



## Research article

## Predictors of diabetes risk in urban and rural areas in Colombia



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## ABSTRACT

**Background:** Nutritional habits low in fruits and vegetables and sedentary lifestyle are associated with a higher risk of developing Type 2 Diabetes (T2D). However, it is important to assess differences between urban and rural areas. This study aimed to analyze the associations between the risk of developing T2D and setting in the Colombian north coast in 2017.

**Methods:** This cross-sectional study included 1,005 subjects. Data was collected by interviewing self-identified members of an urban community and a rural-indigenous population. The interaction terms were evaluated as well as the confounders. Then, adjusted binary logistic regressions were used to estimate the odds ratio (OR) and 95% Confidence Intervals (CI).

**Results:** subjects with a high risk of T2D are more likely to belong to the urban setting (OR = 1.908; 95%CI = 1.201–2.01) compared with those with lower T2D after adjusting for age, Body Mass Index (BMI), physical activity, history of high levels of glycemia, and diabetes in relatives.

**Conclusions:** Urban communities are more likely to have T2D compared with rural-indigenous populations. These populations have differences from the cultural context, including personal, and lifestyle factors.

## 1. Introduction

According to the World Health Organization (WHO), 422 million people worldwide have diabetes. The accelerate economic development, as well as urbanization have drive to a rising burden of T2D in several parts of the world [1]. In Colombia, 3 out of 10 people have T2D [2]. However, the prevalence varies according to areas, even inside the same country [3, 4, 5, 6]. Historically, T2D has shown like an inequity between urban and rural areas [7, 8], and recently there are concerning trends of rising prevalence in lower-income countries [9].

The urbanization allows to see the changes in lifestyles susceptible to interventions. Urban populations have been posed as most affected due to adopt unhealthy habits [10, 11]. In Colombia, there is an ethnic and cultural diversity due to the differing ethnic backgrounds, as well as the geographical characteristics of the country [12], where 77.1% of the

population lives in urban areas and 22.9% in rural areas [13]. Likewise, within the country, there are 115 fully identified indigenous communities. Indigenous population in Colombia is defined as a group of people who live in an area legally defined as an indigenous area by the Colombian Ministry of the Interior, and who also identify themselves as belonging to an ethnic group. The most numerous indigenous communities in the country are Wayuu, Zenú, Nasa, and Pastos. These have 58.1% of the country's indigenous population, including the Zenú community, with 307,091 people self-recognized as belonging to this ethnic group [14].

The Zenú indigenous community is mainly located in San Andrés de Sotavento Reserve in the Córdoba department and El Volao in Urabá [15, 16]. They are in several small settlements throughout Sucre, Antioquia, and Chocó. This diversity is closely related to the culture, diet, and lifestyle of the populations being considered risk factors for the development

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of cardiometabolic diseases, especially for heart illnesses, arterial hypertension, obesity, and T2D [17].

Early detection of diabetes favors timely actions to reduce the burden of the disease. Transforming differentiated care by integrating health care services for indigenous communities is highly relevant due to their vulnerability [16]. There are few studies in indigenous communities and urbanized population which identify risk factors for diabetes [18, 19]. However, in some indigenous populations, the recognized influential factors as health disparities in care, socioeconomic status, smoking, and obesity could influence mortality from diabetes [16].

There are few studies that examine the relationship of the effect of setting (urban/rural) that allows the analysis of factors that identify differences to develop health analyzes under the context of territory [20, 21]. In T2D, there is a close relationship between being overweight, obesity, and old age, as well as with ethnic origin, family history, low consumption of fruits and vegetables, low level of physical activity and a combination of a multigene predisposition and environmental triggers [22]. To date, no national study has examined whether the Findrisc survey, which is a survey to detect the risk of developing T2D in the next 10 years, estimates in urban populations and in vulnerable indigenous communities show variations. The objective of our study was to analyze the associations between the risk of developing T2D and setting (urban vs. rural) in the Colombian north coast in 2017.

## 2. Methods

### 2.1. Study design and population

This cross-sectional study used data-source from PREDICOL Project (urban setting) and APS-CHINÚ (rural setting). In both, the recruitment period was between 2018 to 2019. The Findrisc survey validated in Colombia was applied, accompanied by biometric and glucometer parameters [4]. The urban population came from PREDICOL Project carried out in Barranquilla, which is an industrial city with more than 1,500,000 inhabitants located in the north of the country with one of the main maritime and river harbors in Colombia. These participants are part of the baseline evaluation of the educational health program for the prevention of T2D and other cardiovascular risk factors in Colombia (PREDICOL Project. ClinicalTrials.gov Identifier: NCT03049839), a quasi-experimental study carried out in an adult population to improve lifestyle. The recruitment period starts on February 2018 to March 2019. These individuals received healthy lifestyles education as a benefit because of their participation [23].

The Zenú rural-ethnic population in Chinu comes from the primary health care project for an ethnic community in a vulnerable condition. The estimated population corresponds to 23,224 inhabitants, the 50.8% live in remote rural areas. Of these inhabitants, people over 30 years of age were selected from three townships (Algarobos, Carranzó, and La Floresta) to estimate health needs and support health promotion projects within the framework of the primary health care project (APS CHINÚ for Spanish translation) for indigenous communities. The leaders of these three communities, through a local census, identified families in conditions of social vulnerability that need to receive help from the Colombian government (food, people over 60 years of age from nutritional programs or children under 5 years of age in a situation of malnutrition, housing in poor conditions or not having access to drinking water). Therefore, the selection of indigenous families to the APS CHINÚ project was a decision of the indigenous council, considering customs, community criteria, and national guidelines. This sample included Zenú indigenous, which was chosen by the leaders of the indigenous council, who prioritized the most vulnerable families within the dispersed rural population. The recruitment period for this study starts on July 2018 to February 2019. The Zenú indigenous Reserve in San Andrés de Sotavento is an indigenous community integrated by 177 councils located in six municipalities in the Córdoba and Sucre departments on the north coast of Colombia. The indigenous Zenú communities have an ancient agricultural tradition and

a diversity of crops that support their food habits, as well as their culture [17, 24].

The study populations corresponded to 2 clusters (one in each geographic region). Both places had similar socioeconomic status (SES). Visits were done in every locality, people over 30 years of age, that live in that town were interviewed. As exclusion criteria were defined people with diabetes, institutionalized, pregnant women and those who did not want to give their consent to participate. More than 400 household interviews were carried out. The sample size for this study was 1005 subjects (728 from urban individuals and 277 from rural individuals). A convenience sampling was developed where all the subjects who were in the dataset of the mentioned projects and who met the eligibility criteria described for this study were included (Figure 1).

### 2.2. Measurements/study variables

Sociodemographic data included age, sex. Age was measured in years. Waist circumference (WC) was measured in centimeters at the midpoint of the last rib and the iliac crest (The highest part of the hip bone) with the participant standing, following the recommendations of the WHO [25] and was classified according to International Diabetes Foundation (IDF) guidelines [26] as central obesity >90 cm in men and >80 cm in women and the WHO criteria as central obesity >94 cm in men and >90cm in women. Height was measured in cm with the participant standing and weight was measured without shoes and with light clothing. The BMI was calculated using the rule of weight (Kg) divided by height squared ( $m^2$ ) using an OMRON electronic portable scale and was classified used the WHO criteria for classifying it as normal ( $BMI \geq 18.5$ – $24.9 \text{ kg/m}^2$ ) – overweight ( $BMI \geq 25 \text{ kg/m}^2$ ) - obesity ( $BMI \geq 30 \text{ kg/m}^2$ ). The risk of T2D was classified using the Finnish Diabetes Risk Score (FINDRISC) questionnaire used and validated in several European countries [27, 28, 29, 30, 31], in Latinoamerica (LA) using a cut-off value >12 points to high risk [4, 23]. It was additionally investigated for the consumption of medications for high blood pressure, history of high glycemic levels and/or relatives with T2D or a history of gestational diabetes in women. Likewise, it was evaluated the intake of fruits and vegetables every day or the performance of at least 30 min of physical activity 5 days per week. The application of the FINDRISC surveys were carried out by health professionals trained and standardized in the development of the process. Anthropometric measurements were taken as mentioned previously. All the information was recorded digitally and stored in the REDCap V. 8.11.0 software. The information record and inconsistencies in the measurements (extreme and lost values) were verified daily, which guaranteed that none of the collected variables presented missing information. All high-risk participants were given healthy lifestyle advice and offered an optional assessment at the health center.

### 2.3. Statistical analysis

All analyses in the final sample were conducted in SAS® 9.4. Descriptive statistics were first performed to check for missing data. Then, we evaluate the distribution of both categorical and continuous variables. Mean and standard deviation (SD) were estimated for continuous variables, and proportions for categorical variables. In this analysis, the dependent variable was setting categorized as urban (reference category) or rural. Additionally, Bivariate analyses were performed to check for the distribution of the participant's characteristics according to the living area. Collinearity diagnostics were conducted to check for correlations between all variables. Additionally, it was evaluated the interaction terms, as well as the change-in-estimate (CIE) approaches (confounders evaluation). Furthermore, variables with Likelihood ratio tests <.05 were kept in the final model, as well as those with CIE over 10% of change compared with the crude and full models. These confounder selection processes were carried out in adjusted binary logistic regression models one-by-one. The forward and backward manual selection process, as well as the estimating odds ratios (OR) and 95%

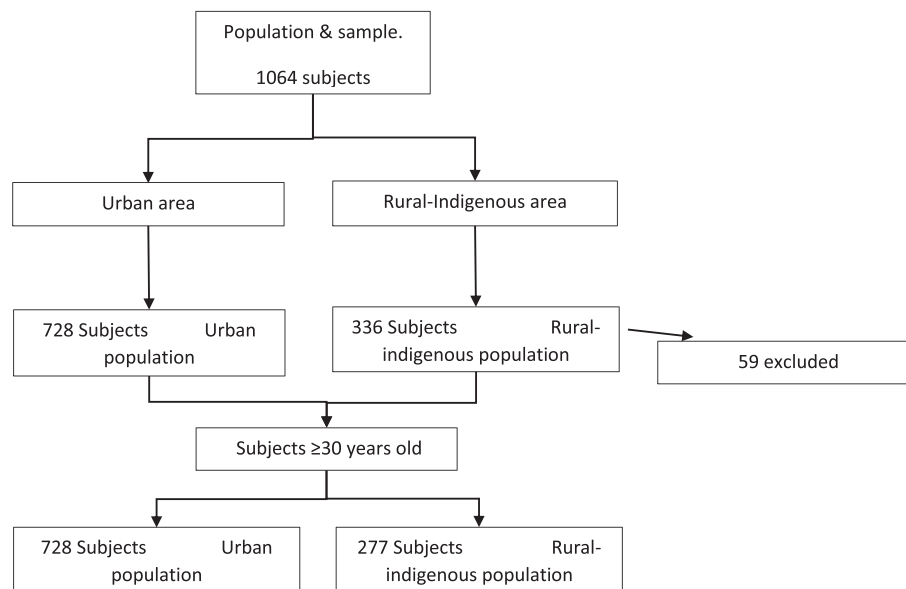


Figure 1. Flow chart of study population.

Confidence Intervals (CI) were done with binary logistic models. Model fit was evaluated using Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC). When comparing the BIC and the AIC, the penalty for additional parameters was higher in BIC than in AIC. Thus, the model fit difference between the full model compared with the crude model was lower.

#### 2.4. Ethical considerations

This study utilized a secondary source. Thus, it did not require the endorsement of the ethics committee or informed consent, according to Colombian laws (Res. 8430, 1993). Nevertheless, both PREDICOL and APS CHINÚ projects have the ethical endorsement and compliance with international standards of the Declaration of Helsinki and research integrity. The Ethics Committee at Universidad del Norte reviewed and approved both the PREDICOL and APS CHINÚ research protocols according to approval minutes 141 of April 28, 2016, and 175 of June 28, 2018, respectively.

### 3. Results

A total of 1005 participants were included in the final analysis of this study. The overall mean age was 53 years (SD: 14.4), and it was not significantly different between urban and rural area. Regarding the geographical location of the participants, 27.56% of the total sample belonged to the rural context. Being a woman independent of the region marked a difference in participation ( $p = 0.001$ ); 72.94% (urban) and 61.73% (rural). The waist circumference was estimated according to the IDF and the WHO, as well as the BMI, physical activity, the consumption of fruits and vegetables showed significant differences ( $p < 0.05$ ) according to the region. Particularly, a markedly different distribution was observed in fruit and vegetable intake, where 83.75% of individuals in the rural region reported consuming them, compared to 26.92% of the residents of the urban area. The FINDRISC total score showed a normal distribution. Additionally, the average FINDRISC score for the urban area was higher ( $11 \pm 4.9$ ) compared to the rural area ( $9.4 \pm 4.6$ ) (Table 1).

The odds of belonging to the urban or rural region concerning each variable evaluated are shown in Table 2. Compared with the main (crude) relationship between to be from urban and rural setting and risk of T2D (OR = 1.84; 95%CI = 1.373–2.469), the inclusion of people with family history of diabetes mellitus had the most change in the main point estimated in the forward selection process (OR = 2.55; 95%CI:

1.794–3.629). Likewise, the age was an important confounder in the main relationship (OR = 2.05; 95%CI = 1.513–2.788). The final model showed that people with high risk of T2D is 1.9 likely to belong to urban setting compared with those with lower risk of T2D (OR = 1.908; 95%CI = 1.201–3.03) after adjusted by age, BMI, physical activity history of high glycemic level and family history of diabetes mellitus. Finally, the physical activity is an important factor in the mentioned relationship (Table 2).

### 4. Discussion

This study revealed that urban setting people is likely to have a higher risk of T2D in the next ten years, as well as to have a BMI over  $25 \text{ kg/m}^2$ ,  $\text{BMI} \geq 18.5\text{--}24.9 \text{ kg/m}^2$ , low physical activity and history of high glycemic. Studies carried out in urban areas of young people and adults show a prevalence of abdominal obesity of 23.14% in Cuba [32], in Spain, there are records of abdominal obesity in 33.4% of adults [33], and in Cuenca, Ecuador the prevalence is around 80.5% [34]. A comparative study between urban and rural communities carried out in Segovia, Spain registered that rural areas have a higher prevalence of abdominal obesity affecting women compared to urban areas ( $p = 0.001$ ) [35]. Similarly, the study by Arroyo et. al in Yucatán - Mexico showed that most women in rural areas have abdominal fat, and that it is greater in women in rural areas. According to the authors, these results can be explained to the body morphology and lifestyle of people in rural areas [36, 37]. In Colombia, a comparative study in the Andean area showed that 53.4% of women have a waist circumference  $\geq 90/80\text{cm}$  and 7.4% of men have a waist circumference  $>102/88\text{cm}$ . The highest records of waist circumference and abdominal obesity in men were found in urban areas [38]. These findings demonstrate the differences that could be found in the urban-rural and urban-rural (indigenous) contexts, which suggest the conduct of research with cultural approaches.

Historically, the BMI has been used to manage the nutritional status of individuals, classifying them in the different categories as normal, overweight, or obese according to the measurements established worldwide. Our study showed that the highest proportion of individuals overweight belong to the urban population. These results coincide with an investigation carried out in Peru where 47.4% and 19.1% of the participants were overweight and obese respectively [39]; in Mexico, there is a record of 45% obesity in rural areas and 48% in urban areas [36], and in Venezuela it was evidenced that 60% of both populations are obese and overweight [40]. This variable is highly influenced by the

**Table 1.** Characteristics of the study population according to setting (urban vs rural) in Northern Colombia in 2017.

|   | Urban                |       | Rural                 |       | p-value <sup>+</sup> |
|---|----------------------|-------|-----------------------|-------|----------------------|
|   | N                    | %     | N                     | %     |                      |
| <b>Gender</b>   |                      |       |                       |       |                      |
| Female  | 531                  | 72.94 | 171                   | 61.73 | <b>0.001</b>         |
| Male  | 197                  | 27.06 | 106                   | 38.27 |                      |
| <b>Age [years]</b>  | <b>[52.6 ± 14.3]</b> |       | <b>[54.05 ± 14.6]</b> |       |                      |
| <45   | 262                  | 35.99 | 81                    | 29.24 | 0.107                |
| 45 a 54   | 143                  | 19.64 | 67                    | 24.19 |                      |
| 55 a 64   | 151                  | 20.74 | 53                    | 19.13 |                      |
| >64   | 172                  | 23.63 | 76                    | 27.44 |                      |
| <b>Waist Circumference (IDF)<sup>+</sup> [Mean ± SD]</b>      | <b>[95.3 ± 12.3]</b> |       | <b>[93.6 ± 10.6]</b>  |       |                      |
| Low Risk  | 119                  | 16.35 | 78                    | 28.16 | <b>&lt;0.001</b>     |
| High Risk   | 609                  | 83.65 | 199                   | 71.84 |                      |
| <b>Waist Circumference [WHO]<sup>**</sup></b>                 |                      |       |                       |       |                      |
| Low Risk  | 276                  | 37.91 | 131                   | 47.29 | <b>0.007</b>         |
| High Risk   | 452                  | 62.09 | 146                   | 52.71 |                      |
| <b>BMI [kg/m<sup>2</sup>] [WHO]<sup>***</sup> [Mean ± SD]</b> | <b>[27.4 ± 5.4]</b>  |       | <b>[25.4 ± 4.4]</b>   |       |                      |
| Normal  | 248                  | 34.07 | 133                   | 48.01 | <b>&lt;0.001</b>     |
| Overweight  | 283                  | 38.87 | 100                   | 36.1  |                      |
| Obesity   | 197                  | 27.06 | 44                    | 15.88 |                      |
| <b>Physical activity [&gt;30 min/day]</b>                     |                      |       |                       |       |                      |
| No  | 584                  | 80.22 | 158                   | 57.04 | <b>&lt;0.001</b>     |
| Yes   | 144                  | 19.78 | 119                   | 42.96 |                      |
| <b>Fruits and vegetable Intake</b>                            |                      |       |                       |       |                      |
| Yes   | 196                  | 26.92 | 232                   | 83.75 | <b>&lt;0.001</b>     |
| No  | 532                  | 73.08 | 45                    | 16.25 |                      |
| <b>Hypertension treatment</b>                                 |                      |       |                       |       |                      |
| No  | 555                  | 76.24 | 224                   | 80.87 | 0.116                |
| Yes   | 173                  | 23.76 | 53                    | 19.13 |                      |
| <b>History of high glycemic levels</b>                        |                      |       |                       |       |                      |
| No  | 644                  | 88.46 | 257                   | 92.78 | <b>0.045</b>         |
| Yes   | 84                   | 11.54 | 20                    | 7.22  |                      |
| <b>Family History of Diabetes Mellitus</b>                    |                      |       |                       |       |                      |
| No  | 403                  | 55.36 | 148                   | 53.43 | 0.499                |
| Grandparents/Uncles/Cousins                                   | 120                  | 16.48 | 41                    | 14.8  |                      |
| Parents/Siblings/Children                                     | 205                  | 28.16 | 88                    | 31.77 |                      |
| <b>FINDRISC Score<sup>****</sup> [Mean ± SD]</b>              | <b>[11 ± 4.9]</b>    |       | <b>[9.4 ± 4.6]</b>    |       |                      |
| Low Risk  | 398                  | 54.67 | 191                   | 68.95 | <b>&lt;0.001</b>     |
| High Risk   | 330                  | 45.33 | 86                    | 31.05 |                      |

<sup>+</sup> Chi-square

<sup>\*</sup> International Diabetes Federation classification (>90 cm in male: High risk- >80 cm in female: High risk)

<sup>\*\*</sup> World Health Organization classification (>94 cm in male: High risk - >90 cm in female: High risk)

<sup>\*\*\*</sup> World Health Organization classification Normal (IMC ≥18.5–24.9 kg/m<sup>2</sup>) – Overweight (IMC ≥25 kg/m<sup>2</sup>) - Obesity (IMC ≥30 kg/m<sup>2</sup>)

<sup>\*\*\*\*</sup> <12 score: Low risk of Diabetes; ≥12 score: High risk of Diabetes

lifestyle and customs of the two populations. Some underlying causes can be proposed for these results: rural indigenous communities, overall, retain a large part of their eating habits and the availability from their traditional vegetable plots. These are the majority of their food [17, 37, 41]. On the contrary, in urban areas the food environment offers a great variety of foods. However, the lifestyle in urban areas makes people opt for foods that are easily prepared, generally canned, and fast foods [42, 43]. That consistently shows the trend that is maintained, with urban areas having higher proportions of overweight or obese people compared to rural areas.

The findings in the Kenyan population contrasted by urban-rural area and ethnicity show similar results to ours with respect to physical activity, BMI and waist circumference in favor of those residing in urban areas, especially women [7]. On the other hand, the Kalahooz study detects a higher proportion of risk factors for diabetes in the indigenous

population compared to other ethnicities in Canada [18]. It is worth noting the parallelism in the Kuna in Panama and its relationship with prediabetes, diabetes and obesity; as well as the Comitan studio in Mexico [44, 45].

Outdoor activities are a lifestyle variable that is highly influenced by the environment. Different studies have shown that physical activity is a protective factor that significantly reduces the risk of Chronic Non-Communicable Diseases (NCDs), including T2D [42, 46]. When recommending physical activity, both the individual risks and benefits must be evaluated. In many regions of the world, especially but not exclusively in the rural areas of developing countries, a considerable part of the population continues to perform tasks that require physical effort, for example, agricultural practices and domestic tasks carried out without mechanization or with rudimentary tools. Even children at very young ages can be forced to perform tasks that require great physical effort in

**Table 2.** Stepwise Selection of Confounders of the Association Between setting and Risk of T2D.

Table for Stepwise Selection of Confounders of the Association Between setting and Risk of D2T

| Model #            | Covariate/s for Adjustment                    | Adjusted OR | 95% CI |       | %CIE | Final model <sup>f</sup> | 95% CI | AIC     | BIC                  |          |
|--------------------|---|-------------|--------|-------|------|--------------------------|--------|---------|----------------------|----------|
|                    |   |             | Lower  | Upper |      |                          |        |         |                      |          |
| Crude <sup>f</sup> |   | 1.84        | 1.373  | 2.469 |      | 1.908                    | 1.201  | 3.03    |                      |          |
| 1                  | Gender  | 1.84        | 1.373  | 2.47  | 0%   |                          |        |         |                      |          |
| 2                  | Age [years]                                   | <b>2.05</b> | 1.513  | 2.788 | -12% | 0.875                    | 0.765  | 1.000   | Crude Model          |          |
| 3                  | Waist Circumference (IDF) <sup>*</sup>        | <b>1.58</b> | 1.156  | 2.166 | 14%  |                          |        | 1170.18 | 1166.18              |          |
| 4                  | Waist Circumference [WHO] <sup>**</sup>       | 1.72        | 1.246  | 2.364 | 7%   |                          |        |         | Full Model           |          |
| 5                  | BMI [kg/m <sup>2</sup> ] [WHO] <sup>***</sup> | <b>1.45</b> | 1.046  | 2.022 | 21%  | 1.254                    | 1.001  | 1.571   | 1115.6               | 1101.584 |
| 6                  | Physical activity                             | <b>1.59</b> | 1.176  | 2.154 | 14%  | 2.646                    | 1.941  | 3.608   |                      |          |
| 7                  | Fruits and vegetable Intake                   | <b>1.44</b> | 1.027  | 2.022 | 22%  |                          |        |         | Model fit difference |          |
| 8                  | Hypertension treatment                        | 1.82        | 1.335  | 2.489 | 1%   |                          |        | 54.60   | 64.60                |          |
| 9                  | History of high glycemic levels               | 1.77        | 1.299  | 2.407 | 4%   | 1.211                    | 0.692  | 2.117   |                      |          |
| 10                 | Family History of Diabetes Mellitus           | <b>2.55</b> | 1.794  | 3.629 | -39% | 0.744                    | 0.609  | 0.911   |                      |          |

In **bold** variables with % CIE equal or higher than 10% compared with the crude model (forward selection process).

OR: Odds ratio. 95%CI: 95% Confidence Interval. BMI: Body Mass Index. T2D: Type 2 Diabetes. CIE: Change-in-estimate.

<sup>\*</sup> International Diabetes Federation classification (>90 cm in male: High risk - >80 cm in female: High risk).

<sup>\*\*</sup> World Health Organization classification (>94 cm in male: High risk - >90 cm in female: High risk).

<sup>\*\*\*</sup> World Health Organization classification Normal (IMC  $\geq 18.5$ – $24.9$  kg/m<sup>2</sup>) – Overweight (IMC  $\geq 25$  kg/m<sup>2</sup>) - Obesity (IMC  $\geq 30$  kg/m<sup>2</sup>)

<sup>f</sup> Forward selection process: Note that the crude ORs are unadjusted for the main effect only of the Risk of T2D on the setting.

<sup>f</sup> It includes only variables from forward and backward selection processes.

minor household chores. Similarly, residents of lower-income urban neighborhoods are forced to walk long distances to reach their worksites, where many of them tend to perform manual tasks that require a great deal of energy. Some authors have proposed as evidence that the recommendation of complementary physical activity does not concern these sectors of the population [14, 47]. However, historically, the contribution of agricultural activities as physical activity has been underestimated, for which reason it is recommended to review in more detail the differences between urban and rural contexts, identifying in the latter such activities, including the type of agricultural activity carried out.

A low-fat, high-fiber consumption has been shown to decrease the likelihood of T2D [42]. Thus, the regular consumption of fruits and vegetables is a protective factor over the risk of suffering from diabetes. In rural populations, the availability of seasonal fruits or crops added to the low cost *in situ* allows consumption in greater quantities. On the other hand, in urban areas, there is a greater variety of fruits, but a higher cost. Likewise, fruit and vegetable intake are influenced by socioeconomic status. The national profile of consumption of fruits and vegetables in Colombia shows that 27.9% of the general population does not consume vegetables in their daily diet in most departments. In urban areas, there is a higher consumption of these. However, it also indicates that this trend is related to the increase in family income, being higher as family income increases and lower in the lower socioeconomic status of urban areas than in rural areas [48, 49, 50].

Hypertension is a highly prevalent disease worldwide. The distribution of drug use for arterial hypertension (HT) shows that the proportion of individuals with HT is higher in the urban population than in the rural communities, which coincides with studies carried out in Peru where the prevalence of HT was 18.6% in urban areas and 3.9% in rural areas [51]. The Peruvian jungle shows that in urban areas the prevalence of HT is 18.4% and in rural areas 6% [39], and Mexico reports a prevalence of 36% in urban areas and 18% in rural areas [36]. In Colombia, the report of the urban area by sex reports that in men the prevalence of HT is 37.3% while in women it is 28% [38]. The prevalence of HT in the urban population is related to lifestyle, unhealthy diets, and sedentary lifestyle; these have been proposed as factors with a direct relationship [52].

We highlight the need to open lines of research with the application of non-invasive instruments in the prevention of diabetes in different communities, especially rural populations, which would allow the

monitoring of communities depending on the context in which they are in. However, we indicate that both urban and rural populations have personal and lifestyle risk factors that are influenced by the culture and environment of each community. Rural contexts are characterized by a food style in which indigenous products are of high relevance. Especially in those communities that, in addition to belonging to rural areas, are of indigenous background, they are conducted by a lifestyle of working the land that keeps individuals active for a long time, participating in activities that define their culture. However, urban environments are characterized by a lifestyle that is probably “much more dynamic”. People there have a greater amount and variety of food products, even though not all the population has access to them, which calls for a different approach to the prevention of NCDs in terms of public policies. In this way, it is appropriate to open markets with greater access to the consumption of fruits and vegetables in urban areas, facilitating access to these and/or detecting those populations with less access and providing them with the necessary support to increase this.

## 5. Limitations

Naturally, our study has some limitations. Due to the cross-sectional design, inferences about a causal association cannot be drawn. It is reasonable to expect that individual behavior may change as health entities develop actions to change circumstances in overweight and obese participants who do not have diabetes, yet. We believe that future studies would benefit from the longitudinal analysis of screened populations to direct specific actions in chronic disease health programs to overcome this problem. Furthermore, the data collected is self-report leading to a possible measurement bias. Participants usually underreport unhealthy behavior and overestimate healthier behavior.

Finally, estimating predictive factors for diabetes in the indigenous community, favors recommending specific actions for the entities that provide health care services. However, an aspect not addressed is the genetic identification of potential markers to guide individuals with the risk to develop T2D.

## 6. Conclusions

Our data identified differences in individual behavior between indigenous people in rural areas and those living in urban areas. Urban

communities were more likely to have T2D compared with rural-indigenous populations. These populations have differences in regard to the cultural context, including personal, and lifestyle factors. Our results should guide political decision makers to address this important health issue in order to decrease the incidence of T2D. Although people in urban areas present greater risk, adaptations in the indigenous rural context are required in relation to traditional practices and knowledge that are not taken care of in the current health care system.

## Declarations

### Author contribution statement

Rafael TUESCA MOLINA, Tania Acosta Vergara and Victor Alfonso Florez-García: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Víctor Rodríguez Gutiérrez, Karen Florez Lozano and Noél C Barengo: Analyzed and interpreted the data; Wrote the paper.

Ana Liliana Ríos García: Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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### Data availability statement

Data will be made available on request.

### Declaration of interests statement

The authors declare no conflict of interest.

### Additional information

No additional information is available for this paper.

## References

- [1] E.M. Onyango, B.M. Onyango, The rise of noncommunicable diseases in Kenya: an examination of the time trends and contribution of the changes in diet and physical inactivity, *J. Epidemiol. Glob. Health* 8 (1-2) (2018) 1.
- [2] MSPS. Ministerio de Salud de Colombia, Tres de cada 100 colombianos tienen diabetes. 19 de junio de 2020. Bogotá. Boletín de Prensa 493 de 2020, 2020. Disponible en: <https://www.minsalud.gov.co/Paginas/Tres-de-cada-100-colombianos-tienen-diabetes.aspx>.
- [3] L.E. Bautista, M. Oróstegui, L.M. Vera, G.E. Prada, L.C. Orozco, O.F. Herrán, Prevalence and impact of cardiovascular risk factors in Bucaramanga, Colombia: results from the countrywide integrated noncommunicable disease intervention programme (CINDI/CARMEN) baseline survey, octubre de, *Eur. J. Cardiovasc. Prev. Rehabil.* 13 (5) (2006) 769–775.
- [4] N.C. Barengo, T. Acosta, A. Arrieta, C. Ricaurte, D. Mayor, J.O. Tuomilehto, et al., Screening for people with glucose metabolism disorders within the framework of the DEMOJUAN project (DEMOstration area for primary prevention of type 2 diabetes, JUAN Mina and Barranquilla, Colombia): screening for People at High Risk for Glucose Metabolism Disorders in Barranquilla, septiembre de, *Diabetes Metab. Res. Rev.* (2013). n/a-n/a.
- [5] L. Rodríguez, C. Mendoza, A. Sirtori, I. Caballero, M. Suarez, M. Alvarez, Riesgo de diabetes mellitus tipo 2, sobrepeso y obesidad en adultos del distrito de Barranquilla, 2018, pp. 1–10.
- [6] S. Montes-Ochoa, K. Serna-Arrieta, S. Estrada-Ávila, F. Guerra-López, I. Sánchez, Caracterización de los factores de riesgo de diabetes mellitus tipo 2 mediante el test de Findrisk en una población de 30 a 50 años de Medellín, Colombia, *Med. Lab.* 22 (2016) 563–576.
- [7] D.L. Christensen, H. Friis, D.L. Mwaniki, B. Kilongo, I. Tetens, M.K. Boit, et al., Prevalence of glucose intolerance and associated risk factors in rural and urban populations of different ethnic groups in Kenya, junio de, *Diabetes Res. Clin. Pract.* 84 (3) (2009) 303–310.
- [8] H. King, R.E. Aubert, W.H. Herman, Global burden of diabetes, 1995–2025: prevalence, numerical estimates, and projections, 1 de septiembre de, *Diabetes Care* 21 (9) (1998) 1414–1431.
- [9] M.A.B. Khan, M.J. Hashim, J.K. King, R.D. Govender, H. Mustafa, J. Al Kaabi, Epidemiology of type 2 diabetes – global burden of disease and forecasted trends, *J. Epidemiol. Glob. Health* 10 (1) (2019) 107.
- [10] E. Guevara-Romero, V. Flórez-García, L.E. Egede, A. Yan, Factors associated with the double burden of malnutrition at the household level: a scoping review, 10 de abril de, *Crit. Rev. Food Sci. Nutr.* (2021) 1–12.
- [11] P. Aschner, Epidemiología de la diabetes en Colombia, abril de, *Av. En. Diabetol.* 26 (2) (2010) 95–100.
- [12] CSJ, Consejo Superior de la Judicatura de la República de Colombia. Constitución Política de Colombia 1991, 2016, pp. 1–170. Actualizada con los Actos Legislativos a 2016.
- [13] G. Torres-Luque, D. Molero, A. Lara-Sánchez, P. Latorre-Román, J. Cachón-Zagalaz, M.L. Zagalaz-Sánchez, Influencia del entorno donde se habita (rural vs urbano) sobre la condición física de estudiantes de educación primaria, octubre de, *Apunts Med. Esport* 49 (184) (2014) 105–111.
- [14] DANE. (Departamento Administrativo Nacional de Estadística(DANE), Resultados Colombia Censo Nacional de población y vivienda, 2018. Colombia.
- [15] E.M. Ochoa Acosta, K. Patiño Gutiérrez, C.A. Pérez Suescun, L.F. Lambrano Escobar, E. Sierra Caro, Tradiciones culturales y prácticas de cuidado bucal en los indígenas zenúes, en Sucre, Colombia. *Rev. Nac. Odontol.* [Internet]. 30 de junio de, 2015 [citado 24 de abril de 2021];11(20). Disponible en: <https://revistas.ucc.edu.co/index.php/od/article/view/765>.
- [16] D. Yu, Z. Zhao, U.L. Osuagwu, K. Pickering, J. Baker, R. Cutfield, et al., Ethnic differences in mortality and hospital admission rates between Māori, Pacific, and European New Zealanders with type 2 diabetes between 1994 and 2018: a retrospective, population-based, longitudinal cohort study, ebrero de, *Lancet Glob. Health* 9 (2) (2021) e209–e217.
- [17] A.E.C. Puello, A.C.E. Amador, R.J.M. Luna, Determinantes sociales de salud en los agricultores del resguardo indígena Zenú, 1 de enero de, *Rev. Univ. Ind. Santander Salud* 48 (1) (2016) 17–26.
- [18] F. Kolahdooz, F. Nader, M. Daemi, S.L. Jang, N. Johnston, S. Sharma, Prevalence of known risk factors for type 2 diabetes mellitus in multiethnic urban youth in edmonton: findings from the WHY ACT NOW project, abril de, *Can. J. Diabetes* 43 (3) (2019) 207–214.
- [19] J. Oetzel, M. Rarere, R. Wihapi, C. Manuel, J. Tapsell, A case study of using the He Pikinga Waiora Implementation Framework: challenges and successes in implementing a twelve-week lifestyle intervention to reduce weight in Māori men at risk of diabetes, cardiovascular disease and obesity, diciembre de, *Int. J. Equity Health* 19 (1) (2020) 103.
- [20] M. Das, S. Pal, A. Ghosh, Prevalence of cardiovascular disease risk factors by habitat: a study on adult Asian Indians in West Bengal, India, 1 de julio de, *Anthropol. Anz.* 68 (3) (2011) 253–264.
- [21] L.B. Lumagbas, H.L.S. Coleman, J. Bunders, A. Pariente, A. Belonje, T. Buning, Non-communicable diseases in Indian slums: re-framing the social determinants of health, *Glob. Health Action* 11 (1) (2018) 1438840, enero de.
- [22] A. Steinbrecher, Y. Morimoto, S. Heak, N.J. Ollberding, K.S. Geller, A. Grandinetti, et al., The preventable proportion of type 2 diabetes by ethnicity: the multiethnic cohort, julio de, *Ann. Epidemiol.* 21 (7) (2011) 526–535.
- [23] T. Acosta, R. TUESCA, K. Florez, N.C. Barengo, L. Anillo, V. Flórez-García, et al., Factors associated with low physical activity in two Latin American populations at risk of developing type 2 diabetes: an exploratory analysis, 14 de enero de, *Front Public Health* 8 (2021) 589484.
- [24] GRAIN. Colombia. Resguardo Indígena Zenú. Cabildo Mayor Regional. Declaración del Resguardo Indígena Zenú, Córdoba y Sucre, como Territorio libre de transgénicos, San Andrés de Sotavento, 2010.
- [25] WHO - guía para las mediciones físicas, Vigilancia STEPS, [https://www.who.int/ncds/surveillance/steps/Parte3\\_Secccion4.pdf](https://www.who.int/ncds/surveillance/steps/Parte3_Secccion4.pdf).
- [26] International Diabetes Federation, Recommendations for Managing Type 2 Diabetes in Primary Care, 2017. [www.idf.org/managing-type2-diabetes](http://www.idf.org/managing-type2-diabetes).
- [27] T. Saaristo, M. Peltonen, J. Lindström, L. Saarikoski, J. Sundvall, J.G. Eriksson, et al., Cross-sectional evaluation of the Finnish Diabetes Risk Score: a tool to identify undetected type 2 diabetes, abnormal glucose tolerance and metabolic syndrome, mayo de, *Diab. Vasc. Dis. Res.* 2 (2) (2005) 67–72.
- [28] J. Lindstrom, J. Tuomilehto, The Diabetes Risk Score: a practical tool to predict type 2 diabetes risk, 1 de marzo de, *Diabetes Care* 26 (3) (2003) 725–731.
- [29] M. Franciosi, G. De Berardis, M.C.E. Rossi, M. Sacco, M. Belgiglio, F. Pellegrini, et al., Use of the diabetes risk score for opportunistic screening of undiagnosed diabetes and impaired glucose tolerance: the IGLOO (impaired glucose tolerance and long-term outcomes observational) study, 1 de mayo de, *Diabetes Care* 28 (5) (2005) 1187–1194.
- [30] K. Makrilakis, S. Liatis, S. Grammatikou, D. Perrea, C. Stathi, P. Tsiligras, et al., Validation of the Finnish diabetes risk score (FINDRISC) questionnaire for screening for undiagnosed type 2 diabetes, dysglycaemia and the metabolic syndrome in Greece, abril de, *Diabetes Metab.* 37 (2) (2011) 144–151.
- [31] D. Gomez-Arbelaiz, Evaluation of the Finnish Diabetes Risk Score to predict type 2 diabetes mellitus in a Colombian population: a longitudinal observational study, *World J. Diabetes* 6 (17) (2015) 1337.
- [32] M. Diéguez, S. Miguel, H. Rodríguez, B. Lopez, Ponce, Prevalence of abdominal obesity and associated cardiovascular risk factors in young adults, *Rev. Cubana Salud Publica* 43 (3) (2017).

- [33] J. Aranceta-Bartrina, C. Pérez-Rodrigo, G. Alberdi-Aresti, N. Ramos-Carrera, S. Lázaro-Masedo, Prevalencia de obesidad general y obesidad abdominal en la población adulta española (25–64 años) 2014–2015: estudio ENPE, junio de, *Rev. Esp. Cardiol.* 69 (6) (2016) 579–587.
- [34] M. Torres, R. Ortiz, W. Sigüencia, A. Ortiz, R. Añez, J. Rojas, Prevalencia de la obesidad en individuos adultos en las parroquias urbanas de la ciudad de Cuenca, Ecuador 3 (4) (2013) 76–88.
- [35] M. Martínez-Larrad, C. Fernández-Pérez, J.L. González-Sánchez, A. López, J. Fernández-Álvarez, J. Riviriego, et al., Prevalencia del síndrome metabólico (criterios del ATP-III). Estudio de base poblacional en áreas rural y urbana de la provincia de Segovia, octubre de, *Med. Clínica* 125 (13) (2005) 481–486.
- [36] P. Arroyo, V. Fernández, A. Loria, J. Pardo, H. Lavadia, L. Vargas-Ancona, et al., Obesidad, morfología corporal y presión arterial en grupos urbanos y rurales de Yucatán, *Rev. Sal. Publ. Mex.* 49 (4) (2007) 274–285.
- [37] E. Escobar, A. Ulloa, Las mujeres indígenas en los escenarios de la biodiversidad 186, UICN, Colombia, 2005, p. 2005.
- [38] P. Aschner, Síndrome metabólico en una población rural y una población urbana de la región andina colombiana, *Rev. Med.* 15 (2) (2007) 154–162.
- [39] Y. Martínez-Espichan, R. Zambrano-Huaila, A. Zambrano-Huaila, A. Manrique-Acha, J. Mayta-Calderón, A. Cardenas-Rojas, et al., Características de los factores de riesgo cardiovascular en una población urbana y rural de la selva peruana, *Horizons Medicaux* 2017 (2) (2017) 38–42.
- [40] M.I. Querales, S.A. Rojas, E. Silva, J. Ochoa, K. Santiago, et al., Factores de riesgo cardiovascular en comunidades urbana y rural: tinaquillo, Venezuela, *Rev. Salud Pública.* 19 (2) (2017) 188–193.
- [41] M. Elvas, Naturaleza, alimentación y medicina indígenas en Cartagena de Indias en el siglo XVI, *Rev. Digit. Hist. Arqueol Desde El Caribe* 8 (2007) 1–21.
- [42] WHO. Dieta, Nutrición y prevención de enfermedades crónicas, Ser. Inf. Tech. 152 (2003).
- [43] WHO. World Health Organization, Informe sobre la situación mundial de las enfermedades no transmisibles 2010 Resumen de orientación, Ginebra (Suiza), 2011.
- [44] D.R. Hanna, R.J. Walker, B.L. Smalls, J.A. Campbell, A.Z. Dawson, L.E. Egede, Prevalence and correlates of diagnosed and undiagnosed hypertension in the indigenous Kuna population of Panamá, diciembre de, *BMC Public Health* 19 (1) (2019) 843.
- [45] A. Jimenez-Corona, R.G. Nelson, M.E. Jimenez-Corona, P.W. Franks, C.A. Aguilar-Salinas, E.O. Graue-Hernandez, et al., Disparities in prediabetes and type 2 diabetes prevalence between indigenous and nonindigenous populations from Southeastern Mexico: the Comitan Study, junio de, *J. Clin. Transl. Endocrinol.* 16 (2019) 100191.
- [46] A. Cordero, M.D. Masiá, E. Galve, Ejercicio físico y salud, *Rev. Esp. Cardiol.* 67 (9) (2014) 748–753.
- [47] C.O. Gregory, J. Dai, M. Ramirez-Zea, A.D. Stein, Occupation is more important than rural or urban residence in explaining the prevalence of metabolic and cardiovascular disease risk in Guatemalan adults, 1 de mayo de, *J. Nutr.* 137 (5) (2007) 1314–1319.
- [48] K. Amado, Determinantes sociales de la alimentación en las familias de estratos 1, 2 y 3 de la localidad de chapinero [Internet], Javeriana, 2010. Disponible en: <https://www.javeriana.edu.co/biblos/tesis/ciencias/tesis707.pdf>.
- [49] L.M. Arboleda Montoya, M.M. Duque Gallego, J.A. Urea Cepeda, Significados del consumo de frutas y hortalizas en dos comunidades de zona rural del municipio de Turbo, Urabá Antioqueño, *Saude e Soc.* 22 (4) (2013) 1247–1256.
- [50] F.A.O. Food, Agriculture Organization- Perfil nacional de consumo de frutas y verduras, 263, Bogotá -Col, 2013.
- [51] D. Lopez, M. Chiriboga, G. Gonzáles, Prevalence of some cardiovascular risk factors in two populations in Huaraz (3.100 m above sea level), *Act. Med. Per.* 24 (1) (2007) 18–21.
- [52] M. Morales, V. Pacheco, J. Morales, Influence of physical activity and nutritional habits on the risk of metabolic syndrome, *Enfermería Glob.* 15 (44) (2016) 209–221.