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Educational disparities in diabetes: a mediation analysis through BMI among urban adults from Argentina

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ABSTRACT

Introduction: Low socio-economic status is linked to a higher probability of having type 2 diabetes mellitus in adulthood, including body mass index as a mediation factor in such association. However, the evidence from low- and middle-income countries is scarce and the mechanisms beyond this relationship are not yet completely acknowledge.

Objective: The purposes of this study are to i) evaluate the potential mediating role of body mass index in the relationship between educational background and diabetes mellitus; ii) assess whether these associations vary by gender and age.

Methods: Cross-sectional study. Data came from the Argentine National Health Survey of Risk Factors 2013 (n=30,119, 18-years-old and older). Age-adjusted gender-specific simple mediation modeling was conducted to estimate the potential mediation role of body mass index, in the association between educational level and self-reported diabetes mellitus.

Results: In women there was a positive direct (OR 1.11; 95% CI 1.09, 1.13) and indirect -through body mass index- associations (OR 1.12; 95% CI 1.09, 1.36) between low education and diabetes mellitus. The associations were also significant for older women (50 years +), directly (OR 1.28; 95% CI 1.12, 1.44) and indirectly (OR 1.09; 95% CI 1.07, 1.13). In men, low education was associated with lower odds of diabetes mellitus (OR 0.86, 95% CI 0.76, 0.98).

Conclusion: Decreasing body mass index might be an intermediate target to reduce the occurrence of diabetes mellitus among Argentinean adults, particularly among socially disadvantaged women.

KEYWORDS

BMI; mediation; diabetes; educational level; Argentina.

ABBREVIATIONS

BMI: body mass index.

DM: type 2 diabetes mellitus.

$ENFR_{2013}$: Encuesta Nacional de Factores de Riesgo 2013.

LMICs: low and middle income countries.

INTRODUCTION

Nowadays diabetes mellitus (DM) is one of the main causes of disability and death worldwide, while more than 90% of DM cases correspond to type 2 DM[1]. According to the International Diabetes Federation, there are currently 351.7 million people of working age (20–64 years) with diagnosed or undiagnosed diabetes in 2019[2]. The prevalence of DM increased dramatically over the last two decades, while the adult population with DM has tripled[2]. The trends are projected to rise, with the largest increase coming from low- and middle-income countries (LMICs)[3].

In Latin America, it was estimated that over 41 million adults had DM in 2015[4], and it was also reported that approximately

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half of the patients were undiagnosed[5]. Moreover, DM became one of the main causes of mortality and premature disability in the last five decades in this region[5]. In Argentina, although it was suggested that better health care access -but not an actual increase in incidence- was likely the reason for increasing DM rates[6], the prevalence of DM showed an alarming increasing trend in the last years, moving from 8.4% in 2005 to 12.7% in 2018[7].

Among the factors that have been pointed out to explain the rising tendencies in type 2 DM are urbanization, population ageing, energy dense dietary patterns, sedentary lifestyle and obesity[1]. Additionally, socio-economic position -and especially educational background- was reported to be associated with the occurrence of type 2 DM[8]. Although several studies have found that low educational background was linked to a higher probability of having type 2 DM in adulthood[9], the mechanisms beyond this relationship are not yet completely understood[10].

Previous studies have shown educational differences in insulin resistance among 8- to 11-year-olds, mediated by body fatness, whole blood n-3 LCPUFA and dietary fiber[11]. Moreover, social inequalities in the risk of type 2 DM were found in the elderly, and appeared to be linked to socio-economic variations in modifiable lifestyle factors, such as physical activity, dietary habits and the consequent nutritional status[10].

Although the reasons to explain the effect of body mass index (BMI) on the occurrence of type 2 DM remained to be acknowledged, it was suggested that low educational level may influence unhealthy lifestyle behaviors such as poor diet quality and physical inactivity[12]. Furthermore, BMI was considered a mediator of the association between educational level and DM[13,14]. Thus, BMI seems to play an important role in that process.

In this sense, previous evidence from Western European countries suggested that the inverse relationship between educational level and type 2 DM was only partially explained by BMI[13]. However, the interplay between educational background, type 2 DM and BMI seems to be different when comparing LMICs[9]. In point of fact, in contrast to the association seen in high-income countries, in LMICs the DM risk was highest among those with greater educational attainment, independent of BMI[15].

In Argentina, a middle-income country with high social disparities, DM is more frequent among individuals with lower educational level, compared with those with greater educational attainment[7]. Additionally, the prevalence of self-reported DM was higher in men (9.5% vs. 7.4% in women), and among individuals aged ≥ 50 years (around 14%; two or three times the prevalence of younger adults)[7]. Despite that previous studies have shown social disparities by educational attainment for both, DM and BMI[16], to the best of the author's knowledge, no studies in Argentina have so far assessed the education-DM association, considering BMI as a potential mediator. Thus, the objectives of this study are to: i) evaluate the potential mediating role of BMI in the relationship between educational level and DM among the adult population of Argentina; ii) assess whether these associations vary by gender and age.

METHODS

Sample

Data used in this study came from the Argentine National Health Survey of Risk Factors 2013 ('Encuesta Nacional de Factores de Riesgo', $ENFR_{2013}$), a cross-sectional nationally representative survey conducted in locations with at least 5,000 inhabitants. Sample size and response rate of the $ENFR_{2013}$ were 32,365 and 70.7%, respectively. After excluding individuals with missing data on education, self-reported weight and height and DM, the selected sample included 30,119 individuals, 18-years-old and older (mean age in years (SD) 44.5 (17.7); 55.1% women). Further methodological aspects of the ENFRs can be found elsewhere[17].

Variables

The exposure variable in the analysis was the level of education, a well-known indicator of individual socio-economic status. The level of education has been largely associated with both DM and BMI[9]. For analytical purposes, the educational indicator was dichotomized into 'low education' (up to complete primary, including no formal education) and 'high education' (secondary or university).

The mediator variable, BMI (height (kg) / weight $(m)^2$), was estimated by self-reports of height and weight. BMI was independently associated with the risk of being diagnosed with DM[18], and was reported to mediate part of the educational differences in DM[14].

The individual probability of self-reported DM was evaluated as the main outcome in the analysis. DM was defined as having been told by a health professional that one had DM or high blood sugar. Thus, a dichotomous variable with 1. yes and 0. no, was created. In this study, 'DM' was referred without distinguishing between type 1 and type 2 DM.

Other variables used in the analysis included age and gender, since it was reported that the occurrence of DM varies by gender and age[1,19].

Statistical analysis

Age-adjusted gender-specific associations between educational level and the presence of self-reported DM were analyzed, including BMI as a potential mediator of such association. Simple mediation modeling was conducted to estimate direct and indirect associations between educational level and

DM. While the direct association involved the education–DM relationship, the indirect path included such association through BMI, the proposed mediator. Therefore, the indirect association was obtained by multiplying two regression coefficients: the coefficient when education was the exposure and BMI the outcome (*a*, see Figure 1); and the coefficient when BMI was the exposure and DM the outcome (*b*). Figure 1 describes the conceptual simple mediation model for these associations.

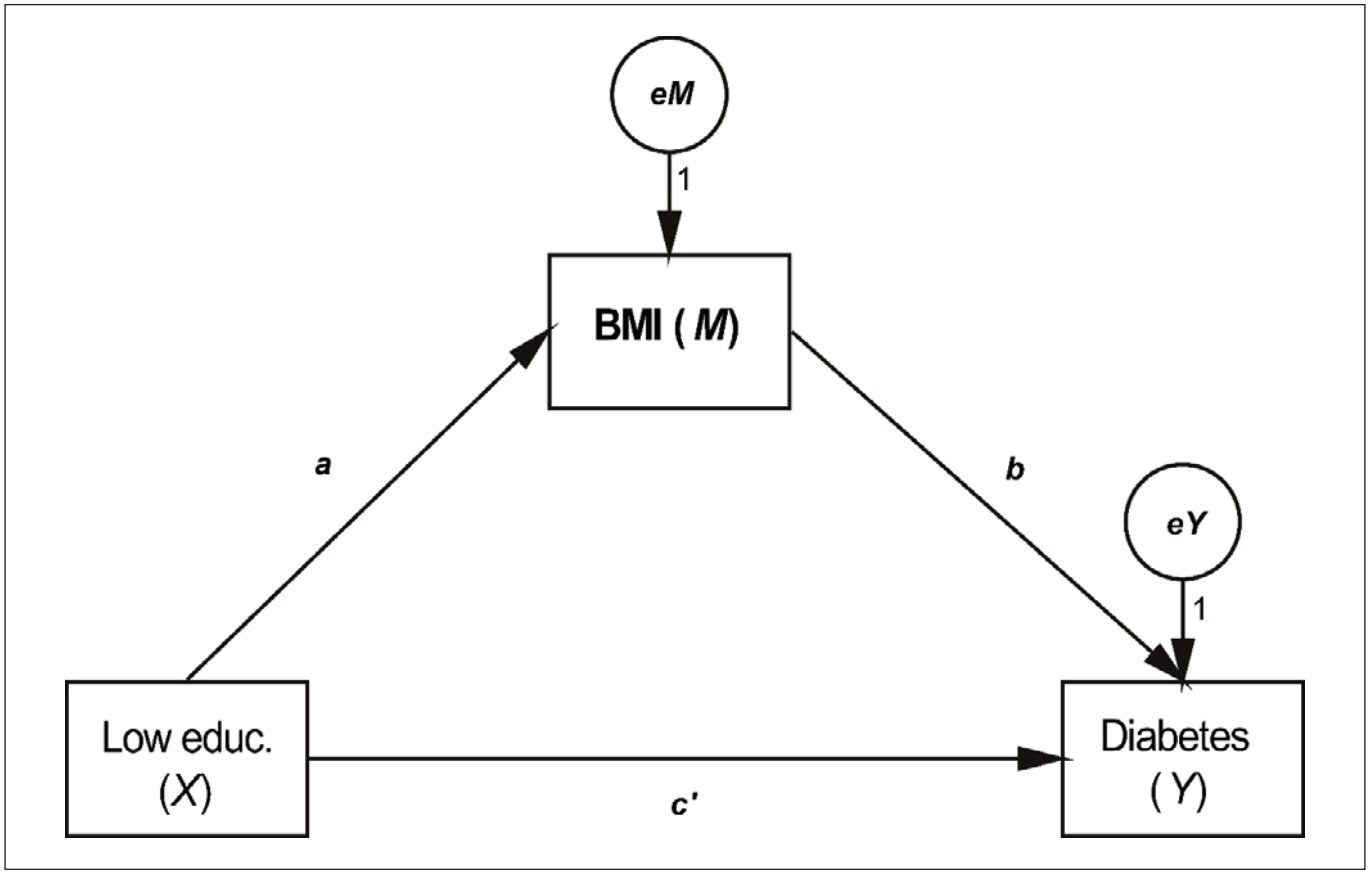
Rather than hypothesizing only a direct causal relationship between education and DM, the use of a simple mediational model allowed to test the hypothesis that education level was associated with BMI (mediator), which in turn influenced DM[20]. The mediator variable then serves to clarify the nature of the relationship between education and DM.

The modern path modeling approach applied here[20] has three major advantages over the traditional approach to testing mediation[21]. First, the capacity to determine whether there is a significant indirect 'effect' (association) and quantify it; second, the application of a non-parametric bootstrapping mediation method to determine the significance of direct and indirect associations between variables (this is beneficial because it better respects the irregularity of the sampling distribution of the indirect association); and, third, the application of a more powerful approach to conducting inferential statistics. Mediation modeling involved ordinary least squares path analysis using the 'PROCESS' tool v3.4 for SPSS (version 24)[20]. Results were derived from 1,000 bootstrapped samples, obtaining unstandardized regression coefficients, heteroscedastic-consistent standard errors and bias-corrected 95% CI. Odd ratios were calculated when appropriated.

RESULTS

Table 1 shows the characteristics of the study sample. DM was present in 11.2% of women and in 9.4% of men; accounting for 10.4% of the sample. BMI was higher among men (27.4%) compared to women (26.1%) ($p < 0.001$), and even higher among those individuals with diabetes (29.3% and 28.7%, respectively; $p < 0.01$). There was an educational gradient in BMI in both women and men, with higher values in those with primary (low) education ($p < 0.001$). Additionally, BMI was higher among older individuals, with the exception of those older than 65 years, where BMI showed a small decrease. This pattern was similar in both men and women ($p < 0.001$) (Table 1).

Figure 1. Conceptual simple mediation model for estimating the direct association between educational level and diabetes, and the indirect mediating association through body mass index (BMI). National Health Survey of Risk Factors of Argentina 2013.



X: independent variable; Y: dependent variable; M: mediator; *c'*: direct association; *axb*: indirect association

Table 1. Gender-specific mean body mass index (BMI), according to the study characteristics. $ENFR_{2013}$, Argentina.

	BMI[a], mean (kg/m²)		
	%	Women	Men
		n = 16,592	n = 13,527
BMI, mean (SD)***		26.1 (5.4)	27.4 (4.8)
Diabetes, yes**	10.4	28.7	29.3
Education***			
Primary	32.3	27.6	27.9
Secondary	40.4	26.0	27.3
University	27.4	24.9	26.8
Age groups***			
18-24	13.4	23.6	24.7
25-34	21.7	25.2	26.8
35-49	27.8	26.6	28.1
50-64	20.4	27.5	28.5
65+	16.6	27.1	27.5

[a] based on self-reports of weight and height weight; SD: standard deviation; Comparisons of mean BMI and BMI in individuals with diabetes were calculated by t-test; differences in BMI by categories of education and age were calculated by gender, using ANOVA; ***p < 0.001; **p < 0.01; * p < 0.05 (for each category within each gender).

Table 2 presents the direct association (*c'*) and the coefficients for the components of the indirect association (*a* and *b*). There were gender differences in the direct association between education and DM: while there was a positive relationship between low education and DM in women (p < 0.001), there was a negative association among men (p < 0.05). The indirect path is represented by two components: while low education was associated with higher BMI only in women (*a*; p < 0.001), BMI was positively associated with DM in both men and women (*b*; p < 0.001).

Table 2. Unstandardized regression coefficients for the gender-specific direct and indirect components of simple mediation models analysis. $ENFR_{2013}$, Argentina.

	Women	Men
	n = 16,592	n = 13,527
a, β for low education	1.372***	0.123
b, β for BMI	0.075***	0.065***
c', β for low education	0.197***	-0.150*

Age-adjusted analyses; a: β for low education when BMI is the outcome; b: β for BMI when diabetes is the outcome; *c'*: direct association (β for low education when diabetes is the outcome); *axb*: indirect association; ***p < 0.001; **p < 0.01; * p < 0.05.

The age-adjusted direct and indirect associations between primary (low) education and DM, including the analysis for old and young individuals, are shown in Table 3. In women, there were positive direct (OR 1.11; 95% CI 1.09, 1.13) and indirect (OR 1.12; 95% CI 1.09, 1.36) associations between low education and DM. Additionally, among older women, low educational level was associated both directly (OR 1.28; 95% CI 1.12, 1.44) and indirectly through BMI (OR 1.09; 95% CI 1.07, 1.13) with the presence of DM (Table 3). However, among younger women, this association occurred only indirectly (OR 1.14; 95% CI 1.11, 1.18). Contrarily, in men, low education was associated with lower odds of DM (OR 0.86, 95% CI 0.76, 0.98). However, this association disappeared when stratifying by age groups. Gender differences in the magnitude of the mediation by BMI might be due to the occurrence of a stronger influence of low educational level on high BMI in women (see Table 2; *a*, β =1,372; p < 0.001).

Table 3. Odds ratio (95% CI) for simple mediation models on the gender-specific and age-adjusted direct and indirect associations between low educational level and DM. Indirect associations represent the mediation through body mass index (BMI). $ENFR^{2013}$, Argentina.

	Women			Men		
	Total	≤ 50 years	> 50 years	Total	≤ 50 years	> 50 years
	n = 16,592	n = 10,292	n = 6,300	n = 13,527	n = 8,776	n = 4,753
	OR (95% CI)					
Direct association	1.11 (1.09, 1.13)	1.14 (0.95, 1.36)	1.28 (1.12, 1.44)	0.86 (0.76, 0.98)	0.87 (0.69, 1.10)	0.86 (0.74, 1.01)
Indirect association	1.12 (1.09, 1.36)	1.14 (1.11, 1.18)	1.09 (1.07, 1.13)	1.01 (0.99, 1.02)	1.02 (1.00, 1.04)	1.00 (0.99, 1.02)

Indirect association = association between education level and diabetes through body mass index (BMI); Exposure: primary (low) education vs. other; Outcome: self-reported diabetes; OR: odds ratio; 95% CI: 95% confidence interval; Unstratified analyses were adjusted by age.

DISCUSSION

This study evaluated the mediating role of BMI in the association between educational background and DM among adults from Argentina. BMI was found to be a mediating factor in the relationship between educational level and DM, only in women: there was a positive indirect association -through BMI- between low educational level and DM. Thus, low education was associated with higher BMI (*a*), which in turn influenced higher odds of DM (*b*). While the direct association was significant only among younger women, the indirect path was significant and similar in both old and young women, suggesting that the mediation of BMI is relatively independent of age. On the contrary, in men the low education-DM association occurred only directly -and negatively-, indicating a lower probability of DM among men with low educational background, without the mediation path through BMI and with no age differences.

Several studies have shown that individuals with low educational level status have higher morbidity and mortality rates for non-communicable diseases, including DM[22]. The epidemic of DM unequally affected educational groups: it increased more rapidly in lower educational groups[14] and, consistently with the results of this study, an inverse association between education and the risk of DM has been widely reported[14,22].

Individual education level is one the most frequently studied indicator of social status, with various studies reporting a higher probability of DM occurring among those with lowest educational attainment[22]. Educational differences in DM were broadly reported in high-income countries, in detriment of lower educational levels[8,13]. In contrast to the association reported for high-income countries, in LMICs the risk of DM was highest among those with greater educational background[15]. However, results of the present study showed low education associated with lower odds of DM only among men, and with higher probability of DM among women. Previous studies in Argentina evidenced educational disparities in DM, in detriment of those with lower educational and income levels[16], but no gender-specific differences were assessed.

Although the pathways to explain the association between educational background and type 2 DM remain unknown, it was suggested that lower education was linked to worse DM related health outcomes, including health behaviors[22,23]. Disparities in the access to healthy foods, places for physical activity and health information were factors proposed to explain the social patterning of DM[10]. Closely related, diet has been often pointed out as a mediator to explain the associations between educational level and DM[25]. Since diet quality varies greatly across the social spectrum, groups having low educational level suffer greater diet-related risk, including excess weight[25].

The relevance of BMI as a mediator in the association between education and DM was previously highlighted[13,14,27]. Steele et al.[14] identified seven risk factors underlying the DM-education linkage in older adults, with BMI representing the greater contribution. However, another study among adult Chinese did not report significant variations in the education-DM association, after including BMI as a mediator[25]. The mediation process through BMI could be partially explained by physiological and behavioral mechanisms related to BMI and DM, as described in other studies[27]. Our results were in line with the former studies, although we found gender differences in such associations.

There were gender differences in the direct and indirect –though BMI– associations between low educational level and DM. On the one hand, low educational level was associated with a higher probability of having DM in women, while in men it was associated with lower odds of DM. While some studies found that social inequalities in type DM were greater in women than in men[19], others evidenced a positive association between low educational level and the occurrence of DM in both men and women, but with steeper gradients among women[28]. On the other hand, in the present study an indirect -mediated by BMI- low educational level-DM association was found only among women. The educational differences in DM through the indirect path observed in women but not in men, could be explained by the existence of a stronger relationship between low education and high BMI among women. Similarly to the results reported in this study, Espelt et al.[28] found inequalities in the occurrence of type 2 DM, mediated by BMI, only in women.

The importance of considering gender when assessing the educational level-DM relationship was previously highlighted[22]. Both biological and psychosocial factors underlie sex and gender disparities in DM risk. Regarding biological factors, women experiment greater changes in body weight and hormones due to reproductive factors[29]. Psychosocial stress also appears to have a larger impact on women[30]. Additionally, low educational level contributes to unhealthy lifestyle behavior that leads to a higher BMI and type 2 DM, particularly in women[19]. Further, gender differences in the interplay between education, BMI and DM were reported for LMICs[9]. In this regard, Seiglie et al.[15] suggested that LMICs may be at an advanced stage in the nutrition transition but with no reversal in the socio-economic gradient of DM risk.

The gender-specific relationship between social position and DM might be also influenced by age[19]. Actually, the results of this study showed differences according to age only in women: a significant direct 'effect' of low education level on DM was found only among 50-year-old and older women, and the indirect association was stronger among the younger women. Ageing is closely related to metabolic disorders, such as type 2 DM[31]. The typical body fat increases, and the concomitant reduction in lean body mass during the ageing process contributes to the development of insulin resistance. Besides, ageing is related to a reduction in the insulin sensi-

tivity and insufficient compensation of beta cell function during the insulin resistance phase[32]. Furthermore, differences in access to physical activity and age-related attitudes around body weight could also be involved[33]. Thus, both physiological and social differences might be also playing a role in explaining the age and gender-differences described in the present study.

This study presented some limitations. First, a cross-sectional design was used, which was not well suited to assess the direction of causation. Second, the nature of the outcome -self-reported DM- did not allow to differentiate between types 1 and 2 DM. What is more, the self-reported DM may be biased since some individuals are not be aware of their condition. The unnoticed DM could be related to barriers to access to health services and low health literacy skills, both factors usually more frequent among lower educational level groups[6]. Third, since the underdiagnosed DM might be higher among groups of low educational background[14], the use of self-reported DM may lead to a larger under-representation of individuals with low education. Fourth, spurious results from confounding cannot be ruled out. Several other factors not considered here -in addition to BMI-, may lie in the mediating path between education and DM. Analyses were performed controlling for the average daily consumption of fruits and vegetables - as a proxy of diet quality-, but due to the lack of significance it was decided not to include this variable. However, this limitation was beyond the main objective of this study, which was focused on evaluating the role of BMI in the educational differences in DM. Overall, and given the described limitations, the use of simple mediation analysis proposed by Hayes[20] was an adequate alternative to test mediation and the associational hypothesis, and a proper approach to estimated cross-sectional associations, making the findings of the study somehow more reliable.

In summary, in this study BMI was a mediator of the association between educational level and DM, being more important in women: low education was associated with higher BMI, which in turn, was associated with higher risk of DM. This added to the absence of an indirect association through BMI in men, where low education was directly associated with lower risk of DM, suggesting that the role of BMI was minor.

CONCLUSIONS

The described findings highlighted the importance of taking into account BMI as a mediator in the association between educational level and the occurrence of DM, as well as assessing variations in these relationships by age and gender. Particularly in socially disadvantaged women, decreasing BMI might be considered an intermediate target to reduce DM risk.

The results of this study have some clinical and public health implications. Evidence leads to highlight the importance of prioritizing weight control strategies, among the initiatives to prevent DM in Argentina, since weight control represents a common platform of most non-communicable diseases, including DM. Social class-sensitive and gender-specific public health interventions, considering the mediating role involved in the education-DM interrelationship are also recommended to reduce social and gender inequalities in the occurrence of DM. Further, longitudinal evidence is needed in order to elucidate the mechanism underlying the educational differences in DM, particularly in LMICs within contexts of high gender, social and health inequalities.

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