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Understanding the role of inequality of opportunity in body mass index and waist circumference among Mexican adults

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Abstract. Mexico faces one of the most acute obesity crises worldwide. While most of the literature has focused on studying the immediate causes of the phenomenon, very few have gone further to explore the structural causes of the public health problem, such as *inequality of opportunity* (IOp). The research agenda after the canonical work of John Roemer acknowledges that not all inequalities are equally illegitimate or unfair. The essence of the concept of inequality of opportunity relies on identifying the sources behind the variation of an outcome. Equality of opportunity is defined as a situation where individuals face equal circumstances (exogenous factors in which people do not have any control and therefore, cannot be held responsible for)for an outcome. This study aims to measure, identify and characterise the dynamics of the role of IOp in body mass index (BMI) and waist circumference (WC) for Mexican adults. Results show that inequalities in BMI and WC related to circumstances exist and vary between sex, geographical regions and percentiles of the distribution. Age and diabetes inherited from the parents are the main drivers of inequality. These findings highlight the need to design differentiated health policies that provide equality of opportunity; mitigate unequal circumstances of origin and compensate people for inherited unequal playing fields.

Key words. Inequality of opportunity in health; distributive justice; inequality related to circumstances; overweight and obesity; Mexico.

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1 Introduction

Mexico faces an acute obesity crisis. The prevalence of overweight and obesity (OWOB) in the adult population is the second highest in the world. 75 out of 100 adults in Mexico are either overweight or obese. Recent data showed that this joint prevalence increased from 71.3% in 2012 to 75.2% in 2018 (National Institute of Public Health, 2018). Furthermore, the joint prevalence of overweight and obesity is expected to be 88% for men and 91% for women in 2050, meaning that out of 100 people only 9 will be classified as normal weight; 34 as overweight, and 57 as obese (Rtveladze et al., 2014).

Obesity is a public health problem that represents a health, social and economic burden, not only in Mexico but on a worldwide scale. For the one part, obesity and its comorbilities are factors that increase the rate of death and decrease both quality and duration of life expectancy (Jarolimova et al., 2013). For the other, since type two diabetes, hypertension, cardiovascular diseases and some types of cancer are closely correlated with abdominal obesity (Sánchez-Castillo et al., 2005), the future treatment of obesity and its comorbilities represent a burden to any public health budget.

It has been estimated that globally, obesity costs 2.8% of the gross domestic product (GDP) of the world (Dobbs et al., 2014). For Mexico, it is estimated that 33.2% of the federal public health budget was spent to treat obesity-related comorbilities in 2008. Should the OWOB prevalence continue its rising trend, it is estimated that the cost could increase up to 110% by 2050 (Rtveladze et al., 2014). From a health economic perspective, this scenario raises concerns about the sustainability of the public health system to prevent and treat this conditions, together with other diseases among the population.

OWOB can be simply defined as the result of a prolonged positive energy balance where energy intake is greater than energy expenditure. However, there are many ways in which this imbalance can happen, since obesity is a multiple etiological problem. The causes of obesity can be classified, according to its proximity, as: immediate, intermediate and structural that occur through the life course (Rivera Dommarco et al., 2018). Immediate causes refers to those factors related to people's lifestyles and behaviours, for instance high consumption of energy-dense food and/or low physical activity. People's propensity to obesity given genetic conditions, is also an immediate cause. Intermediate causes are those linked with the production and distribution of food, this mainly refers to the National food system. Structural causes are mainly related to the social, economic and political gradient of the situation.

Many studies have focused on studying the different aspects of the causes of obesity, with many focusing on the immediate causes. For instance, a number of studies have documented the alarming increase in energy intake from sugar-sweetened beverages (SSBs) and nonessential high caloric energy-dense food in Mexican adults (Barquera et al., 2008; P. A. H. Organization and W. H. Organization, 2015). Barrientos-Gutiérrez and others (2017) also found that the rise in the prevalence of OWOB prevalence is due to a greater intake of high energy food and beverages, as well as changes in lifestyles towards inactive physical activity (Barrientos-Gutierrez et al., 2017). Other analyses have documented an increase in the prevalence of physical inactivity among Mexican adults (Medina et al., 2013). A recent study also corroborated that eating patterns of the Mexican population differ substantially from recommendations for healthy living (Batis et al., 2018).

The interplay between immediate and intermediate causes in Mexico has been studied by Clark *et al.,* (2012). They analysed the effects of the North American Free Trade Agreement (NAFTA) on Mexico's food environment. Their results shows that, as a consequence of this policy, the Mexican food system has been influenced and modified such that it has contributed to changes to dietary patterns. Particularly, a higher consumption of soft drinks, snacks, meat and diary products among the population (Clark et al., 2012).

Within the structural causes, there has been several studies from the socioeconomic viewpoint about how the prevalence of OWOB in Mexico increased from 34.5% in 1988 to 72.5 % in 2017 (Ministry of Health and National Institute of Public Health, 2017). Results from a recent analysis showed that differences in obesity trends are related to rapid changes in the food environment and cultural institutions. One of the consequences is that Mexican people in the lowest deciles of the income distribution have become the most vulnerable to the obesogenic environment (Pérez Ferrer, 2015). Other studies have found associations between socioeconomic indicators (wealth, education, occupational status and marital status) and excess of body weight, for both women and men and for 2006 and 2012 (Quezada and Lozada-Tequeanes, 2015). Levasseur (2015) also analysed the effect of household socioeconomic status on nutritional outcomes among urban Mexican adults. His results showed that there is a strong effect of socioeconomic status on central adiposity for men (Levasseur, 2015). In the same regard, Beltrán-Sánchez and others (2011) found an association between education and obesity rates. For the case of Mexican men, low education was related with lower obesity, while there was an inverse association for women: more education was translated into lower obesity rates (Beltrán-Sánchez et al., 2011).

The results of these analyses point out that health outcomes and socioeconomic circumstances are related. Nevertheless, for Mexico, there are no studies that have analysed the sources, characteristics and differences behind these associations. In particular, there are no studies that have explored the extent to which inequalities of opportunities have shaped people's choices and behaviours; or the extent to which people had the opportunity to deliberately choose their lifestyles and consumption decisions. Therefore, this paper explores the role of inequality of opportunity in nutrition-related health outcomes, and adopts an *ex-ante* approach to identify, measure and characterise inequality of opportunity and its role in the OWOB epidemic in Mexico.

2 Defining Inequality of Opportunity

John Roemer (1998) defined two concepts to understand the fairness of (in)equality within a society: circumstances and efforts. Circumstances are exogenous situations in which people do not have any control and, therefore for which they cannot be held responsible. Sex, race, parental education or place of birth are examples of circumstances. Efforts are acts that embrace individual responsibility. For example, life-styles decisions or consumption behaviours.

Given these concepts, there are two approaches to analyse IOp: *ex-ante* and *ex-post*. The *ex-ante* approach conceptualises the idea that equality of opportunity exists if, before exerting any effort and achieving any outcome, people have an equal opportunity set. The *ex-post* approach looks at what happens after efforts and outcomes are observed. This approach defines the existence of equality of opportunities in outcomes when people that exerted the same level of effort, observe the same outcomes (Davillas and Jones, 2019; Ramos and Van de Gaer, 2016).

Under the *ex-ante* approach equality is a situation in which outcomes are orthogonal to circumstances. From this point of view, equality of opportunity encompasses the ethical position of "responsibility-sensitive *egalitarianism*". This concept aims to study the pathways from people's circumstances to health outcomes (Jones, 2019) and is applied when concerns about health inequality are tied to questions about access to rights that may guarantee an equal playing field.

This study adopts an *ex-ante* approach to identify, measure and characterise inequalities related to circumstances. It assumes that an equal playing field for people is translate to an equal set of opportunities for everyone, irrespective of whether such opportunities are acted upon. Therefore, if differences in circumstances explain part of the variation of an outcome, then, public intervention is acceptable in order to level the terrain.

2.1 Opportunities and inequalities in Mexico: the empirical evidence

Media reports have documented various situations that depict unequal circumstances in Mexico. One of these reports was released in 2018, when the *New York Times* documented the case of San Cristóbal de las Casas, a town in the south-eastern state of Chiapas in Mexico[1] where families were reported to consume more coca-cola than bottled water for hydration (López and Jacobs, 2018). This appears to be due to a combination of a lack of water and the water being heavily chlorinated, together with coca-cola being cheaper to purchase than bottled water. In this regard, a recent anthropological study also confirmed that in the Highlands of Chiapas, a high percentage of Mayans have substituted the intake of water for sweetened beverages and beer. It was estimated that the average person in Chiapas drinks annually 3,285 glasses of soda (of 250 ml), compared with the Mexican average of 600 glasses or the global average of 100 glasses, per person in a year (Pliego, 2019). Unsurprisingly Chiapas has the highest consumption of coca-cola per person in the world. This behaviour, that could be conceptualised as irresponsible and risky, in fact reflects not only the lack of options, but also the lack of enforcement to implement the Mexican Constitution, which states that running water should be available in all households.

In 2015, *The Guardian* documented the case of Mexico City which, as many other cities in Mexico has been described as a *"fat city"*. The report pointed out that poor levels of physical activity among its inhabitants could be the main cause of the obesity epidemic. The report exemplified how factors such as the urban environment; the city's dynamics; long commutes; crime and air pollution could offer an explanation as to why physical activity is low (Masse, 2015). This empirical evidence has been corroborated with research studies and data from a national survey about physical activity. Results from research concluded that most of the physical activity that people undertake is related to need, rather than choice or convenience (Salvo et al., 2018). Results from the

[1]Chiapas is the poorest State of Mexico, with the highest poverty and extreme poverty rates: 74.7% and 46.7%, respectively (Levy et al., 2015).

Sports Practice and Physical Exercise 2017 survey revealed that the two main reasons reported for being inactive were: 1) lack of time to do it, and 2) fatigue because of heavy workloads (INEGI, 2018).

This evidence demonstrates that health status is not only shaped by personal decisions or efforts, but also by social conditions and contexts. Therefore, the objective of this study is to identify, measure and characterise the role of inequality of opportunity in BMI and WC among Mexican adults. This analysis aims to explicitly and exhaustively study the role of inequalities related to circumstances underlying variation in BMI or WC, as indicators of OWOB. From a health policy perspective this is important given that many policies could potentially be focusing on the immediate causes, at the expense of structural ones. It is paramount that the design of policies incorporates discussions about how equal underlying opportunities are, and the extent to which effective access to social rights has been guaranteed, so that health outcomes do not overly depend on circumstances of origin.

3 Source of data: the National Survey of Health and Nutrition (ENSANUT)

Data from the cross-sectional National Survey of Health and Nutrition (ENSANUT, using its Spanish acronym) for 2012 and 2016 are analysed. The two datasets are nationally representative surveys whose target population are the inhabitants of private households in Mexico. These national cross sections are multi-stage stratified surveys and have the statistical power to make distinctions between areas of urbanicity (rural, urban and metropolitan), geographical areas (North, South, Central and Mexico City) and level of municipal deprivation. The sample design of both versions of the survey allows national inferences about the health of the Mexican population. A full and detailed description of the sampling methodology is described elsewhere (Romero-Martínez, Shamah-Levy, Cuevas-Nasu, et al., 2017; Romero-Martínez, Shamah-Levy, Franco-Núñez, et al., 2013).

Both datasets consist of a collection of demographic, social and economic conditions, as well as the state of nutrition-related health outcomes of the population, via anthropometric measurements such as weight, waist circumference and height. Even though both surveys share the same methodology, there are small differences between the two versions:

1. Unbalanced sample size. The number of households interviewed in the 2012 survey was 50,528; and 9,479 in 2016. This difference is due to an early collection of information. The ENSANUT survey was supposed to be undertaken every six years. Nevertheless, given the accelerated increase in the prevalence of overweight and obesity, it was decided to conduct a *mid-term* survey to monitor the health and nutritional status of the population (National Institute of Public Health, 2016).

2. State-level data collection. The 2016 survey did not collect data from Colima and Oaxaca States. It was reported that the data that was supposed to be collected from Oaxaca was reassigned and instead collected from the states of Chiapas, Tabasco and Veracruz (Romero-Martínez, Shamah-Levy, Cuevas-Nasu, et al., 2017).

3.1 Key variables: outcomes and circumstances

The unit of analysis throughout is Mexican adults, defined in the survey as aged 20 to 69 years old. We used valid data from 28,661 individuals in the 2012 survey and 6,734 from 2016. Pregnant women, observations reported as having problems related to measurement procedures, and individuals with biologically implausible values for BMI[2] and WC [3] were excluded from the analysis: 493 observations (1.69%) for 2012, and 60 observations for 2016 (0.88%).

3.1.1 Outcomes

BMI and WC were used as proxies of nutrition-related health outcomes. These two indicators differ in what specifically they measure. BMI is the most common measure due to its availability in data sets and its simplicity of measurement. It is basically the ratio of weight to height. Nevertheless, BMI has the following disadvantages: 1) It does not take into account the body fat distribution and the mass of abdominal fat (visceral fat), which can be quite different within and across populations (Dalton et al., 2003); 2) It can over-and under-estimate body fat. For example, people with considerable muscle mass will have a higher BMI. Whereas, people with low muscle mass, *e.g* elderly people, will have a lower BMI. Given these concerns, our analysis will also explore another measure that does account for intra-abdominal fat mass: WC. These two indicators are accurate predictors of diabetes (Vazquez et al., 2007), but WC provides a more appropriate measure of coronary heart disease risk (Flint et al., 2010). Anthropometric

[2] BMI$<$10 and BMI$>$59 (González et al., 2013)
[3] Waist circumference$<$51cm and $>$190cm (E. J. Jacobs et al., 2010)

measurements were taken by trained and specialised staff from the National Institute of Public Health (INSP) in Mexico.

Outcomes were defined as follows:

- BMI= $\frac{Weight(Kgs)}{Height^2(Metres)}$
- WC is the circumference of the waist expressed in centimetres.

3.1.2 Circumstances

Research following the canonical work of John Roemer acknowledges that not all inequalities are equally illegitimate or unfair. The essence of the concept of inequality of opportunity relies on identifying the underlying sources behind variation observed in an outcome and categorising these into those related to circumstances. In this context, the literature related to inequality of opportunity in health examines the pathways between circumstances and health outcomes. Furthermore, the *ex-ante* approach is concerned only with circumstances, understood as factors that individuals cannot control or decide upon. Therefore, the set of circumstances chosen for this study takes into account the normative framework embedded in the Mexican Constitution and its relationship with the known socio-economic drivers of nutrition-related health outcomes.

The first article of the Mexican Constitution stipulates that *"any discrimination based on ethnic or National origin, gender, age, disability, social or health condition, religion, opinions, sexual preferences, marital status or any other that threatens dignity is prohibited"* (Federacion, 2017). Furthermore, this is aligned with the "possibilist criterion"(Ramos and Van de Gaer, 2016) to define circumstances, in the sense than contextual factors, i.e. access to basic public services (running water, electricity, sanitation, etc.) are taken into account as potential sources of inequalities, and thus, defined as circumstances.

Therefore, for this analysis circumstances encompass the following characteristics: age, ethnic background, diabetic condition inherited from the mother and/or father and some characteristics of where people live: level of municipal deprivation and the existence of running water in the household.

- Age. In this study, age is considered to be a potential source of illegitimate health inequalities (Davillas and Jones, 2019). From a normative point of view, as OWOB varies across the lifespan, inequalities related to circumstances can be attenuated through specific health policies to target age groups.

- Ethnicity. Research about indigenous people in Mexico have pointed out that these populations have historically been treated unequally in social and economic terms. Regarding health inequalities, one study documented the presence of consistent disparities in this population (Servan-Mori et al., 2014). Another study found that primary health care utilisation by indigenous people faces several barriers (Leyva-Flores, Servan-Mori, et al., 2014). In this regard, ethnicity could be a source of inequalities in the WC and BMI. Ethnic condition was defined according to the National Commission for the Development of Indigenous People of Mexico (CDI, using its Spanish acronym), which asserts that indigenous people are those that declare to speak at least one indigenous language.

- Parental diabetes. This circumstance proxies on inherited condition from parents and acquired behaviours of individuals. It reflects the *genetic luck* which are characteristics genetically inherited (Dworkin, 1981). This circumstance indicates whether either the mother or father reported to have been medically diagnosed with diabetes. This circumstance also accounts for the inherited environment and behaviour present within the household.

- Running water inside the house. The fourth article of the Mexican Constitution declares that *"Everyone has the right to access and dispose of clean water for personal and domestic consumption in a sufficient, healthy, acceptable and affordable way."* (Federacion, 2017). Thus, as evidence highlights that the OBOW situation in Mexico is driven, in part, by the high intake of SSBs and a lack of availability of running water in some parts of the country, the presence of running water in the household was included as a circumstance.

- Municipality deprivation. This is a weighted index that measures social deprivation at the municipality level and takes into account the access to education, health, basic services and housing spaces. This index was estimated by the National Council for the Evaluation of Social Development Policy (CONEVAL). The use of this variable aims to capture the *geography of opportunity*, a concept that describes how the area and geographical space where people live condition the access to opportunities (Rosenbaum, 1995). [4]

[4] The level of deprivation is binary categorised as high or low. For the 2016 survey, this variable had three categories: high, medium and low. Thus, the "medium" category was pooled with the "low" one.

4 Methods

Various approaches have been developed to measure inequality of opportunity in health following two theoretical principles: the compensation and the reward principle. The former claims that inequalities related to circumstances should be eliminated, the latter argues to reward efforts among individuals that share the same circumstances.
Under the compensation principle, there are two approaches to identify inequalities: the *ex-ante* and *ex-post* (Bruoni, 2016; Ramos and Van de Gaer, 2016). The *ex-ante* approach is mainly interested in measuring if, prior to exerting any effort or observing any outcome, circumstances are equally distributed. The *ex-post* approach looks at the outcomes of individuals that share different circumstances and have exerted the same level of effort (Fleurbaey and Schokkaert, 2009; Jones, 2019).

This study aims to measure *ex-ante* inequality of opportunity and adopting a parametric regression-based approach. Thus, the main focus is not only to identify whether circumstances play a role in the distribution of an outcome, but also to evaluate the extent of individual deviation from a benchmark opportunity set. The following sub-section offers a further description of the techniques and methods used throughout this analysis. In the first subsection the approach to measure *ex-ante* IOp will be explained; the second subsection describes the decomposition of IOp among its circumstances. The third subsection presents a decomposition of the regional and counterfactual differences in the level of inequality. Finally, in the spirit of Davillas and Jones (2018), the fourth subsection will address differences in the level of inequality over the distribution of both health outcomes using unconditional quantile regression models along with an inequality-source decomposition (Davillas and Jones, 2019).

4.1 Measuring *ex-ante* Inequality of Opportunity

The regression-based method proposed by Ferreira and Gignoux (2011) is followed. This method relies on the very primary idea that if all individuals have the same set of opportunities, circumstances should not be related with outcomes. It aims to evaluate the extent to which each individual deviates from the *social opportunity set*, which is defined as the average level of advantage across the population (Ferreira and Gignoux, 2011). This approach commences with a health production function in which the health outcome of an individual i is a function of circumstances C, efforts E, and other random factors (i.e. genetic luck or other situations that the individual cannot avoid) but assumes that efforts are also determined by circumstances, for example: people do not exercise in an open-air spaces because of pollution or security reasons. This can be written through the following system of equations:

$$y_i = \alpha_0 + \alpha_1 C_i + \alpha_2 E_i + u_i \tag{1}$$

$$E_i = \delta_0 + \delta_1 C_i + v_i \tag{2}$$

In equation (1), α_1 and α_2 are parameters that reflect the direct effect of circumstances and efforts on the outcome, respectively. δ_1 is a matrix of coefficients that captures the indirect effect of circumstances on efforts. Equation (2) reflects that efforts are conditioned to circumstances.

Then, if equation (2) is inserted into (1) and the terms are arranged, the following reduced form equation is obtained:

$$y_i = (\alpha_0 + \alpha_2 \delta_0) + (\alpha_1 + \alpha_2 \delta_1) C_i + (\alpha_2 v_i + u_i) \tag{3}$$

In this equation α_1 captures the direct effect of circumstances and $(\alpha_2 \delta_1)$ the indirect effect. $\alpha_2 v_i$ includes the effort effect and u_i represents the residual. Equation (3) can be estimated using Ordinary Least Squares (OLS) as:

$$y_i = \beta_0 + \beta_1 C_i + \epsilon_i \tag{4}$$

Where y_i are the health outcomes BMI and WC for individual $i...n$. β_0 =$(\alpha_0 + \alpha_2\delta_0)$ is the intercept, β_1= $(\alpha_1 + \alpha_2\delta_1)$ represents a vector of the parameters of each circumstance and their magnitude, and ϵ_i=$(\alpha_2 v_i + u_i)$ is the error term that captures random variation in outcomes. Thus, using this model, both the direct effects of circumstances and the indirect effects on effort are taken into account and the total contribution of circumstances is estimated.

In order to assess the presence of inequality of opportunity, the predicted distribution of outcomes (or the *smoothed* distribution according to Ferreira and Gignoux, 2011), $E(y_i \mid C_i)$, is used as a counterfactual of equality of opportunity. This counterfactual distribution is inserted into an inequality measure. The choice of the inequality measure is mainly based on some desirable properties we expect the measure to contain. First, it is desirable that the measure meet the basic axioms of: symmetry; transfer principle; scale invariance and population replication. Moreover, since two decomposition analyses are carried out, it is also necessary for the measure to have the property of additive decomposability, and it is well known that only the inequality measures that belong to the Generalised Entropy Family class meet these requirements. Among these measures, the mean logarithmic deviation (MLD) was chosen for its path-independent decomposability axiom, which eliminates all between-group inequality meaning that the only objectionable inequality is that associated with opportunities (Ferreira and Gignoux, 2011). The MLD is the generalised entropy index $GE(\alpha)$ when $\alpha = 0$ and is estimated as follows:

$$MLD(y) = \frac{1}{N}\sum_{i=1}^{N} ln\frac{\bar{y}}{yi} \tag{5}$$

Thus, absolute inequality is defined as the MLD of the counterfactual distribution of health outcomes conditioned on circumstances, such that:

$$\theta_a = I_0(\hat{y}_i) \tag{6}$$

where I_0 denotes the MLD, and $\hat{y}$ depicts the counterfactual outcome $E(y_i|Ci)$. The absolute inequality measures the deviation of the expected level of health outcome from the group's expected average, so if θ_a is zero, the group has the same outcome. Larger values reflect higher levels of inequality.

Furthermore, relative IOp is also estimated. This is the ratio of the absolute level of inequality with respect to the overall inequality defined as:

$$\theta_r = \frac{I_0(\hat{y}_i)}{I_0(y_i)} \tag{7}$$

In equation (7), θ_r is defined as the MLD of the counterfactual distribution of outcomes divided by the MLD of the actual distribution of outcomes, this last defined as overall inequality. Relative inequality is zero when equality is observed, and higher values depict an unequal distribution of the outcomes.

4.2 Decomposition of Inequality

4.2.1 Shapley-Shorrocks decomposition

Estimates of inequality of opportunity in BMI and WC can be decomposed into their sources. That is, the relative importance of each circumstance to the overall inequality of opportunity can be quantified. This will be done using the Shapley decomposition approach. The essential idea behind the Shapley decomposition is to estimate the relative importance of each circumstance.

The method relies on the idea underpinning *transferable utility games* (TU). These games deal with the question of how to allocate the benefits of cooperation among *players* of a *game* in the most fair way. Lloyd Shapley in 1953 proposed a prescriptive solution named "The Shapley value", which comprises a set of attractive axioms that address issues related to fairness. Later, Shorrocks (1982) adapted this framework and applied it to the decomposition of inequality measures by their factor components. The intuition behind the application is that the "benefit of the game" is the inequality of opportunity measure and the "players" are the sources of inequality. Thus, in the game example, the objective would be to estimate the relative contribution of each circumstance to the relative measure of inequality.

As stated before, equation (4) depicts a linear and decomposable model. Then, let N denote the set all circumstances. A *coalition* of circumstances, S, is defined to be a subset of N, $S \subset N$, and the set of all possible coalitions is denoted by 2^N. The relative importance of each circumstance C to the inequality of opportunity, ϕ_c, is estimated by calculating the average marginal effect of each circumstance to the R^2 to each of the possible models. The decomposition is expressed as follows:

$$\phi_c = \frac{1}{N!} \sum_{S \subset N \setminus c} |S|!(|N| - |S| - 1)! \left[R^2(S \cup c) - R^2(S)\right] \tag{8}$$

S denotes the set of circumstances included in the model when excluding the c^{th} circumstance. Therefore, the marginal contribution is calculated as the difference between R^2 when the c^{th} circumstance is included and the R^2 when that c^{th} is excluded. The difference is calculated using all the possible permutations of circumstances. Then, the sum of the differences in averaged by the number of the possible permutations.

4.2.2 Oaxaca decomposition

The Oaxaca-decomposition method is used to understand the sources of the differences in the level of inequalities across geographical regions of Mexico. The method decomposes the mean differences in the outcomes of groups through estimating counterfactuals, where *groups* could be defined as points in time, geographical areas or characteristics of individuals, such as sex or age (Oaxaca, 1973). Differences in the IOp values and their counterfactuals might be due to two effects: the composition effect (differences in the circumstances) and the association effect (differences in how the outcomes change given the circumstances) (Chávez -Juárez and Soloaga, 2014).

Following Chavez and Soloaga (2014) and taking into account equation (4) let us assume that there is a health outcome, y, and 2 groups, 1 and 0. y_{1i} is the health outcome for an individual i in group 1. And y_{0i} is the health outcome for an individual i in group 0. It is assumed that i belongs only to one of the groups.This method is implemented in two steps, firstly inequality of opportunity for each group, 1 and 0, is estimated separately. Thus, for $g = 0, 1$

$$y_{i_g} = \beta_{0g} + \beta_{1g} C_{i_g} + \epsilon_{i_g} \tag{9}$$

Where y represents the health outcomes BMI and WC, C are the set of circumstances, and assuming that $E[\epsilon_i | C_i] = 0$. Then, according to the method described above, the following step to estimate IOp is to obtain $E(y_i \mid C_i)$ and insert the returns into the inequality measure, MLD. In the adaptation of the Oaxaca decomposition proposed by Chávez -Juárez and Soloaga, 2014, the second step is to calculate the counterfactuals for each group using the coefficients obtained in the first step. That is, to calculate the estimated outcome for group 0, using the circumstances observed in group 1, basically: $E(y_{i_0} \mid C_{i_1})$. In the hypothetical example where there are only two groups, the following matrix is created:

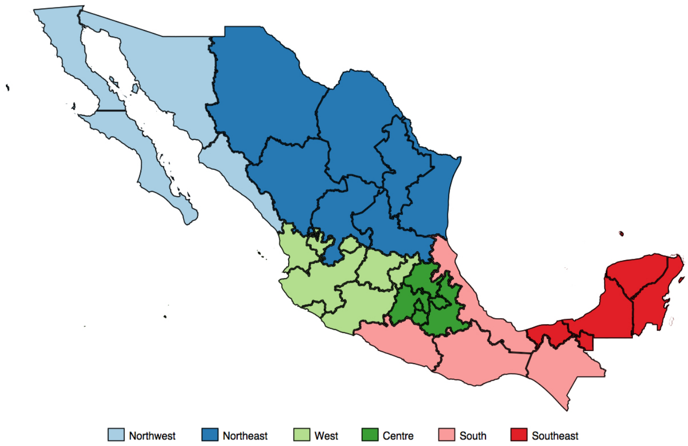
	Coefficients	
Distribution of circumstances	$North$ g_0	$South$ g_1
$North$ $\mathbf{g}_0$	$\hat{y_{g_0}}\vert C_{g_0}$	$\hat{y_{g_1}}\vert C_{g_0}$
$South$ $\mathbf{g}_1$	$\hat{y_{g_0}}\vert C_{g_1}$	$\hat{y_{g_1}}\vert C_{g_1}$

The principal diagonal displays the actual level of inequality of opportunity for each group (g_0, g_1). The values of the off-diagonal are the counterfactual values. It has to be noticed that the cell 1,2 (first column, second row) reports different information than cell 2,1 (second column, first row). Columns show the coefficients of in g_0, given the distribution of circumstances in any other group g_n. Conversely, rows show the coefficients of other groups g_n, given the distribution of circumstances in g_0.

The main objective is to identify not only IOp across geographical regions, but also to explore the well-known disparities between North and South. This is based on recent studies about important disparities in the access to public goods and health depends based on people residency (Luis A., 2019; Mexico, 2018). For this analysis, a regional decomposition will be performed. The 32 Federal States of Mexico have been grouped in six regions, as follows:

- **Northwest**: Baja California, Baja California Sur, Sinaloa and Sonora
- **Northeast**: Coahuila, Nuevo León, Tamaulipas, Chihuahua, Durango, Zacatecas and San Luis Potosí
- **West**: Aguascalientes, Colima, Guanajuato, Jalisco, Michoacán, Nayarit and Queretaro
- **Centre**: México City, State of México, Hidalgo, Morelos, Puebla and Tlaxcala
- **South**: Guerrero, Oaxaca, Chiapas and Veracruz
- **Southeast**: Campeche, Quintana Roo, Tabasco and Yucatán

Figure 1: Regions of Mexico for Oaxaca Decomposition



4.3 Going beyond the mean: Unconditional quantile regression models

In the above methods, IOp was estimated assuming a mean-based approach. In equation (4), inequality was calculated using the expected value of the outcome, given the whole distribution of the set of circumstances. In this section, the approach used by Davillas and Jones (2018), based on unconditional quantile regressions (UQR), is used in order to evaluate the changes in inequality across the whole distribution of the BMI and WC (Davillas and Jones, 2019). This will be achieved via a RIF regression. This is based on the idea that the outcome variable equation (4) can be replaced by a RIF, defined as (Borgen, 2016; Firpo et al., 2009):

$$RIF(y; q_\tau, F_Y) = q_\tau + \frac{\tau - 1\{Y \leq q_\tau\}}{f_y(q_\tau)} \tag{10}$$

where q_τ is the value of y at the τ quantile. y in our case is BMI or WC. F_y is the cumulative distribution function of y, and $f_y(q_\tau)$ is the density of y at the q_τ. $1\{y \leq q_\tau\}$ is the indicator function and identifies if y, for the individual is below q_τ. Thus, using this method, the RIF is the new outcome variable and it can be estimated as before. For this analysis, IOp will be calculated at the 25, 50, 75 and 95^{th} percentiles, The 95^{th} quantile aimed to capture the top end of the BMI and WC distribution.

All analysis have been independently performed for women, men, and year. Furthermore, survey weights were used in the analysis, and standard errors are obtained using a 500-replications bootstrap process.

5 Results

5.1 Descriptive statistics of the sample

Tables 1 and 2 show the statistical description of the sample and the outcomes. Specifically, Table 1 depicts that the sample is relatively balanced in sex terms, around 45-49% of the individuals in each sample are men. Also, 73-75% of the people are between 20 to 49 years old, and the remainder, around 25%, are older than 50 years old. The majority of people in the samples are not from an indigenous ethnicity. 82% and 76% of the sample had a non diabetic father and mother, respectively in 2012 and 79%-74% for 2016. In terms of non-individual characteristics, around 69-72% of the samples have running water in their houses. Finally, 79% of the 2012 sample live in Municipalities considered to be of low deprivation, while the percentage is 67% in the 2016 sample.

Table 1: Descriptive statistics of the circumstances by health outcome and year

	BMI 2012	**BMI** 2016	**WC** 2012	**WC** 2016
Men	0.45	0.48	0.46	0.49
Age20_29	0.27	0.28	0.26	0.28
Age30_39	0.26	0.26	0.26	0.26
Age40_49	0.22	0.20	0.22	0.20
Age50_59	0.16	0.15	0.17	0.15
Age60_69	0.09	0.11	0.09	0.11
Non indigenous	0.93	0.94	0.94	0.94
Father non diabetic	0.82	0.79	0.82	0.79
Mother non diabetic	0.76	0.74	0.76	0.74
Running water inside the house	0.69	0.71	0.69	0.72
Low Municipal Deprivation	0.79	0.67	0.79	0.67
Observations	28,661	6,734	27,846	6,493

Table 2 displays the characteristics of the distribution for each sample. According to their level of kurtosis and skewness both years have heavy and long right-hand tails. The average BMI in both years for women was 29 kg/mts^2 and 27.8 kg/mts^2 for men, which shows that women are observed to have a higher BMI. WC for women was 92.6cm in 2012 and 93.9cm in 2016, while for men these were 94.8cm and 95.7cm respectively. For this outcome, men are observed to have a higher WC than women in both years. Note that these average values are above the cut-off points for overweight or obesity [5].

Table 2: Descriptive statistics of the health outcomes split by sex and year

	2012		**2016**	
	BMI	WC	BMI	WC
Women				
Sample size	17,346	16,553	4,490	4,260
min	13.3	53.5	12.1	56.2
p50	28.4	91.8	28.4	93.4
mean	29.0	92.6	29.0	93.9
max	57.9	168.6	56.9	160.0
skewness	0.8	0.5	0.7	0.5
kurtosis	4.0	3.7	3.8	3.9
Men				
Sample size	11,315	11,293	2,244	2233.0
min	15.0	53.0	16.1	62.0
p50	27.5	94.5	27.4	94.8
mean	27.8	94.8	27.8	95.7
max	57.4	173.0	57.7	170.5
skewness	0.8	0.4	0.7	0.7
kurtosis	4.8	3.9	3.9	4.3
Observations	28,661		6,734	

5.2 Inequality of Opportunity in BMI and WC among Mexican Adults

Table 3 shows the level of absolute and relative IOp for each outcome in 2012 and 2016, split by sex. Overall relative IOp varies from 3% to 12%, with marked differences. Firstly, the relative levels of inequality are higher in WC than BMI, meaning these circumstances explain more the heterogeneity of WC than BMI. Secondly, except for BMI and men, the comparison across years reveals that IOp decreased from 2012 to 2016. Thirdly, the comparison in the level of IOp across sexes does not show a clear pattern. For instance, relative inequalities related to circumstances are higher for men compared to women in WC, but not in BMI. For 2012, women observed higher IOp in 2012 (8.84% vs 6.74%), but lower in 2016 (3.31% vs 6.75%).

[5] BMI: normal BMI 18.5-24.9 kg/mts^2; overweight BMI 25-29.9 kg/mts^2; obesity $>$ 30 kg/mts^2 (WHO, 1995), and for WC: Obesity $>$ 90 cm in males, and $>$ 80 cm in females (Alberti et al., 2009)

Table 3: Absolute and relative inequality of opportunity split by outcome, sex, and year

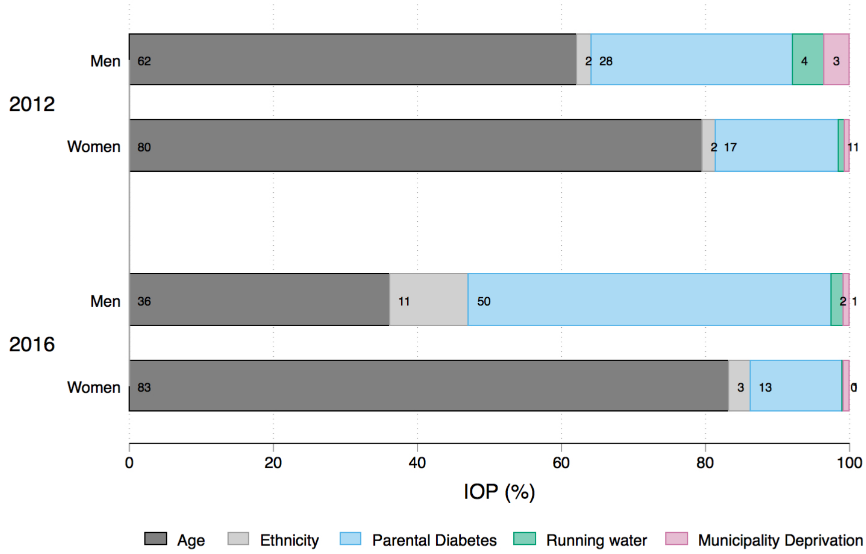
	Body Mass Index		Waist Circumference	
	2012			
	Absolute	**Relative (%)**	**Absolute**	**Relative (%)**
Men	0.0010***	6.74***	0.0011***	12.70***
Sample size	12,897		12,860	
Women	0.0017***	8.84***	0.0011***	11.1***
Sample size	15,763		15,109	
	2016			
	Absolute	**Relative (%)**	**Absolute**	**Relative (%)**
Men	0.001***	6.75**	0.0009***	9.7**
Sample size	3,225		3,212	
Women	0.0005***	3.31**	0.0007***	8.09**
Sample size	3,508		3,348	

Note:*p≤ 0.1, **p≤ 0.05, ***p≤ 0.05

5.3 Shapley decomposition

Figures 2 and 3 show the contribution of each circumstance to the relative inequality of opportunity using the Shapley-Shorrocks decomposition approach for each outcome, sex and year. Both figures show that the relative contribution of each circumstance varies widely. Nevertheless, there are some relevant patterns to note. Age and the parent diabetic condition seem to be the most important circumstances for levels of IOp in BMI and WC. Age is the main driver of the inequality observed for both outcomes, sexes and years, ranging from 36% for men in BMI up to 84% for women in WC. The diabetic condition inherited from the parents is the second most relevant circumstance (11% and 50%). This circumstance is especially relevant for men.

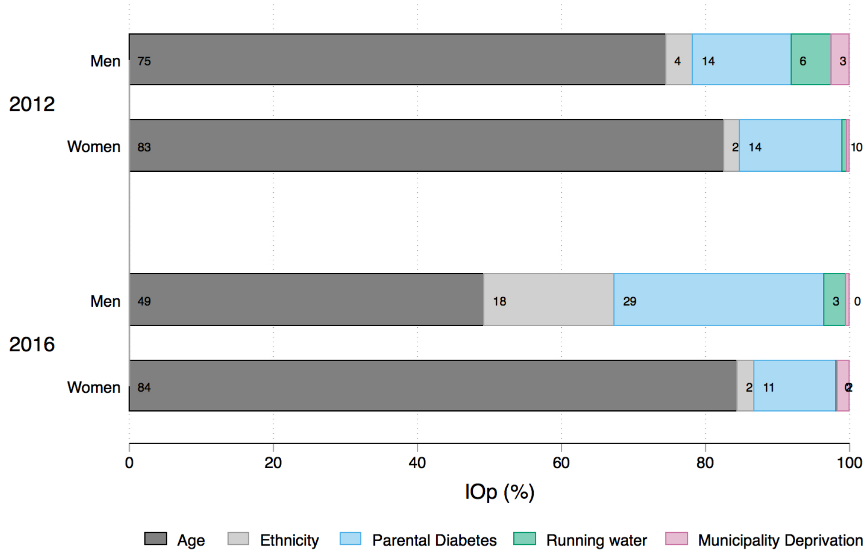
Figure 2: Decomposition of Inequality of Opportunities in the BMI split by sex and year



It is worth taking a closer look at the relevance of being indigenous for men for 2016. It accounts for a non trivial 11% to 18% in both health indicators. This result can be explained given the evidence about higher consumption of SSBs in indigenous communities, the modification of the ancestral diet and the lack of health facilities and health providers across these communities (Betran Vilá, 2006; Leyva-Flores, Infante-Xibille, et al., 2013; Olvera, 2019; Pliego, 2019). Municipal deprivation and running water inside the house, variables that capture the *geography of opportunities*, have a relatively less important role in the level of IOp, with these factors being relatively more important for men in both years and indicators[6].

[6]See table 9 and 10 in the Supplementary Material section for further details

Figure 3: Decomposition of Inequality of Opportunities in the WC split by sex and year



5.4 Oaxaca Decomposition

Tables 4 and 5 show the results of the decomposition of the absolute inequality of opportunity across geographical regions of Mexico for each of the outcomes. The values of the main diagonal are in bold, and represent the absolute inequality of opportunity observed in each region. The off-diagonal values show the counter-factual, that is the level of inequality for a given region, using the distribution of the circumstances of another group.

Table 4 presents the results for BMI by sexes in 2012. For this outcome and year, absolute IOp is slightly higher in the Northwest and Southeast for men. For women, IOp observe the highest levels of IOp in the Northeast and West regions. Table 5 shows the results for the WC indicator. For men, the pattern holds, the highest levels of IOp are in the northwest region. For women, where the highest IOp is observed in the southeast.

About the off-diagonal values, it has been previously described that the columns display the coefficients for a particular group, and the rows show the distribution of circumstances of a group. For instance, the counterfactual value of 0.0019 (table 4,women, first column, second row) indicates the hypothetical level of IOp for women living in the northwest region, but observing not their actual circumstances, but rather those from women in the northeast region would be 0.0019. This means that if their circumstances

Table 4: Oaxaca decomposition of IOp in BMI by geographical regions of Mexico, split by sex

	Men 2012					
Distribution of circumstances	**Coefficients**					
	Northwest	Northeast	West	Centre	South	Southeast
Northwest	0.0013	0.0012	0.0011	0.0011	0.0011	0.0013
Northeast	0.0012	0.0011	0.0010	0.0010	0.0011	0.0012
West	0.0012	0.0011	0.0011	0.0010	0.0011	0.0013
Centre	0.0013	0.0012	0.0010	0.0010	0.0011	0.0013
South	0.0014	0.0013	0.0010	0.0011	0.0011	0.0011
Southeast	0.0014	0.0012	0.0011	0.0011	0.0011	0.0012
	Women 2012					
Distribution of circumstances	**Coefficients**					
	Northwest	Northeast	West	Centre	South	Southeast
Northwest	0.0020	0.0023	0.0021	0.0018	0.0017	0.0014
Northeast	0.0019	0.0022	0.0020	0.0017	0.0017	0.0013
West	0.0020	0.0022	0.0021	0.0017	0.0017	0.0013
Centre	0.0019	0.0022	0.0021	0.0017	0.0017	0.0013
South	0.0020	0.0027	0.0020	0.0017	0.0018	0.0013
Southeast	0.0021	0.0027	0.0020	0.0018	0.0018	0.0014

change and become similar to those that women in the northeast have, IOp would be slightly lower. Conversely, the 0.0023 value depicts the level of IOp if women in the northeast had the circumstances of women living in the northwest region. In this case, IOp would be higher.

For the case of the BMI in 2012, some notable effects are observed. For men, in general the counterfactual values are relatively similar, For instance, the level of IOp of men living in the northwest region, but having the circumstances of men of the northeast is the same (0.0012), as men living in the northeast but with the distribution of circumstances of northwest men. In this case, an association effect is observed. Differences are mainly given by the difference of the relationship between circumstances and outcome. Contrary for the case of women (second column, last two rows) if women from the Northeast had the circumstances of women living in the South or Southeast, the level of absolute IOp would be the highest possible (0.0027) among this group. This result is aligned with the well known dichotomy between North-South regions in Mexico, for which in general better socioeconomic conditions are found in the North than in the South. This results also suggests a composition effect in which the largest part of the difference is driven by the difference in the structure of the circumstances.

Table 5 shows the results for BMI in 2016. For men, as observed in 2012, the highest level of IOp is found for those living in the Northwest region. A relevant counterfactual value of 0.0063 is found if men living in the West observed the circumstances of men living in the Southeast. If this was the case, the level of absolute IOp would be three times the level of actual IOp observed either in the West or the Southeast region. This suggests a relevant composition effect. For women, the highest level of IOp is observed among women living in the Southeast and South regions of Mexico. The highest counterfactual value of absolute IOp (0.0035) is found for women living in the Southeast part of the country should take on the circumstances of women of the South region.

Table 5: Oaxaca decomposition of IOp in BMI by geographical regions of Mexico, split by sex

	Men 2016					
Distribution of circumstances	**Coefficients**					
	Northwest	Northeast	West	Centre	South	Southeast
Northwest	0.0025	0.0015	0.0024	0.0012	0.0012	0.0017
Northeast	0.0017	0.0018	0.0022	0.0014	0.0011	0.0016
West	0.0021	0.0020	0.0021	0.0015	0.0013	0.0017
Centre	0.0028	0.0021	0.0039	0.0015	0.0018	0.0019
South	0.0027	0.0023	0.0040	0.0017	0.0019	0.0018
Southeast	0.0021	0.0021	***0.0063***	0.0015	0.0022	0.0018
	Women 2016					
Distribution of circumstances	**Coefficients**					
	Northwest	Northeast	West	Centre	South	Southeast
Northwest	0.0009	0.0008	0.0010	0.0010	0.0019	0.0029
Northeast	0.0011	0.0008	0.0014	0.0011	0.0023	0.0033
West	0.0015	0.0006	0.0012	0.0012	0.0023	0.0027
Centre	0.0014	0.0014	0.0015	0.0010	0.0022	0.0031
South	0.0020	0.0016	0.0015	0.0010	0.0022	0.0035
Southeast	***0.0023***	0.0019	0.0015	0.0009	0.0020	0.0027

Table 6 and 7 display the same analysis, but for the WC indicator. Table 6 shows the analysis for 2012. The level of IOp across regions is relatively similar for men, at around 0.0010 - 0.0014. The counterfactual values were also similar. For women, higher level of IOp were observed in the North, and as well as with BMI, if women living in the northeast region had the circumstances of women from the south, the level of IOp would be the highest possible for this group.

Table 6: Oaxaca decomposition of IOp in WC by geographical regions of Mexico, split by sex

	Men 2012					
Distribution of circumstances	**Coefficients**					
	Northwest	Northeast	West	Centre	South	Southeast
Northwest	0.0013	0.0012	0.0013	0.0010	0.0013	0.0012
Northeast	0.0012	0.0012	0.0013	0.0010	0.0012	0.0012
West	0.0012	0.0012	0.0013	0.0010	0.0013	0.0012
Centre	0.0012	0.0012	0.0013	0.0010	0.0013	0.0012
South	0.0013	0.0014	0.0013	0.0011	0.0013	0.0011
Southeast	0.0013	0.0013	0.0014	0.0011	0.0013	0.0012
	Women 2012					
Distribution of circumstances	**Coefficients**					
	Northwest	Northeast	West	Centre	South	Southeast
Northwest	0.0014	0.0015	0.0014	0.0013	0.0011	0.0010
Northeast	0.0013	0.0014	0.0013	0.0012	0.0010	0.0010
West	0.0014	0.0014	0.0013	0.0012	0.0011	0.0010
Centre	0.0013	0.0015	0.0013	0.0012	0.0010	0.0010
South	0.0014	0.0017	0.0013	0.0011	0.0010	0.0010
Southeast	0.0014	0.0017	0.0013	0.0012	0.0011	0.0010

Table 7 depicts the oaxaca decomposition analysis for WC and 2016. For men, the highest levels of IOp in the WC are observed in the South and Northwest regions. As with BMI, the highest counterfactual value occurs if men living in the West had the structure of circumstances of men living in Southeastern States. The lowest value depicts the situation in which men living in the southeast had the distribution of circumstances of men from the Northwest.

For women, the analysis shows that the highest level of absolute IOp is in the Southwest. The highest counterfactual level would occur if women living in the Southeast has the distribution of circumstances of women from the South region. This result shows not only that inequalities are higher for women who live in the South of Mexico, but also that there is a nuance, such that higher levels of inequalities can be found when combining the coefficients observed for those women living in the Southeast region, and the distribution of circumstances of women living in the South region. The lowest counterfactual level can be observed if women living in the west region had the structure of circumstances of women from the Northwest.

Table 7: Oaxaca decomposition of IOp in WC by geographical regions of Mexico, split by sex

	Men 2016					
Distribution of circumstances	**Coefficients**					
	Northwest	Northeast	West	Centre	South	Southeast
Northwest	0.0016	0.0011	0.0011	0.0011	0.0013	0.0010
Northeast	0.0013	0.0014	0.0011	0.0013	0.0014	0.0011
West	0.0015	0.0015	0.0010	0.0013	0.0016	0.0011
Centre	0.0018	0.0017	0.0020	0.0014	0.0018	0.0013
South	0.0016	0.0017	0.0020	0.0016	0.0018	0.0012
Southeast	0.0014	0.0015	***0.0028***	0.0014	0.0019	0.0012
	Women 2016					
Distribution of circumstances	**Coefficients**					
	Northwest	Northeast	West	Centre	South	Southeast
Northwest	0.0009	0.0010	0.0006	0.0009	0.0015	0.0023
Northeast	0.0010	0.0009	0.0008	0.0010	0.0017	0.0024
West	0.0013	0.0010	0.0008	0.0012	0.0018	0.0022
Centre	0.0014	0.0012	0.0008	0.0009	0.0017	0.0024
South	0.0018	0.0013	0.0008	0.0009	0.0016	0.0027
Southeast	***0.0019***	0.0013	0.0007	0.0007	0.0013	0.0022

5.5 RIF and UQR models

Regarding the RIF regressions, table 8 display the level of absolute IOp across different points of the outcomes distributions, for 2012 and 2016. The RIF analysis for the 2012 cross-section, for both health outcomes BMI and WC the level of absolute IOp increases along the distribution. The highest levels of IOp is observed at the 25^{th} percentile, and the lowest at the 95^{th}. Across the health outcomes and sex groups, the highest level of IOp is found in BMI for women. A similar pattern was found for 2016. For both health outcomes absolute inequality is higher at the lower parts of the distribution. Lower the percentiles, higher the level of IOp. In 2016, the highest level of inequality is observed in BMI and for men.

These results suggest that inequalities are higher for those people categorised as overweight. The 25th and 50th percentiles for BMI in women and men in both years is about 24-25 kg/mts^2 and 27-28 kg/mts^2, which fits into the cutoff point of classification for overweight (25-29.9 kg/mts^2). The situation for WC is slightly different across sexes. Inequalities are higher for overweight men and for obese women. The 25th percentile for men in both years is 86.5-87cm, while for women it is 84-86cm. The cut-point for obesity according to the WC is above the 80cm for women and above 90cm for men.

Table 8: Distributional analysis of the IOp split by sex and year

	2012			
	BMI Men	**BMI Women**	**WC Men**	**WC Women**
25th	0.0028***	0.0038***	0.0030***	0.0026***
50th	0.0010***	0.0017***	0.0011***	0.0012***
75th	0.0006***	0.0008***	0.0006***	0.0006***
95th	0.0004***	0.0003***	0.0002***	0.0002***
	2016			
25th	0.0028***	0.0021***	0.0014***	0.0015***
50th	0.0012***	0.0007***	0.0009***	0.0008***
75th	0.0006***	0.0002***	0.0006***	0.0003***
95th	0.0009***	0.0002***	0.0004***	0.0004***

Note: *p≤ 0.1, **p≤ 0.05, ***p≤ 0.05

6 Discussion

In Roemer's view, a first step in identifying illegitimate inequality of opportunity is to disentangle the extent to which inequalities in outcomes are due to circumstances or efforts. In this regard, if circumstances play a role in achieving a certain outcome, then people should be compensated for an unequal playing field. This study adopted an *ex-ante* approach to measure inequalities related to circumstances.

This paper identify and analyse the level of inequality of two health outcomes in Mexico, given a set of circumstances. It also identified the relative importance of each circumstance and the variation of inequality across geographical regions. Moreover, the study estimated the potential level of IOp given different structure of circumstances and identified how circumstances impact inequality at different points of the distribution. The findings indicate that inequalities related to circumstances of origin exist for the Mexican adult population.

Overall, the level of inequality attributed to circumstances for BMI varied from 6.1% to 7.5%, and from 8.3% to 12.2% for WC. A recent study that focused on measuring *ex-ante* health inequalities in waist-to-height ratio in the United Kingdom estimated a level of 17% (Davillas and Jones, 2019). However, the set of circumstances was defined differently. In this regard, given the approach used in this paper lower-bound levels of inequality were estimated (Ferreira and Gignoux, 2011), meaning that only taking into account the set of observed circumstances that were included, IOp accounts for 3-12% of the heterogeneity in BMI and WC. This provides evidence that it is not only immediate causes that explain the alarming levels of obesity in Mexico.

The findings related to the decomposition of inequality according to circumstances suggest that age and people's parental conditions, such as having diabetes, represent conditions of origin related to inequality for BMI and WC indicators. Age accounts for between 36.2% and 84.5% of the inequality of opportunity for adults. There are also differences in the impact of circumstances across and within outcomes, as well as across sexes. Age is a relatively more relevant circumstance in WC than BMI. This may be related to evidence that suggests that abdominal-visceral fat tends to accumulate with age, and this accumulation is more pronounced in women (Mateo-Gallego et al., 2012; Stevens et al., 2010). It is worth to mention that in this paper age is defined as an illegitimate source of inequality. Nevertheless, this is a matter of debate. One advantage, as pointed out by Davillas and Jones, 2019 is that one advantage of the Shapley decomposition method is that it allows to neglect the contribution of age, without affecting the relevance of the other circumstances to the level of IOp.

In the same regard, parental diabetic condition is of more relevance for BMI than for WC. This could potentially be associated with mechanisms in which parents with obesity-related diabetes pass to their children certain physical characteristics that leads to inter-generational obesity (Brisbois et al., 2012; Wrotniak et al., 2004). It can also be closely related with evidence about the association between the fat mass and obesity-associated (FTO) gene and the predisposition to obesity (Teran-Garcia et al., 2013). In Mexico, the prevalence of type two diabetes in adults is around 15-20% (Meza et al., 2015) and 90% of the cases are linked to OWOB. Thus evidently, this represents a relevant policy challenge about how inter-generational and inherited circumstances might be attenuated through public intervention.

Given the egalitarian principle implicit in the *ex-ante* approach, compensatory policies should therefore exist to lighten the effect of unequal circumstances. Compensatory public policies might take the form of differentiated healthcare policies. For example, policies specifically design for for adults at different stages of adulthood might alleviate the effect of age on inequalities. In the same vein, people's parents conditions is an inherited source of inequality that might be alleviated by particular interventions that focused on obesogenic environments in households during pregnancy and children early life stages (Haire-Joshu and Tabak, 2016).

Given that Mexico is a Federal State, the geographical analysis provides evidence to inform the policy-making process in specific geographical regions. The analysis shows the differences in the levels of inequality across regions of Mexico and how the differences across those regions might be explained by the difference in the composition of circumstances or differences in the link between circumstances and outcomes. Overall, the results confirm the usual dichotomy between Northern and Southern regions of Mexico. In general terms, during 2012 the level of IOp was not concentrated in a particular region or sex, neither for BMI nor WC. Notwithstanding, the 2016 analysis showed that inequalities in BMI and WC were higher for women that lived in the Southeast part of Mexico (Campeche, Quintana Roo, Tabasco and Yucatan). While inequalities tended to be higher for men from the Northwestern States (Baja California, Baja California Sur, Sinaloa and Sonora). The Oaxaca decomposition analysis revealed the existence of composition effects, where the differences between the actual level of IOp and the counterfactual is attributable to differences in the structure of circumstances. The most relevant cases are the counterfactuals in 2016, for men between West and Southeast and for women Northwest and Southeast regions. For the first case, the level of IOp would be much higher for men living in the west, but with the circumstances of men from the Southeast region. For the women, the pattern is the same but between Northwest and Southeast regions. These counterfactual values of IOp offer a broad scenario of what effect is driving higher levels of IOp. Evidently, in some geographical regions have a worse structure of circumstances, that might potentially be attenuated by localised health, economic ans social policies.

The analysis of inequality beyond the mean shows that inequalities are higher for those individuals at the lower percentiles of the BMI and WC distribution. This finding suggests that circumstances matter more for individuals at the bottom of the distribution (people with low, normal or overweight) than for individuals at the upper side of the distribution (obesity). Results from this analysis are similar to those in Davillas and Jones, 2019, where higher levels of absolute inequality were found at the lower percentiles of the distribution of an obesity-related outcome (waist-to-height ratio) in the United Kingdom.

This analysis is not without limitations. One important drawback is the data. ENSANUT surveys are cross-sectional datasets. This implies that these surveys were not designed to measure neither health inequality nor its inter-generational transmission. This survey neither collects retrospective data about family background, which is the desirable data for this analysis. Thus, better estimation could be obtained if anthropometric data would be collected over-time in a panel. Another point to mention regarding the data is that one of the most relevant variables is parental diabetic condition. However, this information was self-reported by the respondent and there is no way to confirm the information or adjust it to more precisely capture behaviours transmitted and adopted in the family. For instance, even though the survey asks about the age at which the parents were clinically diagnosed with diabetes, the current age of those parents is not available. In defence of the use of the variable, it can be said that the proportion of parents -mother and father- (20-25%) with diabetes is similar to the national prevalence (20-30%) (Meza et al., 2015), which reflects a credible proxy.

In democratic societies, such as in Mexico, equality of opportunities in health is not only desirable, but also paramount for social well-being and development. Unequal health outcomes across individuals is not necessarily unfair. The problem is that those health outcomes depend on people's age, sex, race, or unequal access to fundamental rights. Within this context, this study aimed to further explore another aspect of the acute OWOB situation in Mexico, unequal opportunities than condition further choices and life-style decisions. In this regard, further public interventions should take into account that equalising the playing field is a premise for more effective public policies to tackle the OWOB crisis.

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7 Supplementary Material

Table 9: Decomposition of Inequality of Opportunities in the BMI split by sex and year

	2012				2016			
	Men		Women		Men		Women	
Circumstances	Value	%	Value	%	Value	%	Value	%
Age	0.0419	62.2	0.0704	79.6	0.0245	36.2	0.0277	83.3
Ethnicity	0.0013	1.9	0.0016	1.8	0.0074	11.0	0.0010	2.9
Parent Diabetic Condition	0.0189	28.0	0.0152	17.1	0.0340	50.3	0.0042	12.8
Running water inside the house	0.0030	4.4	0.0007	0.8	0.0011	1.6	0.0001	0.2
Municipality deprivation	0.0023	3.4	0.0006	0.7	0.0006	0.9	0.0003	0.8
Relative Inequality of Opportunity	0.0674	6.74	0.0885	8.85	0.0676	6.76	0.0332	3.32

Table 10: Decomposition of Inequality of Opportunities in the WC split by sex and year

	2012				2016			
	Men		Women		Men		Women	
Circumstances	Value	%	Value	%	Value	%	Value	%
Age	0.0947	74.5	0.0917	82.5	0.0478	49.3	0.0684	84.5
Ethnicity	0.0048	3.8	0.0025	2.3	0.0176	18.1	0.0019	2.3
Parent Diabetic Condition	0.0173	13.6	0.0157	14.1	0.0282	29.1	0.0092	11.4
Running water inside the house	0.0071	5.6	0.0009	0.8	0.0029	3.0	0.0001	0.2
Municipality deprivation	0.0032	2.5	0.0003	0.2	0.0005	0.5	0.0013	1.6
Relative Inequality of Opportunity	0.1271	12.71	0.1111	11.11	0.0969	9.69	0.0810	8.10