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2022-01

Tuesca Molina , R , Rios Garcia , A L , Acosta Vergara , T , Florez-Garcia , V A , Rodriguez Gutierrez , J , Florez Lozano , K & Barengo , N C 2022 , ' Predictors of diabetes risk in urban and rural areas in Colombia ' , Heliyon , vol. 8 , no. 1 , 08653 . https://doi.org/10.1016/j.heliyon.2021.e08653

http://hdl.handle.net/10138/342781
https://doi.org/10.1016/j.heliyon.2021.e08653

Heliyon 8 (2022) e08653

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Predictors of diabetes risk in urban and rural areas in Colombia

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ARTICLE INFO

Keywords:
Type 2 diabetes
Indigenous peoples
Place of living
Urban health
Predictor
Colombia

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

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https://doi.org/10.1016/j.heliyon.2021.e08653
Received 9 July 2021; Received in revised form 22 November 2021; Accepted 17 December 2021

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 (Algarrobos, 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 ≥18.5–24.9 kg/m^2) – overweight (BMI ≥25 kg/m^2) - obesity (BMI ≥30 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% Confidence Intervals (CI) were done with binary logistic models. Model fit was evaluated using Akaike Information Criteria (AIC) and Bayesian

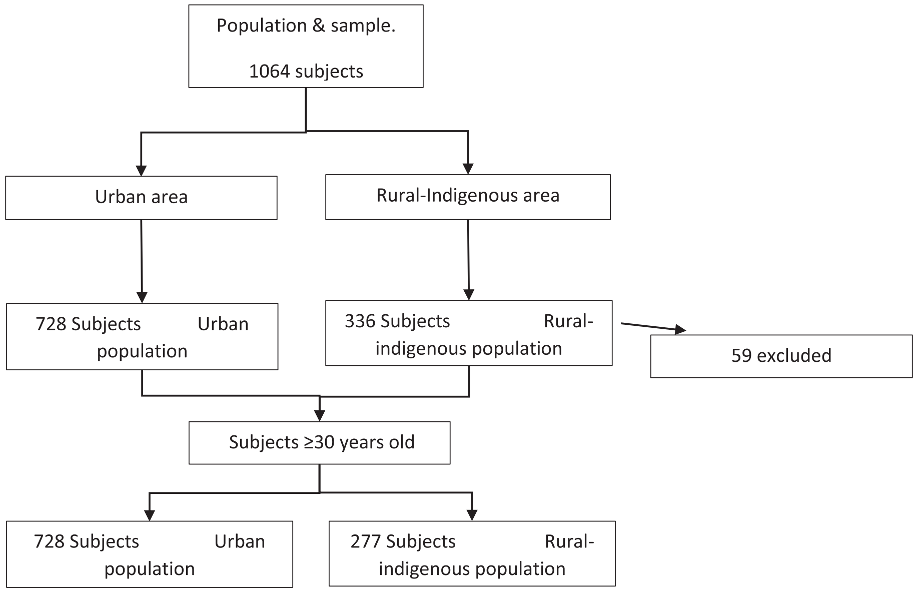

Figure 1. Flow chart of study population.

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 ± 4.9) compared to the rural area (9.4 ± 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 confunder 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 kg/m^2, BMI ≥18.5–24.9 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 ≥90/80cm and 7.4% of men have a waist circumference >102/88cm. 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 lifestyle and customs of the two populations. Some underlying causes can be proposed for these results: rural indigenous communities, overall,

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

	Urban		Rural		*p*-value⁺
	N	%	N	%	
	728	100	277	100	
Gender					
Female	531	72.94	171	61.73	**0.001**
Male	197	27.06	106	38.27	
Age [years]	**[52.6 ± 14.3]**		**[54.05 ± 14.6]**		
<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	
Waist Circumference (IDF)* [Mean ± SD]	**[95.3 ± 12.3]**		**[93.6 ± 10.6]**		
Low Risk	119	16.35	78	28.16	**<0.001**
High Risk	609	83.65	199	71.84	
Waist Circumference [WHO] **					
Low Risk	276	37.91	131	47.29	**0.007**
High Risk	452	62.09	146	52.71	
BMI [kg/m²] [WHO]* [Mean ± SD]**	**[27.4 ± 5.4]**		**[25.4 ± 4.4]**		
Normal	248	34.07	133	48.01	**<0.001**
Overweight	283	38.87	100	36.1	
Obesity	197	27.06	44	15.88	
Physical activity [>30 min/day]					
No	584	80.22	158	57.04	**<0.001**
Yes	144	19.78	119	42.96	
Fruits and vegetable Intake					
Yes	196	26.92	232	83.75	**<0.001**
No	532	73.08	45	16.25	
Hypertension treatment					
No	555	76.24	224	80.87	0.116
Yes	173	23.76	53	19.13	
History of high glycemic levels					
No	644	88.46	257	92.78	**0.045**
Yes	84	11.54	20	7.22	
Family History of Diabetes Mellitus					
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	
FINDRISC Score** [Mean ± SD]]**	**[11 ± 4.9]**		**[9.4 ± 4.6]**		
Low Risk	398	54.67	191	68.95	**<0.001**
High Risk	330	45.33	86	31.05	

⁺ Chi-square
* International Diabetes Federation classification (>90 cm in male: High risk- >80 cm in female: High risk)
** World Health Organization classification (>94 cm in male: High risk - >90 cm in female: High risk)
*** World Health Organization classification Normal (IMC ≥18.5–24.9 kg/m²) – Overweight (IMC ≥25 kg/m²) - Obesity (IMC ≥30 kg/m²)
**** <12 score: Low risk of Diabetes; ≥12 score: High risk of Diabetes

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 minor household chores. Similarly, residents of lower-income urban neighborhoods are forced to walk long distances to reach their worksites,

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[f]	95% CI		AIC	BIC
			Lower	Upper						
Crude[f]		1.84	1.373	2.469		1.908	1.201	3.03		
1	Gender	1.84	1.373	2.47	0%					
2	Age [years]	**2.05**	1.513	2.788	-12%	0.875	0.765	1.000	Crude Model	
3	Waist Circumference (IDF)*	**1.58**	1.156	2.166	14%				1170.18	1166.18
4	Waist Circumference [WHO]**	1.72	1.246	2.364	7%				Full Model	
5	BMI [kg/m^2] [WHO]***	**1.45**	1.046	2.022	21%	1.254	1.001	1.571	1115.6	1101.584
6	Physical activity	**1.59**	1.176	2.154	14%	2.646	1.941	3.608		
7	Fruits and vegetable Intake	**1.44**	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	**2.55**	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 Intervas. BMI:Body Mass Index. T2D: Type 2 Diabetes. CIE: Change-in-estimate.
* International Diabetes Federation classification (>90 cm in male: High risk- >80 cm in female: High risk).
** World Health Organization classification (>94 cm in male: High risk - >90 cm in female: High risk).
*** World Health Organization classification Normal (IMC $\geq$18.5–24.9 kg/m^2) – Overweight (IMC $\geq$25 kg/m^2) - Obesity (IMC $\geq$30 kg/m^2)
[f] Forward selection process: Note that the crude ORs are unadjusted for the main effect only of the Risk of T2D on the setting.
[f] It includes only variables from forward and backward selection processes.

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 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

R. Tuesca Molina, T. Acosta Vergara and V.A. Florez-Garcia: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

V. Rodriguez Gutierrez, K. Florez Lozano and N.C. Barengo: Analyzed and interpreted the data; Wrote the paper.

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

Funding statement

This work was supported by the Colombian research support program, Colciencias, and Empresa Promigas.

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.

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