to the self-reporting of height and weight, education level would have to influence the reporting of height and weight differently in 2005 and 2009. We feel that this is unlikely, and indeed there is some evidence from the literature to suggest that errors in self-reported anthropometric data do not differ over time[46]. SEP was measured at the same time as BMI, precluding inferences regarding causal effects of SEP on BMI. However, the study was intended to evaluate the social patterning of BMI rather than to investigate the causal effect of SEP on BMI. Per capita GDP is an imperfect, though widely used, marker of economic development and other macroeconomic indicators may also be beneficial to understanding the social patterning of body weight[37]. Change in per capita GDP was not inflation-adjusted due to the absence of accurate inflation estimates for Argentina during this period and thus represented a mix of both real economic growth and inflation. However, as our analyses concerned comparisons between provinces, and provinces were likely to experience similar rates of inflation, our results may accurately reflect relative changes in economic growth. Finally, our analyses of temporal trends in BMI by age, SEP and per capita GDP are limited by the relatively short interval between our two surveys.

Study strengths

An important strength of our study is the use of two national surveys done with similar methodology. Our study is among the few that are able to examine temporal trends and predictors of temporal trends using nationally representative data from a middle-income country. By linking these surveys to province-level GDP data at two time periods, we were able to investigate the impact of GDP on social patterning and temporal trends in BMI. Moreover, in contrast to some recent research focusing exclusively on economic development and the social patterning of BMI in women[10,14,16], our study includes men and highlights important differences by gender. Argentina provides an interesting case study for evaluating trends in BMI during a period of economic expansion. Following a national financial crisis in 2001 that precipitated rapid increases in poverty, the country has experienced a period of steady economic growth[49]. Evaluating the health consequences of these macroeconomic changes has been highlighted as an important need in population health[50].

Conclusion

In summary, utilizing two waves of nationally representative data, we found that lower-SEP women, but not men, had increased BMI relative to their higher-SEP counterparts and that BMI is increasing over time for all groups. Province-level economic development significantly modified the SEP–BMI relationship in women, but not men, such that the social patterning of BMI was more pronounced in provinces with higher per capita GDP. Greater change in province-level economic development over the study period was marginally associated with higher annual increases in average BMI in both men and women.

It has become increasingly clear that such trends in BMI should be a concern for public health authorities and policy makers. As a risk factor for multiple chronic diseases, obesity holds the prospect of further exacerbating the already sizeable burden of non-communicable diseases on LMIC[5]. Further, the brunt of the burden due to non-communicable diseases in many middle-income countries is increasingly borne by low-SEP groups, leading to widening disparities in health both within and between countries[5]. Policies and programmes directly targeting obesogenic environments should therefore be central public health priorities in Argentina, and in other middle-income countries, in order to mitigate the rapid increases in overweight and obesity and their concomitant co-morbidities, particularly among low-SEP populations.

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