RESEARCH ARTICLE

High body-mass index and mortality from cardiometabolic diseases in Peru: a comparative risk assessment analysis

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Abstract

Background: High body-mass index (BMI) is a major contributor to the global burden of cardiometabolic diseases (CMD) like type 2 diabetes mellitus (T2DM) and cardiovascular diseases (CVD). We aimed to quantify the mortality burden associated with high BMI in Peru to inform policies and set priorities.

Methods: We computed population attributable fractions (PAF) combining BMI prevalence estimates from the Peruvian Demographic and Health Survey and relative risks between high BMI and CMD mortality from the GBD 2019 Study. PAFs were multiplied by the CMD deaths recorded in the national death registry to obtain the absolute number of CMD deaths attributable to high BMI in each region, sex and five-year age group.

Results: In 2018, the absolute number of T2DM deaths attributable to high BMI in Peru was 1,376 (50.3%) in men and 1,663 (56.0%) in women; the absolute number of CVD deaths related to high BMI was 1,665 in men (23.6%) and 1,551 (24.7%) in women. Most CMD deaths related to high BMI were attributable to obesity class 1 and overweight. Regions with the highest proportions of CMD deaths related to high BMI were in the Amazon (Madre de Dios, Ucayali) and the Coast (Tacna, Moquegua); conversely, regions with the lowest proportions were in the Highlands (Huancavelica, Apurímac).

Conclusions: High BMI is a major contributor to the CMD mortality burden in Peru, with high variability across regions. Health policies need to be strengthened to reduce BMI at the population level, which may have a subsequent reduction in the associated CMD mortality.

Keywords

overweight; obesity; health metrics; population health; global health.

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Introduction

High body-mass index (BMI) has become a global health issue in terms of prevalence, morbidity and mortality^{1–3}. In 2016, overweight (BMI ≥ 25 – 29.9 kg/m²) affected 1.9 billion of adults, and a further 650 million were obese (BMI ≥ 30 kg/m²) globally⁴. Moreover, high BMI is major contributor to the global burden of cardiometabolic diseases (CMD), which account for ~40% of all deaths annually⁵. Strong evidence indicates that a higher BMI is associated with a greater risk of CMD mortality⁶. Therefore, a thorough quantification of the mortality burden associated with high BMI is needed to set priorities and inform policies, especially in low-resource settings in which inequalities call to advance from national to subnational disease burden estimates.

Obesity has become an important problem in Peru where the prevalence in 2020 was 20.7% and 28.1% in men and women, respectively⁷. Furthermore, a recent global work estimated that both overweight and obesity caused almost 50% of diabetes deaths and 20% of cardiovascular diseases (CVD) deaths in adults in 2019^{2,8}. Nonetheless, there are large differences in the BMI distribution across regions in Peru⁷; for instance, high BMI (≥ 25 kg/m²) prevalence in adults in 2019 ranged from ~73% in southern coast regions (i.e., Tacna and Moquegua) to ~40–46% in some Highlands regions (i.e., Huancavelica, Apurímac and Cajamarca)⁷. These variations in the subnational BMI distribution, and further disparities in socioeconomic status along with inequalities in health access, may lead to differences in the CMD mortality burden associated with high BMI in Peru. This information at the subnational level could help targeting policies and programs regarding CMD control in Peru, which is relevant for the Peruvian Health System's resources allocation⁹.

We aimed to estimate the proportion and absolute number of deaths in 2018 attributable to high BMI at the subnational level in Peru. This information could help to promote and guide health policies to halt the rise of overweight and obesity across regions in Peru.

Methods

Study design

We used the comparative risk assessment framework to estimate the proportion and absolute number of deaths from diabetes and cardiovascular diseases attributable to high BMI in the 25 regions of Peru in 2018. Of note, the combination of type 2 diabetes (T2DM) and CVD mortality is referred to as CMD mortality. We calculated population attributable fractions (PAF) attributable to high BMI combining BMI prevalence estimates¹⁰ and relative risks (RR) of the association between 5 unit increase in BMI and cause-specific mortality¹¹. We quantified the absolute number of deaths attributable to high BMI multiplying the PAFs by the absolute number of registered deaths for each outcome, region, sex and 5-year age group.

Data sources

Prevalence of BMI categories. Age- and sex-specific prevalence estimates of all BMI categories (<18.5 [malnutrition], 18.5–24.9 [normal weight], 25–29.9 [overweight], 30–34.9

[class 1 obesity], 35–39.9 [class 2 obesity], and ≥ 40 kg/m² [class 3 obesity]) in adults ≥ 20 years were extracted from the Peruvian Demographic and Health Survey (DHS, ENDES for its name in Spanish)¹⁰. Annually, the ENDES survey measures weight and height in a nationally- and regionally-representative sample of adults from Peru. We used measured weight and height to compute BMI at the individual level. BMI records outside the range 10–80 kg/m² were discarded. We did not apply other selection criteria.

To get representative samples to compute prevalence estimates for each BMI category stratified by region, sex and age groups, we had to pool individual-level data from the ENDES surveys conducted between 2014 and 2018; that is, we pooled five surveys to maximize sample size. We assumed that the prevalence estimates herein computed would represent 2016 (middle year between 2014 and 2018). We computed BMI prevalence estimates by 10-year age groups and assumed the prevalence would be the same in the corresponding 5-year age groups. For example, we computed BMI prevalence in the 30–39 age band, and assumed this prevalence was the same in the age groups 30–34 and 35–39 years. Even though we pooled five surveys, sample size was not enough to compute prevalence estimates by 5-year age groups. All prevalence calculations accounted for the complex survey design of the ENDES survey¹².

Relative risks. The relative risks (RRs) of the association between 5 units increase in BMI and mortality from diabetes and CVD were obtained from the Global Burden of Disease (GBD) 2019 Study (extended data, Supplementary Table 1¹³)^{2,11}. GBD 2019 methods have been reported elsewhere². Age- and sex-specific RRs of the association between risk factors and cause-specific mortality were derived from meta-analysis and combined analysis of prospective studies².

Cardiometabolic diseases mortality. The mortality data according to region in Peru, sex and 5-year age groups in 2018 was obtained from the national death registry of the Peruvian Ministry of Health (MINSA)¹⁴. We analysed a complete-case dataset regarding demographic variables (region, sex and age) and the underlying cause of death. We used the International Classification of Diseases 10 (ICD-10) coding system to define our outcomes¹⁵. The ICD-19 codes in the underlying cause of death we studied were: atrial fibrillation and flutter (I48), ischemic heart disease (I20–I25), hypertensive heart disease (I11), ischemic stroke (I63, I65–I67, I69.3), haemorrhagic stroke (I60–I62, I69.0–2) and T2DM (E10–E14). Because of limited number of registered deaths from individual ICD-10 codes, subnational results (i.e., proportion and absolute number of deaths) were reported as CMD, which was the aggregation of T2DM and CVD results (CVD included atrial fibrillation and flutter, ischemic heart disease, hypertensive heart disease, ischaemic and haemorrhagic stroke)¹⁶. Conversely, national results were reported as T2DM, CVD and CMD.

Statistical analysis

The PAF attributable to high BMI quantifies the proportion of cause-specific deaths that could be prevented if the

distribution of BMI was reduced to an optimal level. We used the following equation¹⁷.

$$PAF = \frac{\sum P_i R R_i - \sum P'_i R R_i}{\sum P_i R R_i}$$

Where P_i is the prevalence of each BMI category; P'_i is the prevalence of the alternative (ideal) scenario; and $R R_i$ are the relative risks of the association between high BMI and cause-specific mortality. We estimated the absolute number of cause-specific deaths attributable to high BMI multiplying each region-, year and sex-specific PAF by the cause-specific absolute number of deaths registered in the national death registry in corresponding region, sex, and 5-year age band.

To compute the PAF attributable to each range of BMI (i.e., overweight, obesity, etc.), we used an equivalent formula¹⁷.

$$PAF = \frac{P(RR-1)}{P(RR-1)+1}$$

Where P is the prevalence of each BMI category; and RR is the relative risk of the association between the specific BMI category and cause-specific mortality. We computed the absolute number of deaths attributable to each BMI category multiplying the region-, year and sex-specific PAF by the registered cause-specific deaths.

Because our prevalence estimates for each BMI category would represent the year 2016 (middle year between 2014 and 2018), and our CMD mortality data were from 2018, we assumed a 2-year lag period between high BMI exposure and CMD mortality. That is, we computed the absolute number of CMD deaths in 2018 attributable to high BMI in 2016.

We propagated the uncertainty of the prevalence estimates and RRs to our final results using a simulation approach. To do this, we generated 1,000 random draws for each region-, sex-, and age-specific BMI prevalence estimate, and each sex- and age-specific RRs. This resulted in 1,000 PAF for each region-, sex- age-specific group. The median of this distribution was reported as the main result, and the 2.5 and 97.5 percentiles as the 95% confidence interval. For the statistical analysis and figures, we used R (version 4.0.3). The analysis code is available from [GitHub](#) and is archived with [Zenodo](#)¹⁸.

Ethics

We did not seek approval by an Institutional Review Board. We used publicly available individual-level data which do not include any personal identifiers.

Results

National results

In 2018, CMD accounted for 19,068 deaths in Peru, which represented 16.6% of all 114,836 registered deaths in adults ≥ 20 years¹⁹. The absolute number of T2DM deaths in 2018 attributable to high BMI was 1,376 (50.3%) in men and 1,675 (56.0%) in women. In the same year, the absolute number of CVD deaths related to high BMI was 1,665 in men

(23.6%) and 1,551 (24.7%) in women. Most CMD deaths related to high BMI were attributable to obesity class 1 and overweight, which contributed with 17.3% and 16.5% of CMD deaths in men, and 19.4% and 14.6% in women, respectively (Table 1).

Regional results

At the subnational level, because of the reduced number of deaths in some regions, results are presented as CMD mortality (i.e., combination of T2DM and CVD mortality). We found high variability in the proportion and absolute number of CMD deaths attributable to high BMI across regions in both sexes (Figure 1 and Figure 2).

The highest proportions of CMD deaths attributable to high BMI in men were in Madre de Dios (56.8%), Tacna (38.5%) and Ucayali (38.0%); notably, two out of these regions (Madre de Dios and Ucayali) are located in the Amazon. The lowest proportions of CMD deaths attributable to high BMI in men were in Pasco (4.2%), Apurimac (10.3%) and Huancavelica (11.1%); remarkably, all of these regions are located in the Highlands.

The highest proportions of CMD deaths attributable to high BMI in women were in Madre de Dios (47.4%), Moquegua (46.7%) as well as in Ucayali and Tacna (both with 44.9%); notably, two regions (Moquegua and Tacna) are located in the southern Coast and the remaining two regions (Madre de Dios and Ucayali) are located in the Amazon. The lowest proportions of CMD deaths attributable to high BMI in women were in Apurimac (18.4%), Huancavelica (19.2%) and Ayacucho (23.1%); all these regions are in the Highlands.

The region with the highest absolute number of CMD deaths attributable to high BMI in 2018 was Lima for both sexes (Figure 2). In Lima, CMD deaths attributed to high BMI totalled 1,214 in men and 1,113 in women. Notably, no other region had an absolute number of CMD mortality attributable to high BMI comparable to Lima; in fact, all the other regions combined reported <500 CMD deaths attributable to high BMI joining both sexes (Figure 2, extended data, Supplementary Table 2¹³).

In 11 regions (out of 25) in men, overweight accounted for the largest proportion of attributable CMD deaths; this ranged from 6.9% in Apurimac and Huancavelica, to 16.7% in San Martin (Figure 3A, extended data, Supplementary Table 3¹³). In 13 regions, obesity class 1 accounted for the largest proportion of attributable CMD deaths; this ranged from 5.2% in Amazonas to 29.7% in Madre de Dios. In the remaining region (Pasco), the proportion of attributable CMD deaths was 0% across all high BMI categories.

In 1 region in women (Cajamarca), overweight accounted for the largest proportion of attributable CMD deaths (Figure 3B, extended data, Supplementary Table 3¹³). In 23 regions in women, obesity class 1 accounted for the largest proportion of attributable CMD deaths; this ranged from 5.6% in Huancavelica to 28.9% in Madre de Dios. In the remaining region (Puno), obesity class 2 accounted for the largest proportion of attributable CMD deaths.

Table 1. Percentage and absolute number of cardiometabolic diseases (CMD) deaths in 2018 attributable to high body-mass index (BMI) in 2016 in men and women at the national level. BMI categories: 25–29.9 [overweight], 30–34.9 [class 1 obesity], 35–39.9 [class 2 obesity], and ≥ 40 kg/m² [class 3 obesity]. CMD are the aggregation of type 2 diabetes and cardiovascular diseases (i.e., atrial fibrillation and flutter, ischemic heart disease, hypertensive heart disease, ischaemic and haemorrhagic stroke)

High BMI exposure	Outcome	Proportion of deaths attributable to high BMI in 2016 in men (%)	Absolute number of deaths in 2018 attributable to high BMI in 2016 in men	Proportion of deaths attributable to high BMI in 2016 in women (%)	Absolute number of deaths in 2018 attributable to high BMI in 2016 in women
5-unit increase in BMI	Cardiometabolic diseases	31 (29.6-32.6)	3041 (2898-3191)	34.8 (33.3-36.3)	3226 (3090-3362)
5-unit increase in BMI	Cardiovascular diseases	23.6 (22.1-25.1)	1665 (1559-1775)	24.7 (23.1-26.3)	1551 (1451-1651)
5-unit increase in BMI	Type 2 diabetes	50.3 (48.9-51.8)	1376 (1339-1416)	56 (54.8-57.2)	1675 (1639-1711)
BMI 25-29.9	Cardiometabolic diseases	16.5 (16.1-17.1)	1618 (1574-1675)	14.6 (14-15.1)	1351 (1300-1398)
BMI 25-29.9	Cardiovascular diseases	12 (11.5-12.5)	847 (815-881)	9.4 (8.9-9.8)	588 (558-616)
BMI 25-29.9	Type 2 diabetes	28.2 (27.7-29)	771 (759-794)	25.5 (24.8-26.1)	763 (742-782)
BMI 30-34.9	Cardiometabolic diseases	17.3 (16.6-17.9)	1693 (1622-1753)	19.4 (18.6-20.2)	1800 (1726-1871)
BMI 30-34.9	Cardiovascular diseases	11.6 (11-12.1)	818 (775-857)	12.1 (11.4-12.8)	758 (714-802)
BMI 30-34.9	Type 2 diabetes	32 (31-32.7)	875 (847-896)	34.8 (33.8-35.7)	1042 (1012-1069)
BMI 35-39.9	Cardiometabolic diseases	7.9 (7.5-8.3)	777 (730-817)	13.4 (12.7-14.2)	1239 (1180-1314)
BMI 35-39.9	Cardiovascular diseases	4.3 (3.9-4.7)	305 (273-330)	6.6 (6-7.3)	412 (375-457)
BMI 35-39.9	Type 2 diabetes	17.3 (16.7-17.8)	472 (457-487)	27.6 (26.9-28.7)	827 (805-857)
BMI 40+	Cardiometabolic diseases	3.7 (3.4-4.1)	362 (333-401)	9.4 (8.9-10)	876 (826-929)
BMI 40+	Cardiovascular diseases	1.9 (1.6-2.3)	132 (114-163)	3.7 (3.4-4.2)	234 (212-262)
BMI 40+	Type 2 diabetes	8.4 (8-8.7)	230 (219-238)	21.5 (20.5-22.3)	642 (614-667)

Notably in all regions, the proportions of CMD deaths attributable to obesity class 2 and 3 were higher in women compared to men (Figure 3B). For example, in Moquegua, the proportion of CMD deaths attributable to obesity class 3 was 18.3% in women and 1.6% in men.

Discussion

Main findings

In this comparative risk assessment, we provided subnational estimates of the proportion and absolute number of CMD deaths attributable to high BMI in Peru. We found high variability across regions in the proportion of CMD deaths attributable to high BMI, which was the highest in the Amazon

(i.e., Madre de Dios, Ucayali) and the Coast (i.e., Tacna, Moquegua), and lowest in the Highlands (i.e., Apurimac, Huanacavelica). Consistent with its large population, we also found that Lima (i.e., the capital of Peru hosting ~33% of the national population²⁰) had the highest absolute number of CMD deaths attributable to high BMI. Finally, across BMI categories, obesity class 1 and overweight contributed the most to CMD deaths attributable to high BMI in both sexes.

Public health implications

Our results suggest that high BMI is a major contributor to the CMD mortality burden in Peru; in fact, we found 1 out of 3 CMD deaths (1 out of 2 T2DM deaths, 1 out of 4 CVD

Figure 1. Percentage of cardiometabolic diseases (CMD) deaths in 2018 attributable to high body-mass index (BMI) in 2016 by region and sex. Exact number estimates (along with their 95% confidence interval [CI]) are presented in Supplementary Table 2.

deaths) are attributable to high BMI at the national level, which is consistent with global estimates^{2,8}. We found that the proportion of CMD deaths attributable to high BMI is high across regions in the Amazon (e.g., Madre de Dios) and the Coast (e.g., Tacna), where local health policies are needed to tackle the soaring CMD burden attributable to high BMI. In this line, reducing the high distribution of overweight and obesity via established food supplement social programs in Peru could be the first step^{21–23}. These social programs have focused on undernutrition²⁴; however, as Peru currently experiments a double burden of malnutrition (i.e., undernutrition and high BMI coexist)^{25,26}, reducing high BMI via these ongoing national or regional efforts could maximize available resources.

As the fundamental cause of high BMI is the disbalance between caloric intake and output⁴, the elevated consumption of energy-dense foods high in fat and sugar has been addressed in national policies from several countries^{27,28}, including Latin American and the Caribbean (LAC) countries^{29,30}. In 2013,

the Peruvian government passed a law that mandated front-of-package warning labels for processed and ultra-processed foods^{31,32}. While it is still early to see the effects of these pieces of legislation in Peru, our work signals some regions where these population-wide interventions should be strengthened and complemented with individual-level interventions (e.g., foster physical activity)³³.

Research in context

The GBD 2019 provided estimates of the proportion and absolute number of deaths attributable to several risk factors (e.g., high BMI) in 204 countries and territories in the period 1990–2019². Although Peru was included and its national estimates were reported, subnational estimates were not reported, though they have been reported for other LAC countries (e.g., Brazil)^{2,34}. Our results complement the global evidence by providing estimates of the CMD mortality attributable to high BMI in the 25 regions of Peru leveraging on local and national survey and mortality data.

Figure 2. Absolute number of cardiometabolic diseases (CMD) deaths in 2018 attributable to high body-mass index (BMI) in 2016 by region and sex. Exact number estimates (along with their 95% confidence interval [CI]) are presented in Supplementary Table 2.

Compared to the GBD results of the proportion of cause-specific deaths attributable to high BMI in Peru², our national results were roughly similar in both men and women. For instance, our estimates of the proportion of T2DM deaths attributable to high BMI in 2018 were 50.3% in men and 56.0% in women, whereas the estimates by the GBD in 2018 were 50.1% in men and 51.8% in women⁸; furthermore, our estimates of the proportion of CVD deaths attributable to high BMI in 2018 were 23.6% in men and 24.7% in women, whereas the GBD estimates in 2018 were 20.8% in men and 21.8% in women⁸. Although our national estimates of the absolute number of T2DM deaths attributable to high BMI in 2018 were similar (1,376 in men and 1,675 in women by our estimates versus 1,085 in men and 1,214 in women by the GBD⁸), our estimated absolute number of CVD deaths attributable to high BMI in 2018 was lower compared to the GBD results: 1,665 in men and 1,551 in women by our estimates versus 3,117 in men and 2,855 in women by the GBD⁸. These differences between results regarding CVD

mortality could be explained by the mortality data source herein used. We used national death registries, whereas the GBD used global mortality estimates where input data are modelled using standardised tools (e.g., spatiotemporal Gaussian process regression)^{2,35}. Overall, these comparisons suggest that our estimates of the mortality attributable to high BMI in Peru are close to the best available evidence, but our estimates of the absolute number of CVD deaths attributable to high BMI could be underestimated and should be interpreted in line with the data sources and methodology herein used.

Strengths and limitations

We estimated the mortality attributable to high BMI across regions in Peru. We benefited from nationally- and sub-nationally-representative prevalence estimates¹⁰, RR derived from a global work¹¹, and the most recent mortality data from the national death registry in Peru¹⁴. However, our study has some limitations. First, we only provided estimates for 2018 because of data availability, as we had to pooled

Figure 3. Percentage of cardiometabolic diseases (CMD) deaths in 2018 attributable to each high body-mass index (BMI) in 2016 by BMI category and region in men (**A**) and women (**B**). Exact number estimates (along with their 95% confidence interval [CI]) are presented in Supplementary Table 3. BMI categories: 25–29.9 [overweight], 30–34.9 [class 1 obesity], 35–39.9 [class 2 obesity], and ≥ 40 kg/m² [class 3 obesity].

individual-level data from individual surveys (i.e., ENDES 2014-2018) in order to get a strong sample size in each BMI category stratified by region, sex, and age group. Thus, time trends of the proportion of CMD deaths attributable to high BMI could not be explored. Second, we only focused on T2DM and CVD; that is, malignant neoplasms were not included because of limited number of registered deaths in all regions except for Lima. Although global evidence indicates both T2DM and CVD are the major contributors to the total absolute number of deaths attributable to high BMI in Peru⁸, malignant neoplasms also play a substantial role at the national level (642 deaths in men and 998 in women reported by the GBD⁸). Finally, there could be under-registered deaths and therefore, an underestimation of the absolute number of deaths attributable to high BMI; if so, our results show a conservative scenario.

Conclusions

High BMI is a major contributor to the CMD mortality burden in Peru, with high variability in the proportion and absolute number of CMD deaths attributable to high BMI across regions. National and regional health policies need to be strengthened in order to tackle the NCDs burden attributable to high BMI, especially in regions from the Peruvian Amazon and Coast.

Data availability

Underlying data

Prevalence data used in this study are from the individual-level datasets of the Peru 2014-2018 DHS, available from the National Institute of Statistics and Informatics (INEI, for its acronym in Spanish) website at: <http://inei.inei.gob.pe/microdatos/>. Access to the dataset is granted only for legitimate research purposes. A guide for how to apply for dataset access is available at: <http://inei.inei.gob.pe/microdatos/>.

Relative risks data used in this study are from the GBD 2019 Study. They are available to download at: <http://ghdx.healthdata.org/record/ihme-data/gbd-2019-relative-risks>.

Mortality data used in this study are from the individual-level dataset of the Peru 2018 national death registry, available from the Ministry of Health (MINSA, for its acronym in Spanish) website at: <https://www.minsa.gob.pe/portada/transparencia/solicitud/frmFormulario.asp>. Access to the dataset requires registration and a formal request. A guide for how to apply for

dataset access is available at: <http://www.minsa.gob.pe/portada/transparencia/solicitud/AyudaFormulario.htm>.

Figshare: Data - High body-mass index and mortality from cardiometabolic diseases in Peru: a comparative risk assessment analysis. <https://doi.org/10.6084/m9.figshare.16701898.v3>¹⁹.

This project contains the following underlying data:

- BMI_prevalence_by_region_sex_age_1000sims2021-08-11.csv
- Deaths_NCD_Peru_2021-07-17.csv
- Deaths_NCD_Peru_2021-08-08.csv
- Deaths_NCD_Peru_2021-08-11.csv
- RRs_men.csv
- RRs_metaanalysis_1000sims_by_sex_age.csv
- RRs_women.csv

Extended data

Figshare: Supplementary material - High body-mass index and mortality from cardiometabolic diseases in Peru: a comparative risk assessment analysis. <https://doi.org/10.6084/m9.figshare.16701964.v1>¹³.

This project contains the following extended data:

- Supplementary Table 1
- Supplementary Table 2
- Supplementary Table 3

Data are available under the terms of the [Creative Commons Attribution 4.0 International license](#) (CC-BY 4.0).

Analysis code

Analysis code available from: https://github.com/wilmerguzman-upch/cra_bmi_peru

Archived analysis code as at time of publication: <https://doi.org/10.5281/zenodo.5593317>¹⁸

License: [MIT](#)

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