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The body mass index (BMI) as a public health tool to predict metabolic syndrome

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ABSTRACT

Objective: To analyze the body mass index (BMI) as an indicator of metabolic alterations, including the metabolic syndrome (MetS), at both individual level and public health level. Method: We recruited 3683 undergraduate students (17 - 24 years old) from México City identifying metabolic alterations, including the MetS, and comparing its prevalence by BMI ranges. We applied a sensitivity analysis to define BMI optimal cut-off point values. Results: We found 14.6% of MetS prevalence with a BMI average of 24.2%, and 34.5% of overweight prevalence (BMI ≥ 25). A BMI cut-off point value of 22.5 is suggested as an upper limit of a normal weight condition, only for public health purpose; while at individual level the BMI cut-off point of 25 was corroborated as the upper limit for a normal weight condition. A public health tool to estimate the MetS prevalence based on BMI percentages is proposed, and a study case is presented. Conclusion: BMI fails predicting at individual level both, healthy condition or metabolic alterations, when values are lower than 25. At population level, the BMI is a valuable public health tool to estimate MetS prevalence: based on the prevalence of MetS by BMI ranges of a sample of the population.

Keywords: BMI; Metabolic Syndrome; Obesity; Public Health Tool

1. INTRODUCTION

The body mass index (BMI) is a widely used tool to evaluate overweight and obesity based on two anthropometric parameters, height and weight:

$$\text{BMI} = weight/height^2$$

where weight is measured in kilograms, and height in meters.

The World Health Organization (WHO) has emitted recommendations on the reference values (cut-off points), to classify the weight condition of a person (underweight, normal, and overweight). Although some differences in the values of normal ranges for different populations has been recognized by WHO, however arguing compatibility [1], this agency recommends a universal classification of BMI values through a set of cut-off points to classify the weight conditions: <18.5 Underweight; 18.5 - <25.0 Normal weight; ≥25.0 Overweight [2,3]. These universal cut-off points for BMI are based on the probability to acquire diabetes and of mortality [2,4], but it is known that diabetes is only a possible consequence, among many other disorders, associated to obesity, which has increased its prevalence worldwide among young population in recent years, and it has been recognized as epidemic in almost all countries [5-8].

Obesity can be seen as a particular case, stage, or component, of the metabolic syndrome (MetS), and could be better understood when it is analyzed as a component and in some cases, as a consequence of the syndrome. The routes leading to MetS, a multifactorial process, could involve positive and negative feedback between its components. Thus, it is suitable to expect a wide range of combinations of alterations among individuals with MetS, and also in overweighed individuals too (assessed by BMI). That expectation, applied to BMI ranges, could be translated to find individuals with metabolic alteration at both sides of the BMI cut-off point of 25. Then the questions are: which is the relative frequency of individuals with metabolic alterations along BMI values? Is 25 an adequate BMI cut-off point for the age range of young Mexicans? Is there a BMI value under 25 that better differentiates the normal weight from overweight conditions for this population?

In order to have BMI as a more precise indicator of metabolic alterations, it is relevant to assess the sensitivity of BMI reference values [2] in healthy and not healthy conditions for diverse population groups, such as young Mexicans. We hypothesized that BMI of a healthy population shows a normal distribution, *i.e.*, the frequency of BMI values grouped by ranges conforms a bell-shaped curve. That implies that some BMI values are higher than others, both belonging to healthy persons.

If the next five conditions are taken into account to define BMI cut-off points, it could make BMI a more efficient tool in health promotion:

1) BMI should include in the analysis a criteria to classify persons into "healthy"/"not healthy", and not to support the decisions only on percentile curves.

2) BMI should use a wider inclusive health definition, wider than the absence of diabetes or hypertension, by instance, alterations related to MetS.

3) BMI should consider specific populations, including factors as age, gender, and geographic or ethnic origin.

4) BMI should report explicitly the probabilities of being healthy (or not healthy) by each class of BMI ranges.

5) BMI should subdivide its ranges according to the elasticity of probabilities of being healthy.

We propose that there is a percentage of the population with a BMI lower than 25 (the upper cut-off point for "normal weight" range as recommended by WHO), which present metabolic disorders. We conceptualize the BMI scenario as having a fuzzy limits that made the 25 cut-off point only an upper threshold of "normal weight".

If an operational definition of healthy condition is used to establish BMI cut-off points, this tool could detect more efficiently early adverse consequences of obesity for young population's health. In this regard MetS would bring a more comprehensive/inclusive frame to define the cut-off points for BMI ranges, than diabetes or mortality probabilities do. If those cut-off points are adjusted to the probability of acquire obesity-related metabolic disorders, such as those associated with MetS, it will be a more efficient tool to differentiate between healthy and not healthy stages. The analysis and definition of BMI reference values for specific populations yield more accuracy to the index. For example, by defining reference values for age and sex groups, BMI would detect more precisely the obesity classes [9]. In that respect, WHO recommends BMI cut-off points for boys and girls from 0 to 5 years of age [10]. That recommendation is based on a percentile definition perspective, *i.e.*, WHO reports BMI values at 3, 15, 50, 85, and 97 percentiles, but their relation with children's healthy/not healthy conditions is not clear. Some studies used only percentile curves to define BMI cut-off points without assessing at least one healthy condition [9]. Ezzati *et al.*, proposed a universal cut-off point of 21 kg/m^2 based on the risk of several health related problems [11]; in contrast, we propose that BMI cut-off point needs to be related to a more particular set of diseases, *i.e.*, MetS, in order to made BMI a more accurate predictor of healthy problems.

The objective of this study was to define specific BMI reference values (cut-off points) for young Mexicans (ages 17 - 24 years), based on a healthy/not healthy operational definition that could help detecting metabolic disorders, as early stages of MetS. To make BMI a more precise and accurate tool, we propose a subdivision of BMI ranges while reporting the probabilities of being healthy and to have MetS. Also, we want to bring a tool that estimates MetS prevalence in a population based on probabilities by BMI ranges; we give an example to estimate MetS prevalence by State in México.

2. METHODS

2.1. Participants

A total of 3683 undergraduate students, aged 17 - 24 years, participated in a project to evaluate the health of young Mexicans, from years 2008 to 2010. All students signed an informed consent. Blood samples were taken, also anthropometry was measured (waist circumference, blood pressure, height and weight) and collected for each student. Blood samples were analyzed by CARPERMOR S.A. de C.V., an international reference laboratory to obtain blood chemical parameters.

2.2. BMI Calculation for Healthy and Not Healthy Students

BMI was calculated with the well known formula:

$$BMI = weight/height^2$$

where *weight* is measured in kilograms, and *height* in meters. Those 3683 students were classified in two subsamples: "healthy" students and "not healthy" students, dependent if the student bears or not a metabolic alteration; in this study we considered metabolic alterations as those reported by Alberti *et al.*, that define MetS (**Table 1**) [12], which is pretty similar to the American Heart Association

Table 1. Reference values of clinical and anthropometric parameters to define the metabolic syndrome [12].

Parameter	Categorical cut-off point
HDL Cholesterol	<50 mg/dL in women <40 mg/dL in men
Waist circumference	≥80 cm in women ≥90 cm in men
Triglycerides	≥150 mg/dL
Blood pressure	≥130 mmHg systolic ≥85 mmHg diastolic
Fasting glucose	≥100 mg/dL

(AHA) definition [13]. Also, a subsample showing MetS was defined as the set of such students with three or more metabolic alterations. This MetS set was a subsample of the "not healthy" students group.

2.3. BMI Statistics of the Sample

Frequency histograms by WHO BMI ranges and by unit of BMI value (16 - 17 kg/m^2, 17 - 18 kg/m^2, etc.) were built, obtaining the basic statistics, mean and standard deviation. Both, the whole sample and the healthy subsample, were plotted in the same graph to visually exploring it.

2.4. Probabilities of Being "Healthy"/"Not Healthy", "with MetS" by BMI Ranges

For each range of BMI, and for both ranges schemes (by WHO BMI ranges, and by BMI unit ranges), the proportions of "healthy" and "not healthy" students were calculated. These proportions are reported as the probabilities of being healthy/not healthy at each BMI range.

2.5. Cut-Off Points

The cut-off points for BMI were defined using two approaches: 1) percentiles: by defining the BMI values dependent on which proportion of the population is below and above of them, and 2) sensitivity analysis: by classifying as healthy/not healthy condition, and searching for a proportion that minimizes the committed and omitted errors.

2.6. Defining Cut-Off Points Based on Percentiles

The cut-off points setting based on percentiles could be used as threshold values. The BMI value at the 95% cumulated frequency of the healthy sample, could represent an upper BMI value for the normal weight class. If the cumulated frequencies of "not healthy" students are calculated downward, then the 95% could be used as a lower threshold for an inadequate weight. If both subpopulations, "healthy" and "not healthy", show a normal distribution, and if both curves are overlapped, then those lower and upper thresholds could be far away, showing an overlapped region where both healthy and not healthy coexist.

2.7. Defining Cut-Off Point Based on Sensitivity Analysis

This definition is quite similar to that of percentiles, *i.e.*, if both cumulated curves of "healthy" and "not healthy" cases are plotted (the second one calculated in reverse order), then the point where both curves cross, represents the optimum cut-off point that detects the same proportions of "healthy" and "not healthy" cases. That point minimizes both types of errors, committed and omitted. Any other point will displace the error to some of the two classes.

2.8. Estimating MetS Prevalence in México

We applied the found proportions of MetS by WHO BMI range to a public health survey [14], in order to estimate the population (17 - 24 years old) with MetS in México: the proportions were multiplied by the Mexican total population of 17 - 24 years old. To estimate the Mexican population of the target age range, we used the data by México's States obtained from the national population census [15], and from a public sample data of about 10% of the total records [16]. As the available public data report the population in the year 2005, we also applied a mortality rate to estimate the young population at year 2010 [17].

3. RESULTS

3.1. The "Not Healthy" Cases within the BMI "Normal Weight" Class

For the analyzed sample it was a considerable proportion of "not healthy" cases with a BMI value in the "normal weight" class (from 18.5 to less than 25). Only 38% of students with a BMI value in the "normal weight" class are "healthy" (**Table 2**), which suggests that the 25 kg/m^2 upper limit for the normal weight class needs to be revised (for short in the next paragraphs we omitted the units, kg/m^2, for BMI values).

Table 2. Health statistics according to BMI (probabilities of being "healthy", "with 1 or 2 alterations", and "with MetS" by WHO BMI range).

Students	All	Underweight	Normal weight	Overweight	BMI (mean ± SD)	mean ± 1·SD (68%)	mean ± 2·SD (95%)
All	3683 (100.00%)	102 (100.00%)	2312 (100.00%)	1269 (100.00%)	24.2 ± 4.3	(20.0 - 28.5)	(15.7 - 32.7)
"Healthy"	1021 (27.7%)	62 (60.8%)	879 (38.0%)	80 (6.3%)	21.6 ± 2.4	(19.2 - 24.0)	(16.8 - 26.4)
"With 1 o 2 alterations"	2124 (57.8%)	38 (37.2%)	1,319 (57.1%)	767 (60.4%)	24.3 ± 3.9	(20.5 - 28.2)	(16.6 - 32.1)
"With MS"	538 (14.6%)[a]	2 (2.0%)	114 (4.9%)	422 (33.3%)	28.7 ± 4.6	(24.1 - 33.2)	(19.5 - 37.8)

[a]Here is shown that MetS prevalence in the sample is 14.6%.

3.2. BMI Statistics of the Sample

BMI average for all the sample was 24.2 (SD = 4.3; **Table 2**). Disaggregating the sample by healthy condition, BMI averages were 21.6 (SD = 2.4), 24.3 (SD = 3.9), and 28.7 (SD = 4.6) for the "healthy", "not healthy" with 1 or 2 alterations, and "not healthy" with MetS, respectively.

3.3. Probabilities of Being "Healthy"/"with 1 or 2 Alterations"/"with MetS" by BMI Class

The sample studied showed a MetS prevalence of 14.6% (**Table 2**); while 1/3 of the "overweight" WHO BMI range presented MetS (33.3%), MetS prevalence in the other two classes is considerably lower (2.0% in underweight; 4.9% in normal weight; **Table 2**). The prevalence of students with 1 or 2 metabolic alterations is very high in all three WHO BMI ranges: 37.2% in underweight; 57.1% in normal weight, and 60.4% in overweight. The percentages of students without alterations (healthy students) vary across the three BMI ranges, with only 38.0% in the "normal weight" class (**Table 2**). The probabilities of being healthy calculated by ranges of BMI unit (**Figure 1** and **Table 3**) decrease with larger BMI, it shows a linear shape from 78.9% at 16 - 17 class, to 0% at 29 - 30 class. The probability of having 1 or 2 metabolic alterations ranges from 40% to 70% in any class. The probabilities to bear MetS increase linearly from 0% at the 18 - 19 class, to 63.6% at 34 - 35 class.

3.4. Cut-Off Points

The percentile analysis to define the cut-off points shows that 95% of the healthy population has a BMI lower than 25 (**Table 4**), and that 95% of the "not healthy" population has a BMI higher than 19. So, it is plausible to define BMI upper limit as 25 for "normal weight" related to metabolic alteration (including MetS).

The sensitivity analysis to define the cut-off points shows an optimum point at 22.5, detecting correctly 73.8% of

Table 3. Probabilities of being "healthy", "with 1 or 2 alterations" or "with MetS" by BMI unit range (Mexicans, 17 - 24 years old).

BMI class by unit	Total	"Healthy"	"With 1 or 2 alterations"	"With MetS"
16	100.0%	78.9%	21.1%	0.0%
17	100.0%	59.2%	39.5%	1.3%
18	100.0%	55.4%	44.6%	0.0%
19	100.0%	50.4%	47.6%	2.0%
20	100.0%	47.3%	50.6%	2.1%
21	100.0%	41.3%	56.3%	2.5%
22	100.0%	37.9%	57.5%	4.7%
23	100.0%	28.5%	64.8%	6.7%
24	100.0%	21.2%	66.2%	12.6%
25	100.0%	16.3%	70.0%	13.8%
26	100.0%	10.9%	60.2%	28.9%
27	100.0%	5.8%	70.5%	23.7%
28	100.0%	3.1%	64.1%	32.8%
29	100.0%	0.0%	58.7%	41.3%
30	100.0%	1.9%	54.7%	43.4%
31	100.0%	0.0%	48.5%	51.5%
32	100.0%	0.0%	55.9%	44.1%
33	100.0%	2.1%	41.7%	56.3%
34	100.0%	0.0%	36.4%	63.6%
35	100.0%	0.0%	44.4%	55.6%
36	100.0%	0.0%	44.4%	55.6%
37	100.0%	0.0%	45.5%	54.5%

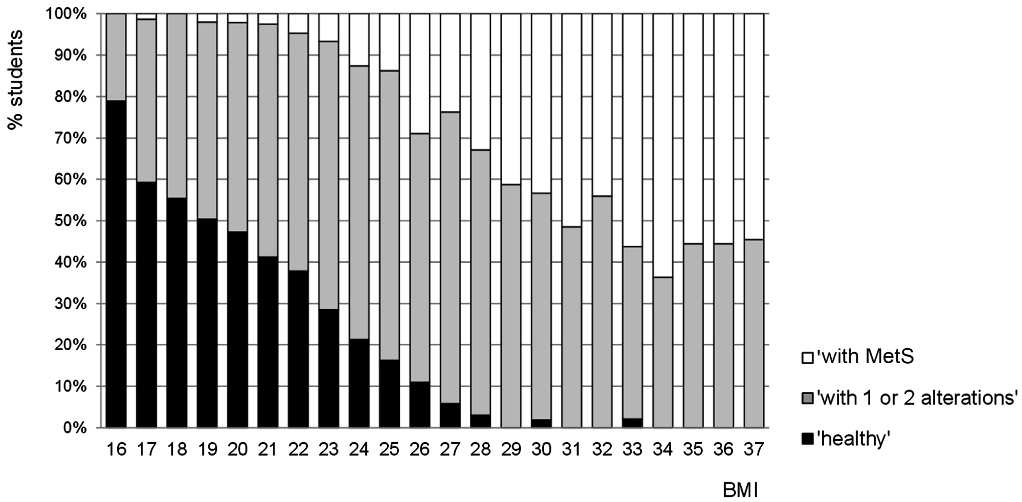

Figure 1. Relative frequency of students grouped into three health conditions according to BMI. Notice that students with a BMI value above 25 are mainly not healthy (either with MetS or with 1 or 2 metabolic alterations), and students with a BMI value below 25 include both, healthy and not healthy. The only BMI classes that include more than 50% of healthy students are 16, 17, 18 and 19.

"healthy" population, and 70.6% of "not healthy" population (**Figure 2** and **Table 4**), *i.e.*, 73.8% of "healthy" students have a BMI lower than 22.5, and 70.6% of "not healthy" students have a BMI higher than 22.5.

3.5. Estimating MetS Prevalence in México

Metabolic Syndrome prevalence estimation based on BMI ranges was 15.94% for the whole country, varying from 14.19% in Chiapas State to 18.22% in Quintana Roo State (**Figure 3** and **Table 5**). The State of México, and those States from Peninsula of Yucatán (Campeche, Quintana Roo, and Yucatán), showed the lowest percentage of "healthy" population; while Baja California and Sinaloa States showed the highest percentage of "healthy", with 28.68%. None of the States has a "healthy" proportion higher than 30%.

We estimated that 2,636,661 of México's population between 17 - 24 years old bear MetS (**Table 5**), and 9,488,508 show 1 or 2 metabolic alterations.

4. DISCUSSION

BMI has been used as a public health indicator, and as individual health indicator. The analysis presented here with young people of México City, shows that BMI could be used as an indicator of metabolic alteration at population level; but it fails when employed at individual level, mainly because the normal BMI-weight range (18.5 - <25.0) includes more than 50% of young people with metabolic alterations related to MetS. Therefore, it is not true to say that is highly probable that a person with a BMI below 25 has no metabolic alterations. However, the converse is true: it is very likely that a person with a BMI value above 25 has metabolic alterations. At individual level, and for young people, the BMI cut-off point of 25 could be used as an upper threshold of a healthy condition. However, a BMI cut-off point of 18.5 could not be used as a lower threshold of a healthy condition, because there is a subpopulation with metabolic alterations at both sides of such cut-off point.

Our finding that the normal distribution of BMI for young Mexicans runs from 19.2 to 24.0 (mean ± 1·SD), is compatible with the WHO's "normal weight" cut-off points 18.5 and 25, only to detect the abnormal weight condition when BMI is out of this range, but not to define a normal condition when BMI is within the range.

Because the origins of the classification of BMI values [2,4], a value above 25 needs to be understood as an indicator of a high probability to lose the healthy condition, but values under 25 are no indicators of a high probability of having a healthy condition, instead it should be understood as an indicator of "not a high probability to lose the healthy condition". This study suggests a BMI cut-off point of 22.5 to classify young Mexicans in relation to metabolic alterations, which is, in fact, lower than 25.

Table 4. Sensitivity and specificity of BMI to MetS-related alterations. *Approximately 95% of "healthy" students have a BMI lower than 25, **and 95% of "not healthy" students have a BMI higher than 19; †A BMI value of 22.5 minimizes both committed and omitted errors.

				Relative frequencies		Cumulated frequencies			Specificity	Sensitivity
BMI	All students	"Healthy"	"Not healthy"	"Healthy"	"Not healthy"	"Healthy"	"Not healthy"	"Not healthy" (sum in inverse order)	"Healthy"	"Not healthy"
<17.5	56	35	21	3.4%	0.8%	3.4%	0.8%	99.2%	3.4%	100.0%
17.5	46	27	19	2.6%	0.7%	6.1%	1.5%	98.5%	6.1%	99.2%
18.0	58	31	27	3.0%	1.0%	9.1%	2.5%	97.5%	9.1%	98.5%
18.5	81	46	35	4.5%	1.3%	13.6%	3.8%	96.2%	13.6%	97.5%
19.0	127	59	68	5.8%	2.6%	19.4%	6.4%	93.6%	19.4%	**96.2%
19.5	121	66	55	6.5%	2.1%	25.9%	8.5%	91.5%	25.9%	93.6%
20.0	165	70	95	6.9%	3.6%	32.7%	12.0%	88.0%	32.7%	91.5%
20.5	164	85	79	8.3%	3.0%	41.0%	15.0%	85.0%	41.0%	88.0%
21.0	199	89	110	8.7%	4.1%	49.8%	19.1%	80.9%	49.8%	85.0%
21.5	201	76	125	7.4%	4.7%	57.2%	23.8%	76.2%	57.2%	80.9%
22.0	245	96	149	9.4%	5.6%	66.6%	29.4%	70.6%	66.6%	76.2%
22.5†	204	74	130	7.2%	4.9%	73.8%	34.3%	65.7%	73.8%	70.6%
23.0	191	53	138	5.2%	5.2%	79.0%	39.5%	60.5%	79.0%	65.7%
23.5	198	58	140	5.7%	5.3%	84.7%	44.7%	55.3%	84.7%	60.5%
24.0	194	45	149	4.4%	5.6%	89.1%	50.3%	49.7%	89.1%	55.3%
24.5	164	31	133	3.0%	5.0%	92.2%	55.3%	44.7%	92.2%	49.7%
25.0	132	25	107	2.4%	4.0%	94.6%	59.4%	40.6%	*94.6%	44.7%
25.5	108	14	94	1.4%	3.5%	96.0%	62.9%	37.1%	96.0%	40.6%
26.0	117	14	103	1.4%	3.9%	97.4%	66.8%	33.2%	97.4%	37.1%
26.5	94	9	85	0.9%	3.2%	98.2%	69.9%	30.1%	98.2%	33.2%
≥27	818	18	800	1.8%	30.1%	100.0%	100.0%	0.0%	100.0%	30.1%
Total students	3683	1021	2662							

Table 5. Prevalence of MetS in States of México. The prevalence was calculated based on BMI range (**Table 2**), applied to the structure of BMI ranges by State obtained from ENSANUT 2006 [14]. *Estimated population based on national population counting [15], age structure [16], and a mortality rate of 76.11 deaths per 100,000 individuals per year from 2006 to 2010 [17].

		Estimated prevalence		Population		
México State	"Healthy"	"With 1 or 2 alterations"	"With MetS"	17 - 24 years old*	"With 1 or 2 alterations"	"With MetS"
Chiapas	28.57%	57.24%	14.19%	176,251	100,879	25,013
Oaxaca	28.33%	57.30%	14.36%	403,141	231,013	57,906
Guerrero	28.22%	57.33%	14.45%	72,260	41,423	10,439
Hidalgo	27.68%	57.76%	14.55%	127,415	73,598	18,540
Baja California	28.68%	56.74%	14.58%	383,145	217,381	55,880
Sinaloa	28.68%	56.63%	14.69%	90,241	51,101	13,255
Puebla	27.44%	57.79%	14.76%	795,548	459,736	117,457
Aguascalientes	28.13%	57.02%	14.84%	484,440	276,251	71,882
Nayarit	28.00%	56.97%	15.02%	1,159,313	660,503	174,127
Jalisco	28.28%	56.61%	15.10%	257,778	145,927	38,936
Zacatecas	28.14%	56.66%	15.20%	842,371	477,274	128,000
Tlaxcala	26.62%	57.83%	15.54%	566,314	327,505	88,016
Durango	26.82%	57.61%	15.57%	396,512	228,428	61,740
Querétaro	26.97%	57.45%	15.58%	1,071,138	615,407	166,835
Veracruz	26.79%	57.55%	15.66%	2,146,396	1,235,255	336,096
Morelos	27.08%	57.22%	15.70%	699,824	400,409	109,857
San Luis Potosí	27.21%	57.08%	15.70%	255,368	145,776	40,095
Coahuila	27.54%	56.60%	15.85%	157,880	89,357	25,030
Michoacán	26.75%	57.19%	16.06%	597,616	341,760	95,954
Guanajuato	26.00%	57.63%	16.37%	628,921	362,418	102,941
Chihuahua	26.73%	56.80%	16.46%	910,346	517,056	149,866
Colima	26.22%	57.26%	16.52%	269,424	154,269	44,507
Baja California Sur	26.23%	57.16%	16.60%	164,758	94,176	27,354
Nuevo León	26.39%	56.89%	16.71%	417,374	237,449	69,759
Tabasco	25.43%	57.76%	16.81%	417,190	240,953	70,125
Distrito Federal	25.09%	57.76%	17.14%	362,461	209,349	62,139
Tamaulipas	25.44%	57.41%	17.14%	343,627	197,276	58,913
Sonora	25.58%	57.25%	17.17%	440,275	252,045	75,606
Yucatán	23.91%	58.28%	17.81%	180,617	105,268	32,161
Campeche	24.03%	58.14%	17.82%	1,189,540	691,653	212,015
Estado de México	24.49%	57.51%	18.00%	291,504	167,637	52,470
Quintana Roo	23.48%	58.30%	18.22%	240,118	139,976	43,747
MÉXICO	26.71%	57.34%	15.94%	16,539,106	9,488,508	2,636,661

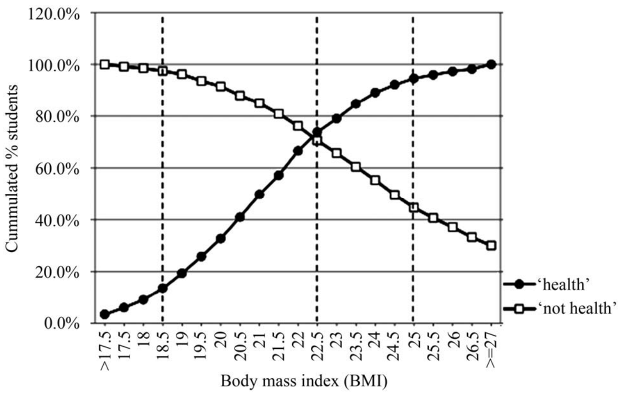

Figure 2. Sensitivity and specificity of BMI to MetS-related alterations. Dashed vertical lines indicate BMI cut-off points to detect, 1) the 95% of "not healthy" students (≥18.5); 2) the 95% of "healthy" students (≤25.0); 3) optimal minimizing both, committed and omitted errors (22.5).

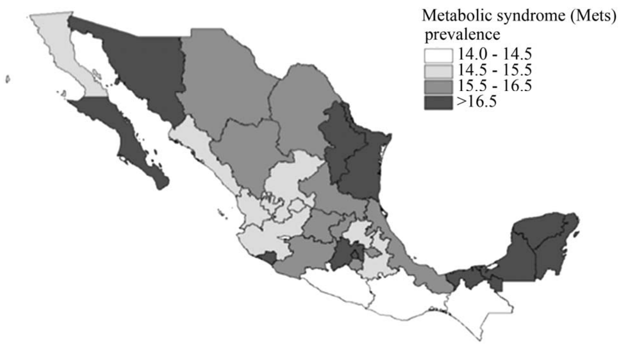

Figure 3. Metabolic syndrome prevalence in México by State.

The ENSANUT 2006 [14] is a valuable database to make estimations at State and nation levels; nevertheless, we detected a bias in the sampling, mainly because a bimodal-shaped curve when histograms for BMI ranges by unit is built. For that reason, we decided to use the prevalence of MetS in WHO classes (**Table 2**) instead of prevalence by BMI unit ranges (**Figure 1** and **Table 3**). We suspect that MetS prevalence calculated here is overestimated, since ENSANUT is most probably biased due to participation of not healthy people. México's MetS map (**Figure 3**) shows a qualitative comparison between states, but more studies are needed to confirm or modify these results with more reliable data.

In conclusion, the BMI of healthy young México City inhabitants (17 - 24 years old) shows a normal distribution pattern that runs mainly from 19 to 24, with a mean of 21.6 and standard deviation of 2.4. The BMI of all young México City inhabitants, including "healthy" and "not healthy" persons is biased to the right, reflecting the high prevalence of obesity (mean = 24.2, SD = 4.3). The BMI could be used as a public health tool to estimate or classify how healthy a young population is regarding metabolic alterations. However, at individual level BMI fails showing inadequate sensitivity and specificity for cut-off points for "normal weight", in the context of MetS-related alterations. The "normal weight" upper cut-off point of 25 is better applied if individuals exclude the possibility of a normal weight condition when BMI crosses this limit. We suggest that BMI of 22.5 is a public health tool useful to classify the population into "healthy" and "not healthy". The estimated MetS prevalence for México, applying the method proposed is 15.95%. The Peninsula of Yucatán States (Campeche, Quintana Roo, and Yucatán) and the State of México present the higher MetS prevalence in young Mexicans (17 - 24 years old), while the South-West States (Chiapas, Guerrero, and Oaxaca) present the lower MetS prevalence. A total of 2,636,661 young people in México are estimated to present MetS.

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