

## Article

# Social determinants of overweight and obesity in Paraguayan adults using quantile regression

Hocheol Lee,<sup>1</sup> Ji Eon Kim,<sup>1</sup> Adriana Amarilla,<sup>2</sup> Yanghee Kang,<sup>1</sup> Boram,<sup>3</sup> Eun Woo Nam<sup>4</sup>

<sup>1</sup>Yonsei Global Health Center, Yonsei University, Wonju, Republic of Korea; <sup>2</sup>Pan American Health Organization (PAHO), Asuncion, Paraguay; <sup>3</sup>Health Insurance Review and Assessment Service (HIRA), Wonju, Republic of Korea; <sup>4</sup>Department of Health Administration, College of Health Science, Yonsei University, Wonju, Republic of Korea

## Abstract

**Background:** The World Health Organization (WHO) defines the double burden of malnutrition as the new face of malnutrition. This is a serious problem in Latin American countries, especially Paraguay, which has a high obesity rate. This study aimed to gather data to inform a national strategy for confronting the double-burden challenge in Paraguay by i) identifying whether the body mass index (BMI) of study subjects differed significantly according to social determinants, and ii) assessing the factors affecting BMI and the extent of their impact according to BMI quantile levels.

**Design and methods:** Data were collected using a questionnaire adapted from the WHO World Health Survey. We collected 2,200 responses from September 16 to October 7, 2018. After excluding the questionnaires with missing data, we analyzed 1,994 respondents aged 18 years and older living in Limpio, Paraguay. The analyses included t-test and chi-squared test to identify significant differences and 10th quantile regression to assess associations.

**Results:** Analyses showed significant differences in participants' BMI levels based on age and diagnoses of diabetes or hypertension. In quantile regression analyses, age was significantly associated with BMI quantiles at all but one level. Educational attainment was significantly associated with the 10-40% and 60-70% quantiles of BMI.

**Conclusions:** Age, education level, diabetes, and hypertension were significant predictors of obesity. Obesity programs that focus on people aged more than 60 years are required. In addition, targeted nutritional education may be a useful intervention.

## Introduction

Globally, approximately 2.8 million people die from complications attributed to overweight and obesity annually, which is

equivalent to the number of people who die from communicable diseases. In 2016, the incidence of obesity has increased by more than three-fold worldwide since 1975. As of 2016, 1.9 billion (39%) adults were overweight, of whom approximately 65 million (13%) were obese.<sup>1</sup> Overweight and obesity are the main causes of chronic non-communicable diseases such as heart disease, stroke, cerebral infarction, dyspnea, and some types of cancer.<sup>2</sup>

In April 2016, the UN General Assembly adopted a resolution to eradicate malnutrition among the poor worldwide. This move has drawn attention and sparked efforts by countries and international organizations to achieve this goal. However, such efforts have relatively neglected the issue of overweight and obesity, resulting in a significant increase in the global burden of obesity.<sup>3</sup> As a result, nine of every ten countries worldwide face the "double burden" of obesity and undernutrition.<sup>3</sup> The World Health Organization (WHO) defines the double burden as the new face of malnutrition, where obesity and undernutrition coexist, and considers it a new public health challenge. The double burden of malnutrition is characterized by the coexistence of undernutrition along with overweight and obesity, or diet-related non-communicable diseases. These problems are not just worrisome for high-income countries but for other countries as well. Recently, the polarization of obesity and undernutrition has become serious in lower-middle-income countries, as the number of obese individuals has increased to a level similar to that in high-income countries.<sup>4</sup> Therefore, the double burden issue in lower-middle-income countries requires evaluation, with findings that can form the basis for national policy.<sup>5</sup> The WHO recommends that, in the development of national policies, local characteristics such as the environment and socioeconomic status be considered and that continuous monitoring be carried out in each country.<sup>6</sup>

The double burden of malnutrition is a serious problem in Latin American countries, including Paraguay, which has a high obesity rate.<sup>7</sup> Paraguayan culture tends to have a more positive perception of obesity than that observed in other countries. For example, a person considered overweight or obese in other countries might receive a greeting of "Looks like you are in good

### Significance for public health

The World Health Organization defines the "Double burden of obesity and undernutrition" as the new face of malnutrition, where obesity and undernutrition coexist. The double burden of malnutrition is a serious problem in Latin American countries, including Paraguay, which has a high obesity rate. The double burden issue in lower-middle-income countries requires evaluation, with findings that can form the basis for national policy to face this public health challenge.

shape” by Paraguayans.<sup>8</sup> A study on factors affecting adult obesity in Paraguay found that obesity was more prevalent in women (35.8%) than in men (35.5%). Less frequent physical activity was associated with a higher body mass index (BMI).<sup>9</sup> Popkin and Reardon<sup>10</sup> reported that the higher the Food Burden ratio of a household, the lower the weight of its members. The Food Burden ratio is defined as the percentage of household food consumption per month divided by the percentage of household average monthly income. This finding highlights the impact of changes in Latin America’s food supply system, including that of Paraguay, on the prevalence of obesity. Obesity is also closely related to lifestyle factors such as smoking, daily vegetable intake, and chronic diseases including diabetes and hypertension.<sup>11-13</sup> However, given the double burden phenomenon, the key factors affecting obesity and the extent of their impact may differ within a country. Therefore, examining the factors associated with obesity within different population groups is recommended.<sup>14</sup>

The Paraguayan government, led by the Ministry of Health, first implemented the “National Strategy for Prevention and Control of Obesity” in 2017. However, the lack of evidence to support these policies has caused confusion among policymakers. Therefore, this study was conducted to provide evidence for public policies. As Paraguay also currently suffers from the double burden phenomenon, this study was designed to analyze the association of sociodemographic factors with different levels of obesity in Paraguay.

The study aimed to make evidence for developing the national strategy for confronting the double burden challenge in Paraguay by: i) identifying whether the BMI of study subjects differed significantly according to social determinants, and ii) assessing the factors affecting BMI and the extent of their impact according to BMI quantile levels.

## Design and methods

### Study design

This cross-sectional study was designed to identify the key social determinants of adult obesity in Paraguay. The research area was the city of Limpio (Figure 1), located 23 km from the Paraguayan capital of Asunción and consisting of 12 “compañias.” The rural areas are divided into places or small settlements called “colonias” or “compañias” in some municipalities. The total population of this area was 103,834, comprising 52,986 men (51%) and 50,848 women (49%) in 2018. This study included adults aged 18 years or older. Data were collected using an adapted questionnaire from the WHO World Health Survey.

### Data collection

To select the study subjects, we used Limpio’s population census lists based on the administrative units of “compañias” and “barrios.” “Barrios” means village in neighborhoods under “compañias.” Barrios were first selected in proportion to the number of people in each “compania,” and households were then selected in proportion to the number of people within the selected barrios. The required number of samples was calculated assuming the confidence intervals and significance levels of 95% and 50%, respectively. Using probability proportional to size sampling (PPS), 2,200 adults aged 18 years and over were identified.

The survey was conducted in four stages. First, a data entry program was developed so that the researchers could conduct investigations using tablet PCs. Second, 60 researchers who lived in the study area, were educated above the level of high school, and had experience conducting survey interviews were recruited. The researchers received training for two weeks on how to administer the questionnaire, from a WHO/Pan American Health Organization (PAHO) expert, and simulated training for two additional weeks to familiarize themselves with the tablet-based survey methods. Third, the survey was conducted using a 1:1 interview survey method by visiting the target households in the surveyors’ assigned areas. During the interviews, the researchers explained

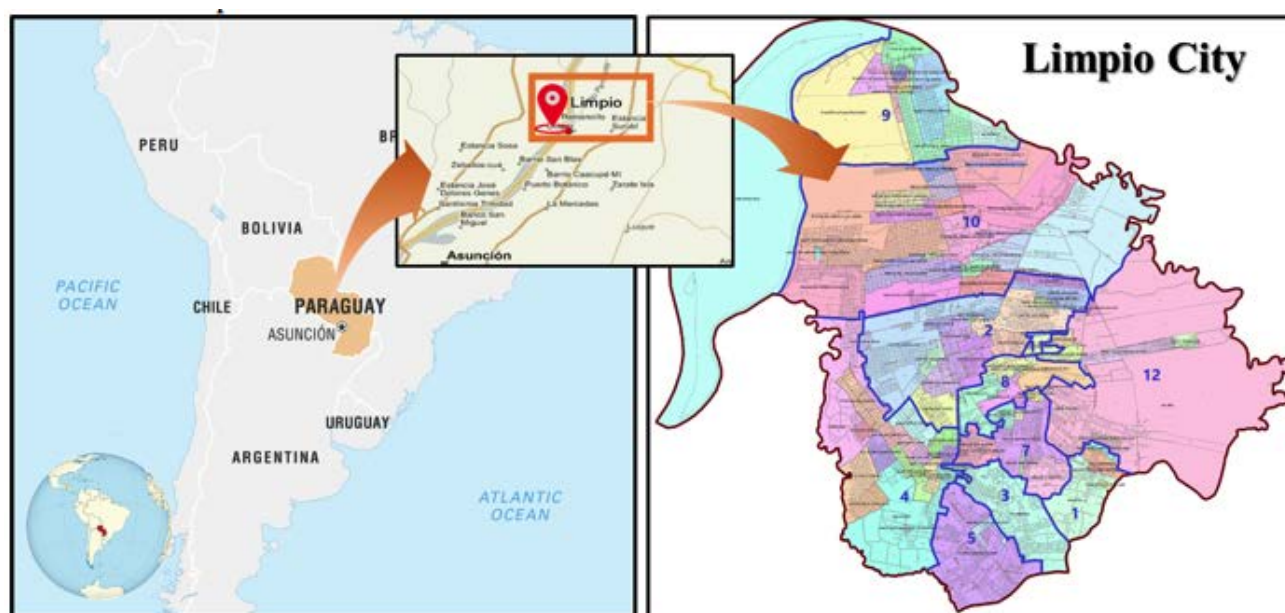


Figure 1. Research area. Source: The map of Limpio City was provided by Limpio City Hall, which authorized the use of the map.

the study objectives to potential respondents and only administered the surveys to those who provided informed consent. The survey period took place from September 17 to October 7, 2018, and approximately one hour per respondent was required for survey completion. Fourth, to ensure the quality of the data, the PAHO quality management team reviewed the results immediately after the survey, and households who answered the questionnaires incompletely or unclearly were revisited. Among 2,200 total responses, 1,994 were included in the final analysis after excluding those questionnaires with missing key responses and those who dropped from the survey.

### Dependent variable

The dependent variable in this study was BMI, defined as the weight (kg) divided by the square of the height (m), a measure often used to determine obesity because it is widely used and accepted worldwide. Weight and height were measured using a weight scale and a height tape, respectively, for BMI calculation. BMI was divided into three categories: normal (18.5-24.9 kg/m<sup>2</sup>), overweight (25-29.9 kg/m<sup>2</sup>), and obese (≥30 kg/m<sup>2</sup>) according to the criteria used by the PAHO.<sup>15</sup>

### Independent variables

The independent variables identified from previous studies of factors affecting obesity were sex, age, education level, Food Burden ratio, diagnosis of diabetes and/or hypertension, and health behaviors such as smoking status, daily physical activity, and daily vegetable intake.<sup>9,11-13,16-19</sup> Respondent age was divided into 10-year intervals, but it was used as a continuous variable in the regression analysis. Educational background was categorized as elementary school, below high school, and higher than university/college. The Food Burden ratio was converted to US dollars from the Paraguayan currency. Diabetes mellitus and hypertension status were defined as having been diagnosed by a medical doctor and still receiving care or experiencing symptoms at the time of the survey. Smoking status was based on the answer of “every day or sometimes” to the question “Do you currently smoke tobacco products such as cigarettes, cigars, or pipes?” Daily intake of vegetables was measured as the average daily servings of vegetables, while the time spent on daily physical activity was measured in minutes.

### Statistical analysis

Student's *t*-test (continuous variables) and chi-squared test (categorical variables) were used to test for significant differences in the independent variables, according to the BMI quantiles. Line graphs for each BMI quantile were used to demonstrate the differences by BMI level. Quantiles were defined as the 10<sup>th</sup> to 90<sup>th</sup> percentiles. All data were analyzed using Stata 15.0 (StataCorp LLC, College Station, TX, USA).

To identify independent associations between the study variables and BMI, we conducted quantile regression analysis along with linear regression analyses, using the ordinary least square (OLS) method and compared the results. Quantile regression analysis, introduced by Koenker and Bassett,<sup>20</sup> is a method of minimizing sample selection bias by estimating median values of the dependent variable distributions by quantiles. This analysis uses the  $Q_{BMI}$  equation to identify factors significantly affecting the BMI of the respondents in each quantile:

$$Q_{BMI} = \beta_0 + \beta_1(t) E_i + \epsilon_i \quad (\text{eq. 1})$$

where *t* represents the *t*<sup>th</sup> quantile of the BMI and represents the respondents in each quantile. The parameter estimates of  $\beta_1(t)$  for each predictor in different quantiles of the BMI distribution were explored.

## Results

### Respondent characteristics

The general characteristics of the respondents are listed in Table 1. The average BMI was 27.4 kg/m<sup>2</sup>, with 38.1% of respondents being overweight (25-29.9 kg/m<sup>2</sup>), 35.4% having normal weight (18.5-24.9 kg/m<sup>2</sup>), and 26.5% being obese. Among the respondents, 69.3% were women, and the average age was 43.7 years. A majority of the respondents were elementary school graduates (46.3%). The average food burden was 36.9%, with 41.3% of the households spending 20-40% of their income on food. Among the respondents, 10.3% and 28.8% had been diagnosed with diabetes and hypertension, respectively. On average, vegetable was

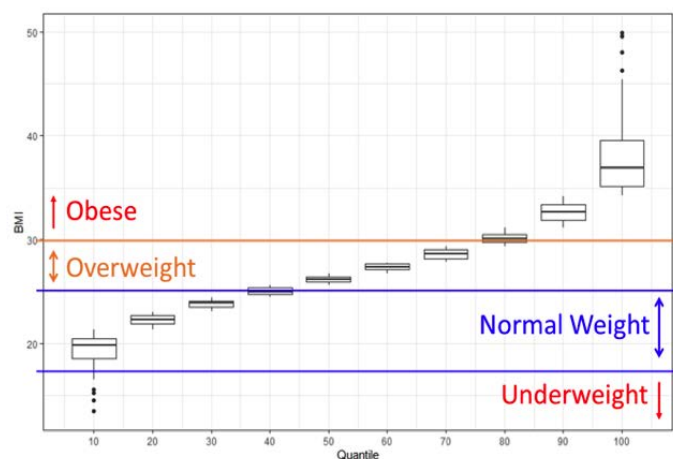


Figure 2. Boxplots of body mass index (BMI) quantiles.



consumed 3.2 times/day, and the average duration of daily physical activity was 16.0 min.

### BMI quantiles according to independent variables

The BMI levels for each category of independent variable were divided into 10% quantiles, as shown in Figure 3. Analysis of the differences in BMI levels for each independent variable showed significant differences in BMI levels depending on age, diabetes, and hypertension, with BMI levels differing significantly for each quantile in 10-year age groups and depending on the presence of diabetes and hypertension (all  $p < .000$ ).

### Factors affecting BMI levels by quantile

The results of the OLS and quantile regressions are presented in Table 2. The OLS regression results showed that age and education level were significantly associated with BMI. BMI levels increased with respondents' age ( $b=0.41$ ,  $p < .001$ ), while respondents who had at least graduated from middle school had significantly lower BMI levels than those who only graduated from elementary school ( $b=0.69$ ,  $p < .05$ ). The quantile regression results showed that age, education level, daily vegetable intake, and physical activity were significantly associated with BMI. Both age and educational level showed significant associations for all quantiles except for the 50% quantile. Educational level was not a significant predictor in any of the quantiles for respondents with education levels above university degree.

## Discussion

This study included adults living in the city of Limpio, Paraguay. At 38.1%, the percentage of overweight respondents was lower than the national average of 46.1%. However, the obesity rate of 26.5% was higher than the national average of 15.1%,<sup>21</sup> indicating a more serious obesity issue in Limpio. Regarding the level of education, 53.7% of respondents were educated to the high school or higher; this rate is lower than the national average of 66.5%.<sup>22</sup> Investigation of the food burden showed that more than 80% of the respondents spent more on food than the national average of 17%.<sup>23</sup> The prevalence of diabetes in Limpio was 10.3%, higher than Paraguay's national average of 9.7%, although the prevalence of hypertension was lower (28.8% compared to 32.3%).<sup>24</sup> Finally, 19.0% of the respondents reported regular physical exercise, lower than the national average of 23.3%.

Regarding the first aim of the study, we identified significant differences in BMI levels according to different social determinants. The relationship between obesity and age appeared similar to that reported previously, in which BMI increased with age. The WHO/PAHO report "Plan of Action for the Prevention of Obesity in Children and Adolescents" emphasizes the efficacy of fiscal policies such as the imposition of taxes on sugar, beverages, and energy-dense nutrient-poor products; the regulation of food marketing; and the promotion of healthy eating. The Ministry of Health in Paraguay also recommended reducing adult obesity as a key step in reducing non-communicable diseases in Paraguay. The results of our study highlight the need to focus on adults aged 60 years and above. Since it can be difficult for adults to exercise, city health departments have recommended developing health-promoting workplaces. In the future, we will examine whether developing health-promoting workplaces is an effective strategy in Paraguay. The WHO and PAHO are also considering developing a "healthy city project" in the Pan-American region.

While a previous study reported significant differences in BMI levels according to sex, with higher levels in men than in women, we did not observe this in our study.<sup>25</sup> This could be due to the data being collected by visiting households during working hours, resulting in the sex ratio of respondents being biased toward women (30.3% men, 69.7% women). The impact of the timing of the visit on the characteristics of respondents should be considered in future studies. In addition, while previous studies have shown a relationship between a higher daily intake of vegetables and a lower BMI,<sup>26</sup> the relationship was not significant in this study. This may be because, while the Paraguayan cuisine is heavy on meat, low-income households eat more vegetables because of their lower

**Table 1. Respondent characteristics (n=1,994).**

Variables n (%) or mean±SD	Total
Body mass index (kg/m <sup>2</sup> )	27.4±5.2
Normal (18.5–24.9)	706 (35.4%)
Overweight (25–29.9)	759 (38.1%)
Obesity (≥30)	529 (26.5%)
Sex	
Male	612 (30.7%)
Female	1,382 (69.3%)
Age (years)	43.7±16.0
18–29	432 (21.6%)
30–39	498 (25.0%)
40–49	365 (18.3%)
50–59	319 (16.0%)
60–69	229 (11.5%)
≥70	151 (7.6%)
Educational level	
Elementary school	923 (46.3%)
High school	794 (39.8%)
≥University/college	277 (13.9%)
Ratio of food burden (%)*	36.9±20.6
≤20	398 (20.0%)
20–39	824 (41.3%)
40–59	444 (22.3%)
60–79	225 (11.3%)
80–100	103 (5.2%)
Diabetes	
Normal	1,789 (89.7%)
Diabetic	205 (10.3%)
Hypertension	
Normal	1,419 (71.1%)
Hypertensive patient	575 (28.8%)
Current smoking	
Non-smoker	1,837 (92.1%)
Smoker	157 (7.9%)
Daily vegetable intake (times)	3.2±2.1
1	521 (26.1%)
2	517 (26.0%)
3	210 (10.5%)
4	84 (4.2%)
5	248 (12.4%)
6	284 (14.2%)
≥7	130 (6.5%)
Daily physical activity (hours)	16 ± 54.1 minutes
None	1,614 (81.0%)
<1	242 (12.1%)
1–2	70 (3.5%)
≥2	68 (3.4%)

\*Ratio of food burden, monthly food expenses=monthly income.

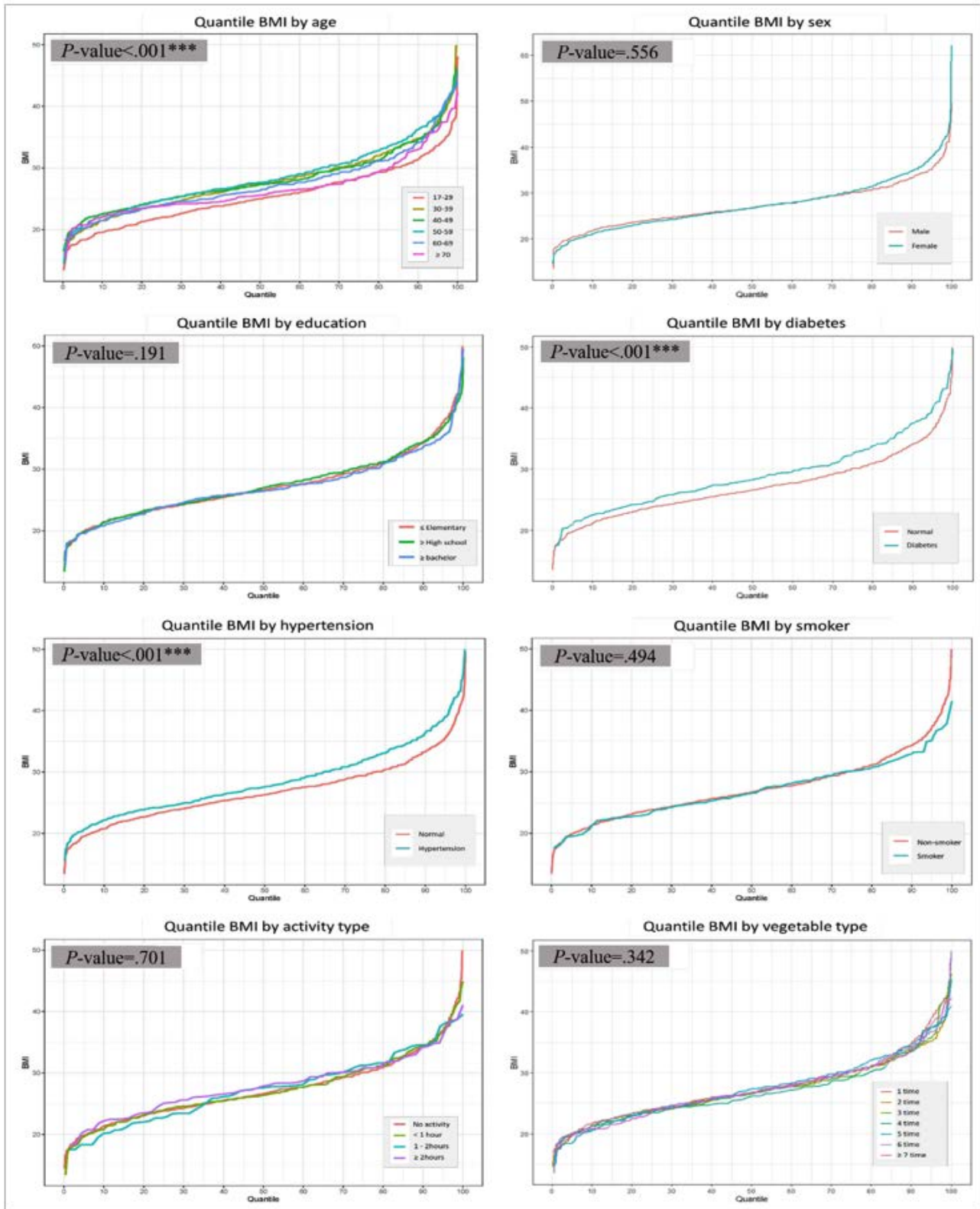


Figure 3. Quantiles of body mass index (BMI) according to independent variables.

cost.<sup>27</sup> Various mediating effects may exist between vegetable intake and weight; for example, vegetable intake has a positive effect on weight loss by reducing depression.<sup>28</sup> In addition, Seeley and Sandoval<sup>29</sup> reported that smoking can cause weight loss due to the effects of nicotine, unlike the findings of the present study, which found no significant differences according to smoking status. Moreover, while regular exercise has been shown to reduce BMI,<sup>25</sup> it was not a significant factor in the present study. However, it is important to consider the environmental context of the research area when comparing the study results. All roads in Limpio are unpaved, except in some central areas, causing a limitation in transportation. Therefore, most residents travel by walking, which results in little to no regular exercise in the region. However, future studies are needed to calculate physical activity levels among the residents of Limpio using pedometers.

The second aim was to identify the factors affecting groups with different BMI values. The prevalence rate of nearly 65% for overweight or obese adults in Limpio is similar to the rate of 62% reported by the WHO for Central and South America and the rates of 48.5% and 23.2% for overweight and obesity, respectively, reported nationally in Paraguay.<sup>30</sup> Age was the only factor that had a significant effect on all BMI quantiles, corresponding to the underweight and normal-weight groups.<sup>31</sup> A study that tracked changes in BMI for over 20 years found that BMI increased significantly with age, especially until age 40, after which it decreased slightly.<sup>32</sup> This is consistent with our findings that BMI increased with age, within normal BMI ranges. Unlike findings in Brazil on sex differences in the occurrence of the double burden of malnutri-

tion,<sup>9</sup> BMI levels did not vary by sex, even in the quantile regression analysis in our study, and this may be related to the unequal sex ratio among our participants.

Regarding education level, both the OLS and quantile regression methods showed significantly lower BMI levels in respondents who had at least graduated from middle school compared to those with lower education level. However, the differences were not significant in the quantiles above 80% (obese group). Similar to previous studies, we also found that diabetes and hypertension were significantly associated with BMI. The present study conducted chi-squared test to compare variables with the presence of hypertension and diabetes. Given the occurrence of the double burden of malnutrition worldwide, WHO and PAHO have proposed policies and guidelines on obesity prevention and control in Latin American countries. PAHO has already implemented an action plan for obesity prevention in children and teens to reduce obesity rates in Latin American countries.<sup>33</sup> The main strategies of this plan are to provide education on the need for well-balanced diets for children at the household level and to minimize the polarization of undernutrition and obesity.<sup>34</sup> Paraguay's policies on malnutrition, similar to those of other countries, are addressing both obesity and undernutrition. Paraguay's Ministry of Health established the National Strategy for the Prevention and Control of Obesity in 2017. In line with this strategy, the government enacted a regulation requiring schools to provide obesity prevention programs. A program targeting teenagers was implemented in cooperation with the United Nations Children's Fund (UNICEF). An additional program by which pregnant women and children under 5 years of age

**Table 2. Comparisons between quantile regression and ordinary least square (OLS) results according to body mass index.**

Variables	Quantile regression (QR)									OLS
	Q 0.1	Q 0.2	Q 0.3	Q 0.4	Q 0.5	Q 0.6	Q 0.7	Q 0.8	Q 0.9	
	Coeff (95% CI)									
Age 0.64*** (0.42, 0.86)	0.48*** (0.28, 0.67)	0.37*** (0.20, 0.54)	0.32*** (0.14, 0.50)	0.26** (0.07, 0.45)	0.15 (-0.04, 0.34)	0.30* (0.06, 0.53)	0.43** (0.12, 0.74)	0.58*** (0.22, 0.93)	0.41*** (0.24, 0.57)	
Sex -0.28 (ref=male)	-0.52 (-0.97, -0.39)	-0.15 (-1.13, 0.07)	-0.15 (-0.67, 0.37)	0.04 (-0.71, 0.39)	0.09 (-0.55, 0.64)	0.11 (-0.50, 0.70)	0.79 (-0.60, 0.84)	1.23* (-0.17, 1.77)	0.22 (0.12, 2.35)	(-0.27, 0.73)
Education level										
Elementary school	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
High school	0.96** (0.24, 1.69)	1.00** (0.36, 1.63)	0.77** (0.22, 1.33)	0.62* (0.03, 1.20)	0.54 (-0.09, 1.17)	0.75* (0.11, 1.40)	0.812* (0.04, 1.58)	0.74 (-0.28, 1.77)	0.87 (-0.30, 2.04)	0.69* (0.16, 1.23)
≥University/College	1.17* (0.17, 2.17)	0.45 (-0.42, -1.33)	0.96* (0.19, 1.73)	0.78 (-0.2, 1.59)	0.03 (-0.83, 0.91)	0.05 (-0.83, 0.93)	-0.37 (-1.44, 0.68)	0.39 (-1.02, 1.81)	0.48 (-1.13, 2.11)	0.33 (-0.40, 1.07)
Ratio of food burden (%)	-0.003 (0.02, 0.1)	0.001 (-0.012, -0.014)	0.001 (-0.011, 0.011)	0.006 (-0.018, 0.005)	-0.004 (-0.018, 0.008)	0.001 (-0.011, 0.015)	-0.003 (-0.02, 0.01)	0.001 (-0.020, 0.022)	0.007 (-0.016, 0.032)	-0.001 (-0.012, 0.009)
Smoking (ref: non-smoker)	-0.093 (-2.1, 0.22)	-0.38 (-1.41, 0.63)	-0.12 (-1.01, 0.77)	-0.58 (-1.52, 0.34)	-0.15 (-0.08, 0.16)	0.49 (-0.53, 1.53)	0.14 (-1.09, 1.38)	-0.17 (-1.83, 1.48)	-0.90 (-2.79, 0.99)	-0.21 (-1.07, 0.64)
Daily vegetable intake	-0.19** (-0.34, -0.05)	-0.05 (-0.18, 0.07)	-0.004 (-0.11, 0.10)	0.01* (-0.09, 0.13)	0.03 (-0.08, 0.16)	0.04 (-0.08, 0.16)	0.01 (-0.15, 0.15)	0.01 (-0.18, 0.22)	-0.02 (-0.26, 0.20)	-0.02 (-0.13, 0.08)
Daily physical activity (hours)										
None	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
<1	0.28 (-0.67, 1.24)	0.24 (-0.60, 1.08)	0.298 (-0.43, 1.03)	-0.13 (-0.90, 0.64)	-0.13 (-0.97, 0.71)	-0.03 (-0.88, 0.08)	0.27 (-0.74, 1.29)	0.75 (-0.61, 2.11)	0.55 (-1.00, 2.11)	0.15 (-0.55, 0.86)
1-2	-1.20 (-2.88, 0.47)	-0.46 (-1.93, 1.01)	-0.62 (-1.91, 0.66)	0.61 (-0.74, 1.96)	0.81 (-0.65, 2.28)	0.57 (-0.91, 2.05)	1.06 (-0.71, 2.85)	1.87 (-0.51, 4.25)	1.08 (-1.64, 3.80)	0.25 (-0.98, 1.49)
≥2	0.59 (-1.11, 2.29)	0.84 (-0.65, 2.34)	1.35* (0.03, 2.66)	1.33 (-0.04, 2.71)	1.13 (-0.36, 2.63)	1.01 (-0.50, 2.52)	1.05 (-0.75, 2.86)	1.12 (-1.30, 3.55)	0.46 (-2.30, 3.24)	0.98 (-0.28, 2.24)
Constant	19.49 (-17.6, 21.32)	21.66 (20.05-23.27)	22.64 (21.24-24.05)	24.33 (22.85, 25.81)	25.32 (23.72, 26.93)	26.55 (24.92, 28.17)	27.62 (25.67, 29.56)	27.40 (24.79-30.00)	29.19 (26.22, 32.17)	25.08 (23.72, 26.43)

OLS, ordinary least squares regression; Coeff, coefficient of regression; 95% CI, 95% confidence interval; \*p<0.05; \*\*p<0.01; \*\*\*p<0.001.

receive timely and quality care to prevent and treat malnutrition and obesity was launched in 2019, specifically targeting undernutrition.<sup>35</sup> With an emphasis on the need for evidence-based policy-making and implementation, monitoring and evaluating these policies are increasingly important.<sup>36</sup>

While this study has provided valuable evidence for governmental policies and programs, it has several limitations. First, cross-sectional designs cannot evaluate the effectiveness of the policies. However, the Paraguayan government and the Korean International Cooperation Agency, with consultation from the PAHO/WHO and the Yonsei Global Health Center, are jointly building a health center in Limpio. When complete, the center will launch a non-communicable disease prevention program,<sup>37</sup> and its effectiveness will be monitored. Further studies on the policies and programs should use the difference-in-difference method.<sup>38</sup> Second, this study used daily vegetable intake as the nutrition vari-

able, which is not exactly representative of nutrient intake. In future, more precise variables based on actual nutritional screening should be included. Third, the survey was conducted by visiting households during working hours, likely creating a female-biased sex ratio. Future surveys should minimize these biases, for example, by including weekends in the survey period. Finally, data were obtained from only one city. However, we used formal data sampling methods and interviewed 2,200 respondents—more than that required by the Central Limit Theorem.<sup>39</sup> In future, formal multi-stage sampling should be conducted around the country in order to generate nationally representative data for policy development.

This study was designed to identify the social determinants of BMI and provide evidence for a national strategy to address the double burden challenge in Paraguay. Based on our results, age, education level, diabetes, and hypertension were significant factors associated with obesity. Age was associated with higher BMI levels, while diabetes and hypertension were negatively associated with BMI levels. Normal weight was significantly associated with educational level. Therefore, targeted nutritional education may be a useful intervention strategy. Further, our findings that weight increased with age highlighted the need to include a focus on people aged over 60 years.

Overall, this study provides evidence for the establishment of weight control and reduction policies and strategies and for strengthening education programs such as “health for all,” “the well-balanced diet,” and obesity prevention programs in Paraguay. In conclusion, it is necessary to develop an age-appropriate obesity prevention program with education that considers the muscles, nutritional status, and obesity, according to age. In addition, it is necessary to analyze the effectiveness of this program with education in the future.

**Correspondence:** Eun Woo Nam, Department of Health Administration, College of Health Science, Yonsei University, 1 Yonseidae-gil, Wonju 26493, Republic of Korea. Tel. +82.033.760-2413 - Fax: +82.033.762-9562. E-mail: ewnam@yonsei.ac.kr

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**Contributions:** HL, EN, conceived the study, developed the methodology, oversaw the analysis, wrote the draft manuscript; HL, JK, conducted the analyses; AA, oversaw data collection; HL, BRS, were responsible for the data cleaning. All the authors reviewed and finalized the manuscript.

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**Ethical Approval:** The survey was approved by the Institutional Review Board of the Ministry of Health in Paraguay, no. D.I.E.E.N 22/2018. This study was approved by the Institutional Review Board of the Paraguayan Health Ministry (no. 136/05062018) and the Bioethics Review Board of the University of Illinois at Chicago (UIC) (no. 2017-0600). Participants were informed of the purpose of the study before they were asked to provide written consent.

**Availability of data and material:** The data used for the current study is available from the corresponding author on reasonable request.

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