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Attitudes and behaviors of university students during the COVID-19 pandemic in a predominantly Indigenous population in Mexico: a survey study

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Abstract

Background The COVID-19 pandemic has become one of the most devastating worldwide crises. The pandemic has heavily affected the most vulnerable groups, including Indigenous communities. Our study aimed to evaluate the attitudes and behaviors relating to care and prevention of COVID-19 in a predominantly Indigenous university population in Mexico.

Methods A cross-sectional descriptive study was conducted in early February 2022 focused on university students in a predominantly Indigenous community in central Mexico. The survey addressed prevention, vaccination, anthropometric data, and food intake.

Results We obtained a high response rate of 71.6%, with 981 students (41.2%) identifying as belonging to an Indigenous group. In the sample, 3.1% (95% CI 2.07, 4.33) of the Indigenous group reported COVID-19 deaths among family members older than 18 years; this rate was 3% (95% CI 2.17, 4.03) in the non-Indigenous group. Whereas most of the students [98% (95% CI 97.62, 98.72)] reported having received COVID-19 vaccines, 36.6% (95% CI 33.57, 39.70) and 39.9% (95% CI (37.32, 42.52) of the Indigenous and non-Indigenous respondents, respectively, reported that their parents were fully vaccinated against COVID-19. Finally, we found important differences in weight and Body Mass Index (BMI) between pre-pandemic baseline and two years after confinement in the general population as well as between Indigenous and non-Indigenous: general BMI increased from 22.9 ± 4.1 kg/m^2 to 23.6 ± 4.1 kg/m^2 (Wilcoxon test; $P < 0.001$). The BMI for the Indigenous went up from 22.4 ± 3.8 kg/m^2 to 23.1 ± 3.8 kg/m^2 (Wilcoxon test; $P < 0.001$), and BMI for non-Indigenous rose from 23.2 ± 4.2 kg/m^2 to 24.0 4.2 kg/m^2 (Wilcoxon test; $P < 0.001$).

Conclusion Our study highlights significant vaccination disparities between our university population and their parents, although no substantial differences regarding attitudes and prevention of COVID-19 between the Indigenous and non-Indigenous populations were found. Findings suggest that efforts to expand prevention to students' families and surrounding communities could lead to significant public health gains and should be further investigated. Furthermore, the university setting may improve access to prevention tools against COVID-19.

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Keywords Survey · Google forms · COVID-19 · Attitudes · Prevention · Indigenous people

Abbreviations

COVID-19	Coronavirus disease
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
BMI	Body Mass Index
INALI	Instituto Nacional de Lenguas Indígenas
INEGI	Instituto Nacional de Estadísticas y Geografía
CDC	Centers for Disease Control and Prevention
WHO	World Health Organization
ENSANUT	Encuesta Nacional de Salud y Nutrición
ILO	International Labor Organization
PAHO	Pan American Health Organization
ECLAC	Economic Commission for Latin America and the Caribbean
H1N1	Swine Flu

1 Introduction

The COVID-19 pandemic can be traced back to late 2019 in Wuhan, China and has had significant repercussions on vulnerable groups, especially the elderly, persons with chronic diseases, and minority groups, including Indigenous populations [1–4]. Indeed, the vulnerability of groups or populations to events that could modify their welfare conditions and their capacity to respond to adversity is considered a "risk for human health" [3]. These groups face challenges usually related to a lack of federal or state support, limited access to health services, inadequate public service management, and lack of access to the Internet [5, 6]. There is a need to understand better how humanitarian crises such as pandemics affect their welfare over time to better allocate limited resources and guide the implementation of effective public health measures.

The global Indigenous population comprises more than 476 million individuals in 90 countries and represents 6.2% of the world's population [7]. Indigenous groups in Mexico frequently face discrimination because of their ethnicity and the language they speak compared with their counterparts [8]. These groups often live in poverty and lack access to high-quality food and health services. The above is especially important because research has indicated that the COVID-19 pandemic affected eating habits and caused hunger in more than 14 million persons globally [9]. The low intake of vitamins and minerals may have increased their risk of severe disease from COVID-19 [10] since an appropriate level of food intake is essential for preventing SARS-CoV-2 infection [10, 11].

In Mexico, about 7.4 million people speak an Indigenous language (6.1% of the total population in the country). According to Mexico's INALI (Instituto Nacional de Lenguas Indígenas), there are 11 Indio-American linguistic families, 68 linguistic groups, and 364 linguistic variants in Mexico [12]. Náhuatl is one of the most frequently spoken linguistic variants, covering 21.5% of the center, northeast, and west of Mexico; Maya, Mixteca, and Tzeltal cover 10.8%, 6.7%, and 6.4% of southern Mexico, and Zapotec covers 6.2% of the south-central region [13].

A significant fraction of Mexico's Indigenous population lives in the central region. According to the INEGI (Instituto Nacional de Estadísticas y Geografía), about 3.6 million live in the state of Hidalgo (12.3% of the total state population in 2020) [14–17]. Over half of the population speaks an Indigenous language in Huejutla, Hidalgo, where our study setting is located [18]. Hence, this is a significant geographic area in Mexico to investigate how the COVID-19 pandemic has affected the lives of Indigenous groups [19].

In Mexico, Indigenous groups self-recognize based on their own culture, traditions, and history; cultural diversity is expressed through language, speech, physical characteristics, religion, and the location of their territories [20, 21]. Mexico's constitution states that an individual's awareness of their Indigenous identity must be a fundamental criterion for identifying Indigenous populations [22]. This consideration gives these communities the sovereign right and power to decide who belongs to them without external interference [23].

While emerging data indicates that Indigenous groups have experienced some of the highest COVID-19 mortality rates relative to the general population [4, 24], information relating to the health, nutrition, prevention attitudes, and other consequences of COVID-19 on these groups is lacking. For instance, life expectancy for Native Americans and Alaska Natives fell by 6.5 years from 2020 to 2022, while the general US population life expectancy fell by three years [25]. This underscores the need to collect additional data to understand how the COVID-19 crisis affected vulnerable groups. To

start filling these gaps, we conducted the first cross-sectional descriptive study using data from a web-based survey to obtain information in a predominantly Indigenous community in Huejutla Hidalgo, México. Our primary goal was to identify insights relevant to Indigenous populations. Our study investigated issues related to the impact of COVID-19, including vaccination coverage, prevention measures, and food intake.

2 Methods

2.1 Survey design

We conducted a web-based survey among college students at the Universidad Tecnológica de la Huasteca Hidalguense in a predominantly Indigenous community in Huejutla, Hidalgo, Mexico. The survey comprised 52 questions and was deployed using the Google Forms platform. The survey was adapted from the work of Diaz and colleagues (Additional files 1, 2) [26]. Questions included closed-choice Likert-scale items, multiple-choice and multiple-select questions, and some open-ended questions on various topics, including prevention, vaccination, anthropometric data (weight, height), and food intake. Of note, the weight before the pandemic lockdown (pre-pandemic weight) and the weight two years after the pandemic lockdown (post-pandemic weight) and height measures were directly provided by the participants at their discretion.

2.2 Statistical analysis

We analyzed the combinations of answers in multi-select questions using geometric coding and hierarchical cluster analysis [27], described by simple descriptive results. Most participants provided weight and height measures (93%; 2215/2382). A total of 981 participants (41.2%) were Indigenous (i.e., spoke an Indigenous dialect or considered themselves to belong to an Indigenous group), whereas 1,401 (58.8%) were non-Indigenous.

We used the Wilcoxon test to compare sample characteristics within Indigenous and Non-Indigenous groups and the Mann–Whitney U Test to compare samples between Indigenous and Non-Indigenous groups. We used SPSS program version 25 for all analyses.

2.3 Target population and data collection procedure

Once Universidad Tecnológica de la Huasteca Hidalguense authorities approved the study survey, the academic coordinator of the university emailed the invitation to participate in the survey to 3007 adult students enrolled in January-May 2022. The survey was administered using Google Forms. The survey was open from January 31 to February 25, 2022. During this period, the academic coordinator of the University sent weekly reminders encouraging the students to participate in the survey voluntarily.

2.4 The sample

We obtained a high response rate of 71.6% (n = 2382), with 981 students (41.2%) identifying as belonging to an Indigenous group. Our analyses mainly focus on differences based on Indigenous status. In our study, an individual belongs to an Indigenous group if he/she belongs to an autochthonous population by self-identification OR speaks an Indigenous language [21, 28].

2.5 Ethics statement

Our study followed ethical standards, institutional regulations, national laws, and the Helsinki Declaration. This study was based on data with no personal identifiers. Informed consent was obtained from all subjects. The respondent's anonymity and confidentiality were ensured. The submission of a completed survey was considered consent to participate in the study. This study was approved by the Institutional Review Committee of the Universidad Tecnológica de la Huasteca Hidalguense.

Table 1 Distribution of dialects spoken by individuals in our sample

Dialects		
Dialect	% (N = 2379)	n
Náhuatl	27.8	663
Huasteco	0.3	6
Otomí	0.2	5
Otros (Tenek, Zapoteco)	0.1	2

Table 2 Average weight and BMI during the pre-and post-pandemic periods in our sample

General		
Variable	Before (pre)	After (post)
Weight (n = 2215)	61.7 ± 13.7 kg	63.7 ± 14.0 kg[a]
BMI (n = 2215)	22.9 ± 4.1 kg/m^2	23.6 ± 4.1 kg/m^{2a}

[a]Statistically significant ($P < 0.001$)

3 Results and discussion

3.1 General characteristics

Our sample of college students included more males [55.5% (95% CI 53.5,57.6)] than females [44.5% (95% CI 42.5,46.5)] (binomial exact test with the expected proportion of 0.5; $P < 0.001$) and is representative of the student population in the same institution (54.1% males, 45.9% females). By comparison, according to the population pyramid from Mexico's INEGI, in 2020, 48.8% of the country were males, and 51.2% were females [14].

Our sample had an average age of 20 ± 1.9 years, and the average height was 1.63 m. Table 1 summarizes the weight and BMI characteristics of the sample. According to the U.S. Centers for Disease Control and Prevention and World Health Organization (WHO) percentile guidelines, females and males in this study are below the fifth percentile for height, with an average height of 1.56 ± 0.64 and 1.69 ± 0.69 m, respectively. On the other hand, their weight and BMI for the age group lie between the 25th and 50th percentiles, which is standard for both genders. According to González-Hermida and colleagues [29], height is a good predictor of adequate health in children and young people. The most frequently cited reason for short stature is malnutrition, a characteristic frequently found in the low socio-economic sector, including Indigenous communities. For instance, in Mexico, among the Tarahumara ethnic communities in the Sierra Madre Oriental, located in northern Mexico, the prevalence of short stature was estimated at 30–50% in 2021 [30]. At the national level, 44.4% of Indigenous children have short stature versus 14.5% for non-Indigenous counterparts [31].

The distribution of the most common spoken dialects among the survey respondents is shown in Table 1. Nahuatl was the most frequently reported dialect at 27.8%. Until 2000, the INEGI reported that 73% of the population in the Huasteca region of Hidalgo state reported Nahuatl as their primary language [32]. In 2020, 53.79% of the Huejutla population spoke an Indigenous language, and 10.15% spoke only an Indigenous language [18]. This substantial reduction could due to families more frequently deciding not to pass their indigenous language on to the younger generation to avoid social discrimination and hostility. Indeed, the Nahuatl speakers face limited access to education, modern medical care, and other social benefits due to their Indigenous language [33].

A total of 2215 responders provided information on their weight and BMI. Results indicate a significant increase in weight and BMI for these individuals between the pre-and post-pandemic periods (Wilcoxon test; P < 0.001; Table 2). We also found significant differences within the Indigenous group (n = 910) before and after, as well as for the non-Indigenous group (n = 1305) (Wilcoxon test; P < 0.001; Table 3). Finally, we found differences when comparing Indigenous and non-Indigenous groups (Mann–Whitney *U* Test; P < 0.001, Table 4).

The apparent increase in weight and BMI could be explained by decreased physical activity and changes in diet due to the pandemic lockdown [34]. According to Caroppo and colleagues [35], spending more time at home results in increased food consumption and a sedentary lifestyle due to the sudden change from face-to-face activities to online or sedentary activities that force individuals to sit for extended periods. Remarkably, in 2020 Paciera Di Zoppola and colleagues reported that 50.6% of the total population in a group of Indigenous people reported a

Table 3 Average height, weight, and BMI within Indigenous and non-Indigenous groups during pre- and post-pandemic periods

Variable	Indigenous (n = 910)		Non-indigenous (n = 1305)	
	Before (pre)	After (post)	Before (pre)	After (post)
Height	1.62 ± 0.8 m		1.64 ± 0.9 m	
Weight	59.2 ± 12.2 kg	60.9 ± 12.6 kg[a]	63.4 ± 14.4 kg	65.6 ± 14.5 kg[a]
BMI	22.4 ± 3.8 kg/m^2	23.1 ± 3.8 kg/m[a]	23.2 ± 4.2 kg/m^2	24.0 ± 4.2 kg/m^{2a}

[a]Statistically significant ($P < 0.001$)

Table 4 Comparison of Indigenous vs. non-Indigenous weight and BMI for the pre-and post-pandemic periods

Variable	Before		After	
	Indigenous (n = 910)	Non-Indigenous (n = 1305)	Indigenous (n = 910)	Non-Indigenous (n = 1305)
Weight	59.2 ± 12.2 kg	63.4 ± 14.4 kg[a]	60.9 ± 12.6 kg	65.6 ± 14.5 kg[a]
BMI	22.4 ± 3.8 kg/m^2	23.2 ± 4.4 kg/m^{2a}	23.1 ± 3.9 kg/m^2	24.0 4.3 kg/m^{2a}

[a]Statistically significant ($P < 0.001$)

lack of physical activity; 37% reported that this behavior was due to a lack of time, and 32% felt discouraged by the COVID-19 environment [36, 37]. It is worth noting that the Mexican Government launched a major campaign to encourage the population to stay in their homes as much as possible during the first two pandemic years to reduce their risk of catching the disease [38].

3.2 Housing situation and employment

Individuals reported that, on average, 4.72 ± 1.7 people live in their dwelling, which is slightly higher than results reported by INEGI for the State of Hidalgo, which had an average of 3.6 people residing in a household based on the 2020 census [39]. Most of those surveyed (85.5% of Indigenous and 84.6% of non-Indigenous) also reported living with their parents. Moreover, 6.6% and 7.5% of Indigenous and non-Indigenous, respectively, shared a household with others (same rental house during the study period) (Fig. 1A).

In Mexico, 87% of the registered households are "family" (those in which at least one of the members is related to the head of the household), while 28 out of every 100 family households are "extended" (formed by a nuclear household in addition to other relatives such as uncles, cousins, brothers, etc.) [40]. In our survey 41.7% of the students shared a home with two or more generations in the same house, and only 5.9% and 5.0% of Indigenous and non-Indigenous live alone, which is a frequent situation for foreign students [41].

Ahmad and colleagues [42] found that for each 5% increase in poor housing conditions (overcrowding as the first problem), there was a 59% increase in the relative risk of COVID-19 incidence and a 63% increase in the relative risk of COVID-19 mortality. A previous study from Mexico has shown a statistically significant positive association between excess mortality during the COVID-19 pandemic and average household size as well as marginalization index (p-value < 0.0001) after adjusting for other covariates [43]. In addition, in a study in the US., 95.2% of COVID-19 deaths were related to housing quality as measured by housing age, size, and energy efficiency, since poor housing and building quality have been associated with mold, moisture, and dust, which can trigger respiratory conditions or make them worse [44].

Regarding employment, 22.4% of the respondents were employed at part-time jobs while studying; 10.1% of Indigenous and 13.6% of non-Indigenous reported that in their job, they had to be in direct contact with other people (Fig. 1-B). Personal contact at work increases the chances of contracting COVID-19. According to Lan and colleagues [45] and Baker and colleagues [46] the workers most exposed to COVID-19 are protective services, administrative support, drivers, and sales workers, just behind personal healthcare.

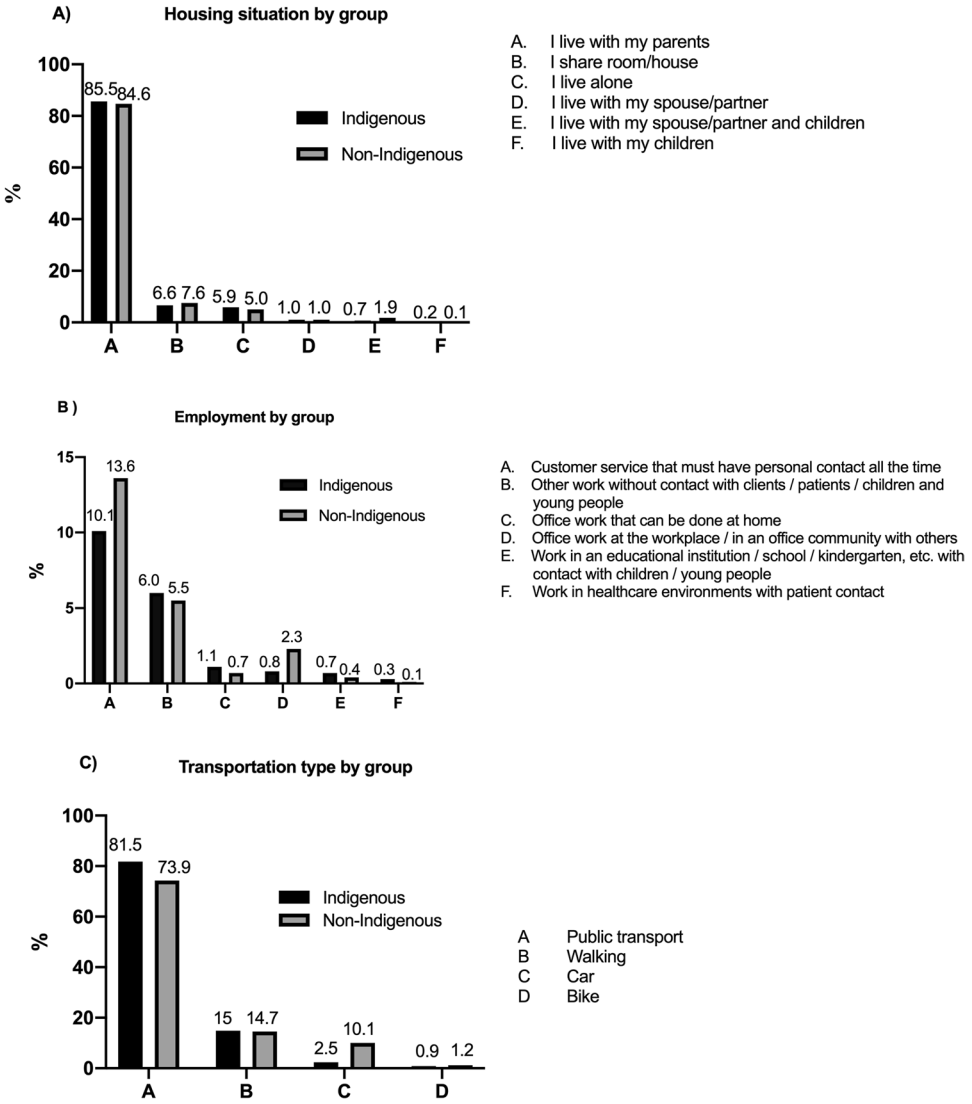

Fig. 1 Distribution of housing situation, employment, and transportation in the Indigenous and non-Indigenous groups. **A** Housing situation; **B** employment distribution between the Indigenous and non-Indigenous groups; **C** mode of transportation to work/school during the pandemic period

3.3 Transportation

When we compared Indigenous and non-Indigenous groups, we found that the former used public transportation more often (81.5% vs. 74.9%) (Fig. 1C). SARS-Cov2 is easily transmitted by close contact with others or inhaling aerosol droplets a sick individual expels through coughing or sneezing [47, 48]. Public transport frequently involves small, unventilated, confined spaces where individuals may spend long periods getting from one place to another, making it suitable for catching COVID-19 and other respiratory pathogens [49].

Consideration of transportation during the pandemic brings to the forefront a discussion of social inequalities because access to safe transportation is less accessible for people of Indigenous origin. In isolated areas where they often live, lack of transportation represents critical delays in access to health care settings, typically located in more distant locations compared to populations living in urban centers. This situation increases the probability that these groups experience poor health outcomes because in a marginalized region such as Huejutla in the State of Hidalgo, having a car for personal transportation is rare [50–52].

Table 5 Changes in food intake in the total population and their 95% CIs

Variable	n = 2382, % (95% CI)
Increased consumption of fruits and vegetables	n = 455; 19.1% (17.54,20.74)
Reduced consumption of fruits and vegetables	n = 238; 10.0% (8.22,11.27)
Increased consumption of processed foods	n = 337; 14.1% (12.77,15.61)
Reduced consumption of processed foods	n = 1252; 56.8% (54.74,58.76)
Total	n = 2382; 100%

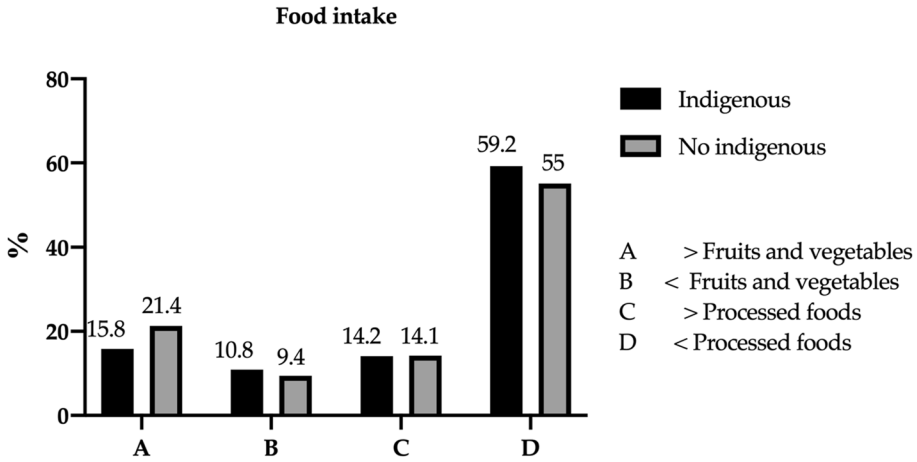

Fig. 2 Food intake in the Indigenous vs. non-Indigenous groups. The Indigenous group reduced their consumption of processed foods slightly more than the non-Indigenous group, but it was not statistically significant 59.2% (56.08, 62.32) vs. 55.0% (52.38,57.66)

3.4 Food intake

Decreased consumption of processed foods was reported by 56.8% of the respondents, whereas 19.1% reported increased consumption of fruits and vegetables during the lockdown (Table 5). When comparing the outcomes between Indigenous and non-Indigenous groups, we found that the former reduced the consumption of processed foods slightly more than the latter (Fig. 2).

Mexico's National Health and Nutrition Survey 2020 (ENSANUT) found that about 42.5% of young people aged 12–19 years consume fruits. Only 32.8% consumed vegetables, but 90.7% consumed sweetened beverages and there was a combined prevalence of 50.1% processed meats and fast-food consumption. Notably, the same survey reported increased consumption of fruits (> 3.5%), legumes (> 12.9%), and natural water (> 6.5%) in rural locations during the COVID-19 lockdown [53]. This result seems in agreement with our finding that the consumption of healthy foods improved. Moreover, Enriquez-Martínez and colleagues [54] reported a similar proportion among Mexicans, where 22.4% adopted healthier and 21.5% less healthy eating patterns. A few studies have shown that during the pandemic, people increased their consumption of fruits and vegetables, ate more healthy foods, and decreased their consumption of snacks [55, 56].

It is worth noting that Universidad Tecnológica de la Huasteca Hidalguense's student body includes out-of-state students who must move from their communities of origin to Huejutla to attend the university and access higher education. When they return to their homes they are able to carry provisions and supermarket products that are only available in the city. However, on March 16, 2020, the Chamber of Deputies of Mexico declared the suspension of school activities at all educational levels [57]. The University returned to face-to-face classes in May 2022, two years after the lockdown. Hence, the pandemic confinement may have influenced a reduced consumption of processed foods in this study group [58]. Huejutla, our study setting, had been the central commercial point for farmer's market and industrial food activities for neighboring regions, including the State of Mexico, San Luis Potosí, Jalisco, Chiapas, Guanajuato, and Veracruz, before the COVID-19 pandemic hit [59, 60]. During the COVID-19 lockdown, mobility was limited, so this ritual was interrupted, and accessing these products was no longer feasible, likely explaining a reduction in the consumption of industrialized foods [61]. In Chile, similar results were reported for an adult population whereby a significant increase in the consumption of fruits and vegetables was reported: 37.2% consumed what is recommended by the health system: five servings of fruits and vegetables, and the consumption of legumes

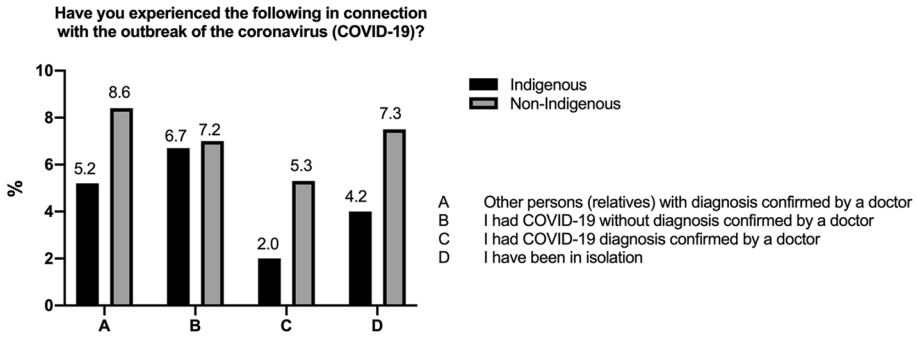

Fig. 3 Have you experienced the following in connection with the outbreak of the coronavirus? Compared to the non-Indigenous group, lower proportion of Indigenous group had COVID-19 without a diagnosis confirmed by a doctor

Table 6 Percentage of cases, hospitalization, and deaths due to COVID-19 in the respondents and their relatives

	COVID-19 case (%)		COVID- 19 hospitalization (%)		COVID-19 Deaths (%)	
	Indigenous (n = 981)	Non-Indigenous (n = 1401)	Indigenous (n = 981)	Non-Indigenous (n = 1401)	Indigenous (n = 981)	Non-Indigenous (n = 1401)
Parents	8.4% (82)	9.7% (136)	1.1% (11)	1.2% (17)	0.2% (2)	0.4% (6)
Partner/spouse	0.2% (2)	0.3% (4)	0 (0)	0 (0)	0 (0)	0 (0)
Person(s) under 18 years	0.8% (8)	0.6% (8)	0.2% (2)	0.3% (4)	0 (0)	0.3% (4)
Persons over 18 years	6.4% (63)	6.4% (90)	2.5% (25)	3.0% (42)	3.1% (30)	3.0% (42)
Me	2.7% (26)	2.6% (36)	0.3% (3)	0.1% (2)	–	–
None	71.7% (703)	69.7% (977)	95.5% (937)	94.7% (1327)	96.4% (946)	96.3% (1349)

increased by 26.4% during the quarantine; however, 77.4% of the participants received an economic income (salary during the pandemic) and were from the medium–high socio-economic level, which allows them to access different food groups [58].

It is well known that the health status and the role of the immune system's defenses against diseases depend directly on the state of nutrition and the supply of nutrients to the body [62]. However, food insecurity in Latin America and the Caribbean grew from 31.9% to 40.9% during the pandemic, so the population faced obstacles in obtaining food, exacerbating malnutrition and comorbidities [63].

The higher risk of severe disease for individuals with some malnutrition is well known [10]. Remarkably, Mexico increased its moderate to severe food insecurity score by 3.5% during the pandemic [63, 64]. In 2021, the poverty rate for those aged 15 years and older was 37%, exacerbating the problem of access to food and attaining good nutritional status and, in turn, increasing complications from COVID-19 [65]. The most severe cases are the rural areas (most economically affected) and Indigenous communities who are deprived by not having essential tools such as access to clean water for continuous hand washing to prevent contagion. For example, according to the International Labor Organization (ILO), more than 86% of Indigenous people are engaged in informal employment compared to non-Indigenous groups, of whom 66% have stable employment and social protection. Lower wages contribute to poorer food intake and higher opportunities to become malnourished [66].

According to several studies, a specific supply of nutrients can aid the immune system in activating signaling cells and gene expression in the intestinal microbiota to define the body's immune reactions and deal with diseases such as COVID-19. As a result, macro and micronutrient deficiencies correlate with a predisposition to important ailments [10, 67, 68].

3.5 COVID-19 diagnosis

Our survey results indicated that relatives of the non-Indigenous group had an attack rate of lab-confirmed COVID-19 that was just slightly higher (8.6%) than that of the Indigenous group (5.2%) (Fig. 3). Furthermore, in both groups, around 4.1% (Indigenous) and 4.6% (non-Indigenous) reported hospitalization with COVID-19 among themselves, and 3.3% (Indigenous and 3.7% (non-Indigenous) reported mortality from COVID-19 complications among other individuals older than 18 years, parents, and relatives (Table 6). It is important to note that the cost of a PCR test for COVID-19 in Mexico

was 17 to 35 times the minimum wage until 2021, at which time the average cost in Hidalgo State was 32 times the minimum wage per month [69, 70]. Additionally, the shortage of equipment for diagnosis and the overload of patients in rural hospitals made timely diagnosis and treatment difficult to access for minorities and Indigenous groups [71].

3.6 COVID-19 prevention and vaccination

When asked about the prevention measures followed in the work/school environment, we did not find significant differences between the two groups. Most students (22.3% of Indigenous and 20.2% of non-Indigenous) reported following at least one of the suggested recommendations for handwashing, wearing a mask, and keeping an appropriate distance (Fig. 4).

In May 2021, the WHO and the ILO established different policies for preventing COVID-19 in schools, businesses, and work institutions that relied on essential personnel [72]. These recommendations were disseminated around the world through infographics on all media platforms. In Mexico, a campaign targeting Indigenous communities was carried out through radio. An informative guide was made that was translated into 51 versions of dialects. Suggestions of the WHO and Pan American Health Organization (PAHO) were heeded during the first wave at the highest peak of infections [66].

More than 70% of the Indigenous and non-Indigenous groups reported receiving seasonal flu vaccines yearly (Fig. 5A). In comparison, only 39.1% (95% CI 36.08, 42.28) and 43.1% (95% CI 40.50, 45, 75) of the Indigenous and non-Indigenous respondents, respectively, reported that their parents received the flu vaccine. Interestingly, this was correlated with their response regarding vaccination against COVID-19: 98% (95% CI 97.62, 98.72) of both groups reported having been vaccinated against COVID-19 (Fig. 5B). Nevertheless, it was reported that 36.6% (95% CI 33.57, 39.70) of their parents received COVID-19 vaccines for the Indigenous group and 39.9% (95% CI 37.32, 42.52) for the non-Indigenous group (Table 7).

Bazan and Akgün [73] reported that by mid-2021 in the US, only 1% of the fully vaccinated group was from the Indigenous population. In comparison, 63% of the fully vaccinated group came from the white population.

A cohort from Huehutla Puebla, Mexico, a locality in that state with a high percentage of Indigenous people, found that by the end of 2021, only 59.2% had been fully immunized. The rest of the unvaccinated population reported that the vaccine had not arrived in the locality, did not know about vaccination, or that essential information was unavailable in their Indigenous dialect [74].

González-Espinosa [75] mentions that self-description as an Indigenous person entails a discriminatory response in health services. According to the Mexican Ministry of Health, 70% of medical care for this group occurred on an

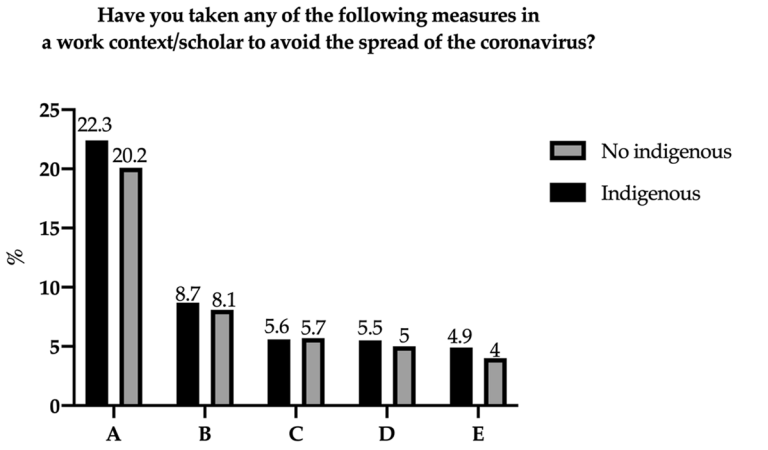

Fig. 4 Measures to avoid the spread of COVID-19

A.- Hand washing / Use disinfectant frequently / Be more careful with washing and cleaning / Protective equipment (mask) / Keep at least one meter from others.

B.- Use of telephone calls/videoconferences instead of physical meetings / Trip canceled or postponed / Conferences / physical meetings canceled or postponed / Keep at least one meter away from family members

C.- Less use of public transport than usual / Having had flexible work schedules to reduce density among employees

D.- Working from home more often than usual / Having had flexible work schedules to reduce the density between employees

E- Nothing

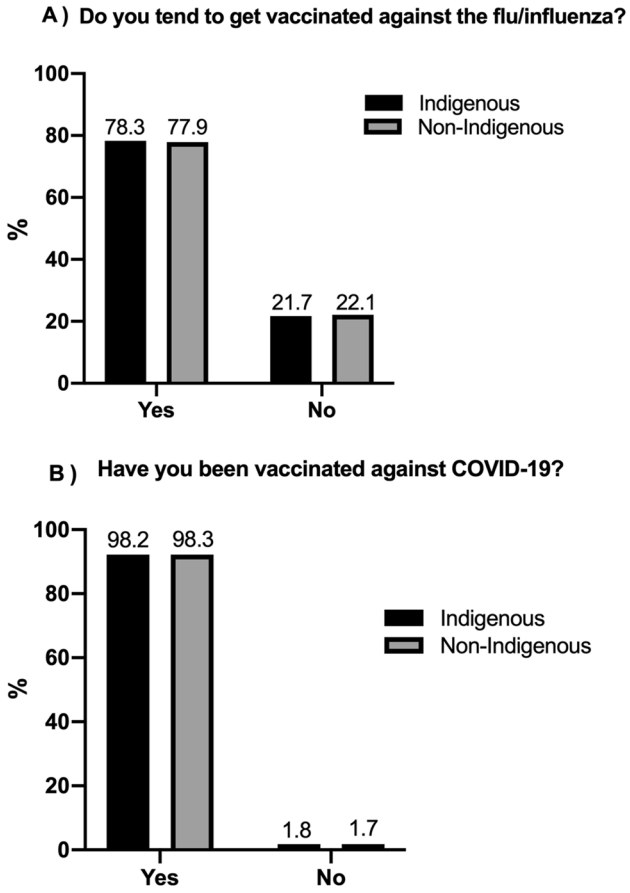

Fig. 5 Vaccination against flu/influenza and COVID-19 for the Indigenous and non-Indigenous groups. **A** Over 75% of both groups usually get vaccinated against flu/influenza yearly. **B** Over 98% of both groups had been vaccinated against COVID-19 in this study

Table 7 Vaccination against influenza/flu and COVID-19 among relatives of respondents

	Usually get the flu shot		Vaccinated against COVID-19	
	Indigenous (n = 981)	Non-Indigenous (n = 1401)	Indigenous (n = 981)	Non-indigenous (n = 1401)
Parents	384; 39.1% (36.08,42.28)	604; 43.1% (40.50,45,75)	359; 36.6% (33.57,39.70)	559; 39.9% (37.32,42.52)
Partner/spouse	5; 0.5% (0.17,1.19)	8; 0.6% (0.25,1.12)	8; 0.8% (0.35,1.60)	9; 0.6% (0.29,1.22)
Person(s) under 18 years	51; 5.2% (3.89,6.78)	49; 3.5% (2.60,4.60)	13; 1.3% (0.71,2.26)	13; 0.9% (0.50,1.58)
Persons over 18 years	67; 6.8% (5.33,8.59)	109; 7.8% (0.06,0.09)	62; 6.3% (4.88,8.03)	107; 7.6% (6.30,9.15)
Me	204: 20.8% (18.30,23.47)	299; 21.3% (19.22,23.58)	15; 1.5% (0.86,2.51)	29; 2.1% (1.39,2.96)

outpatient basis leading to higher percentages of complications and deaths from COVID-19 in households not notified in the surveillance system. The above has been associated with negative experiences in the healthcare system, leading people from these groups to generate mistrust and lack of treatment adherence [73].

Table 8 Multiple combination for question: What are the main reasons you have taken/will take the COVID-19 vaccine?

	Indigenous (n = 981)	Non-Indigenous (n = 1401)
The COVID-19 vaccine provides good protection against serious infections and illnesses	7.5% (74)	6.4% (90)
The COVID-19 vaccine provides good protection against severe infection and illness / Because of the amount of infection in society / The need to protect myself / The need to protect the family/community	5.6% (55)	5.1% (72)
The COVID-19 vaccine provides good protection against severe infection and illness / The need to protect myself / The need to protect the family/community	3.8% (37)	3.9% (54)
The COVID-19 vaccine protects against severe infection and illness/ Because of the amount of infection in society / The need to protect myself / The need to protect the family/community / Recommendation from healthcare professionals I trust / Recommendation of the health authorities/municipality / Recommendations from friends/relatives / Media attention/school requirement	3.6% (35)	2.3% (32)
The need to protect myself	2.2% (22)	3.1% (43)

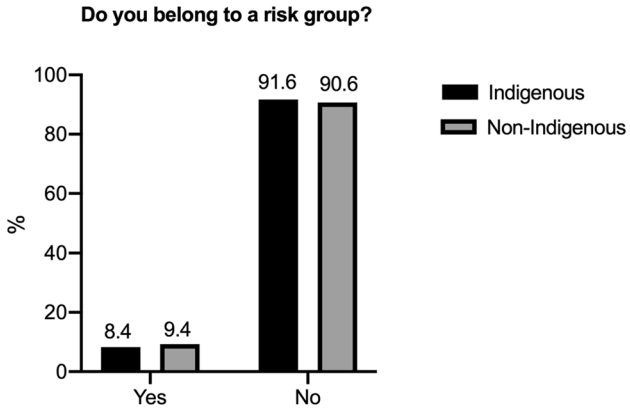

Fig. 6 Belong to a risk group. The percentage of Indigenous and non-Indigenous who belong to a risk group was low in this study

Table 9 To which risk group do you belong?

	Indigenous (n = 981)	Non-Indigenous (n = 1401)
None	90.4% (887)	91.1% (1276)
Lung disease	2.4% (24)	1.9% (26)
Diabetes	1.1% (11)	1.1% (16)
Heart disease	0.6% (6)	0.6% (9)

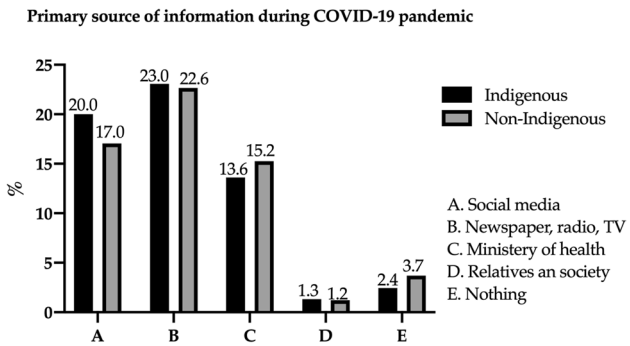

Fig. 7 Primary source of information in Indigenous and non-Indigenous groups

3.7 Reasons to get vaccinated

The reasons provided by the study group for accepting vaccination (Table 8) included having a means of protection against other comorbidities (7.5% of the Indigenous group and 6.4% non-Indigenous) since 8.4 and 9.4% respectively belong to some risk group (lung disease, diabetes, or heart disease) (Fig. 6 and Table 9).

Clinical data have shown that suffering from chronic conditions increases the risk and death from complications of COVID-19 [76–79].

3.8 Source of COVID-19 information

The COVID-19 pandemic has had repercussions on the world economy, the health systems of different countries, and the way news is transmitted nowadays. This study found that the largest source of information on COVID-19 came from social networks (7.2% for Indigenous and 7.4% for non-Indigenous), followed by newspapers, radio, and television channels (6.5% for Indigenous and 8.9% for non-Indigenous) (Fig. 7).

Table 10 Worrying too much about things?

	Indigenous (n = 981)	Non-Indigenous (n = 1401)
Not at all, a little	32.9% (323)	38.8% (543)
A little	27.1% (266)	24.1% (337)
Moderate	18.1% (178)	18.5% (259)
Moderate, Not at all	12.9% (127)	10.8% (151)

Table 11 Feelings/attitudes you might experience from the pandemic

	Indigenous (n = 981)	Non-Indigenous (n = 1401)
Nothing	34.1% (335)	36.2% (507)
Changes in sleep routine	3.5% (34)	3.4% (48)
Fear	1.0% (10)	0.9% (12)
Difficult concentrating	1.0% (10)	0.9% (13)
Anxiety	1.0% (10)	0.8% (11)
Anxiety and changes in sleep routine	1.0% (10)	0.9% (13)
Hopeless about the future	0.6% (6)	1.0% (14)

Venegas-Vera and colleagues [80] mention that the use of social networks increases in crises because of the speed with which one can obtain updated information, so during the COVID-19 pandemic, social networks became a real-time platform for data transmission. However, social networks were also the primary source of false information.

In Mexico, to guarantee a good communication agenda from the Government to the country on COVID-19 issues, the President, in turn, established a morning conference that began on February 29, 2020, with face-to-face access to journalists and the general population. The conference was also available on the Mexico President's social networks [81]. He also started a national registration campaign to allow the population to obtain the complete vaccination schedule through the official website of the Government of Mexico [82], but internet access continues to be a problem. According to Economic Commission for Latin America and the Caribbean (ECLAC), until 2020, 84% of the Indigenous population in Mexico did not have internet access [66]. Related to data from the National Survey on Availability of Information Technology in Homes, 49.6% of rural areas in Mexico do not have any connection to the Internet, 22.7% do not know how to use it, and 50.5% do not have the economic resources to obtain a smartphone that can connect to the Internet to access news, information, or registration [83].

Gómez Navarro and Martínez Domínguez [84] mention that each community in Chiapas, Oaxaca, Guerrero, and Veracrúz (States of México with a higher percentage of Indigenous) managed to find the channels to obtain truthful information independently of social networks. Strategies such as painting fences and handing out brochures or loudspeakers were methods for contacting populations where electricity services are lacking and, therefore, have more limited Internet access to platforms such as Facebook, Twitter, or YouTube.

3.9 Mental health

Few studies evaluate the impact of COVID-19 on mental health, specifically in rural communities or Indigenous inhabitants, and even less have focused on the Mexican population. The results presented below cannot be generalized to these groups. However, they offer valuable information that allows for dimensioning the situation and underscores the need to involve them in future studies.

Indigenous group responses indicated slightly higher levels of worry overall. For instance, 32.9% of Indigenous and 38.8% of non-Indigenous groups reported: "Not at all/a little" in response to the question" Worrying too much about things?" (Table 10). A change in sleep routine was the most significant issue reported in both groups (Table 11).

Quarantined people are most susceptible to depressive and anxiety symptoms as well as insomnia, and social isolation increases suicidal ideation [85].

Brotto and colleagues [86], reported that participants who identified as Indigenous had significantly more psychosocial symptoms than non-Indigenous participants. These differences were not observed before the pandemic, highlighting this impact on the population. Studies from Australia and Canada have also reported a high frequency of psychosocial symptoms among Indigenous participants during the pandemic [87, 88].

It has been pointed out that among the barriers to seeking mental health care are beliefs that the treatment is not effective, and access is difficult in general. There is a lack of information about treatments. Recognized barriers in the Indigenous population group are low schooling, low family income, and the shame of accepting a mental health problem. In addition to these barriers, in rural areas in Mexico, there are no specialized institutions for the care of these health problems, which implies that if a person needs them, the time and cost to access them increase considerably. Due to the lack of mental health care institutions in indigenous populations has appealed more frequently to healers or untrained professionals in this areas [89]. In addition, geographic isolation hinders the possibility of receiving adequate and timely diagnosis and treatment [90].

3.10 Opinion about the Mexican government's handling of the pandemic

Among the respondents, 29.7% of Indigenous and 32% of non-Indigenous respondents mentioned partially agreeing on how the Mexican Government handled the pandemic. Only 7.4% of Indigenous and 6.8% of non-Indigenous respondents disagreed with handling the pandemic even though Mexico experienced one of the highest death tolls in the world. A total of 11.5% reported not taking many measures during the COVID-19 pandemic, and 12.8% and 7.7% answered, respectively, leave it to God or fate to get sick or not (Table 12).

In a similar study carried out through an online questionnaire in 2020 by Adhena and Hiru [91], it was reported that 56.8% of the respondents mentioned that COVID-19 could be controlled by health systems worldwide, and 55.6% believed that their national health systems could control the pandemic. Altayb Mousa and colleagues [92] found that in the Sudan, although the population was aware of COVID-19, 50.7% decided not to use face masks when leaving home, and 30.1% did not use them even in crowded or unventilated areas. In Cameroon, 47% of participants preferred medical care at home and chose not to be tested. In Ethiopia, 90% of the surveyed medical community responded that they would not accept isolation in health care facilities if they became infected with COVID-19 [93].

In 2020, there were more than 90 million Catholics and about 30 denominations based on Christianity in Mexico [94, 95], and they continued to trust their faith. Trujillo Ríos [96] considers that faith in times of the COVID-19 pandemic gives people the "security" of being heard by God and the confidence that even chaos will find a way to make sense of any mess. Therefore, despite the scientific evidence on the decrease in contagion through prevention, 12.8% of the Indigenous population surveyed and 7.7% of non-Indigenous people continue to leave their health in God's hands.

Another factor that influenced the results on knowledge and attitudes toward COVID-19 is the low level of schooling among the Indigenous population. According to ECLAC, Mexico has only 28.9% of the Indigenous population between the ages of 20 and 29 who completed high school [97]. The latest data from the 2020 INEGI census mentioned that the illiteracy rate is 20.9% (35.6% for women and 17.8% for men), and the average schooling of the population aged 15 or over was 6.2 years [98].

Knowledge of the population and prevention measures against COVID-19 is the key to the control of the virus. However, there are still deficiencies in good practices, suggesting that health education intervention in the face of this pandemic must go beyond what was done to reach the most remote populations of the country.

4 Conclusion

There is a need to pursue research that provides distinct insights relevant to indigenous populations. To this end, we conducted the first cross-sectional descriptive study using data from a web survey to obtain information about attitudes and prevention on the COVID-19 pandemic in a predominantly Indigenous community in Huejutla Hidalgo, México. We found similar results between Indigenous and non-Indigenous groups, which is likely explained by the educational level of our population in a university setting. These results are in line with a previous study that found that university students tended to have good knowledge about transmission, prevention, and symptomology during the 2009 A/H1N1 influenza pandemic [99]. However, our results also suggest differences between our study sample and the broader community

Table 12 Opinion about the management and prevention of COVID-19

	Completely disagree		Somewhat disagree		Neither agree nor disagree		Somewhat agree		Completely agree		Do not know	
	IP (n = 981)	N-IP (n = 1401)	IP (n = 981)	N-IP (n = 1401)	IP (n = 981)	N-IP (n = 1401)	IP (n = 981)	N-IP (n = 1401)	IP (n = 981)	N-IP (n = 1401)	IP (n = 981)	N-IP (n = 1401)
I think the Health System of Mexico has done a good job with COVID-19	9.2% (90)	7.9% (111)	8.3% (81)	9.1% (127)	18.8% (184)	17.2% (241)	29.7% (291)	32.1% (450)	25.9% (254)	26.2% (367)	8.3% (81)	7.4% (104)
I trust that Mexican Government has done a good job the pandemic	7.4% (73)	6.8% (95)	9.7% (95)	8.4% (118)	19.3% (189)	18.0% (252)	32.1% (315)	34.8% (488)	23.1% (227)	22.5% (315)	8.4% (82)	9.4% (132)
There is / has been too little protest against the strict COVID-19 measures in México	6.5% (64)	4.8% (67)	9.5% (93)	7.8% (109)	24.7% (242)	25.0% (350)	23.5% (231)	25.3% (354)	10.5% (103)	10.7% (150)	25.3% (248)	26.4% (370)
Many people I know believe that the COVID-19 measures in Mexico are / have been too strict	11.3% (111)	12.5% (175)	15.4% (151)	16.2% (227)	25.9% (254)	25.5% (357)	20.8% (204)	19.1% (268)	9.3% (91)	8.8% (123)	17.3% (170)	17.8% (250)
I have tried to live as normally as possible during the pandemic without taking too many measures	20.9% (205)	22.0% (308)	19.6% (192)	18.1% (253)	20.9% (205)	19.8% (278)	19.7% (193)	19.1% (267)	11.5% (113)	11.6% (162)	7.4% (73)	9.4% (132)
I leave / have left it up to "superior powers" (God or fate) whether I get infected or not	40.2% (394)	39.1% (548)	11.2% (110)	11.4% (160)	20.3% (199)	19.3% (271)	8.2% (80)	9.4% (132)	7.3% (72)	7.8% (109)	12.8% (126)	12.8% (180)

IP Indigenous people

N-IP Non-Indigenous people

of our study setting. Specifically, our results suggest a substantially lower COVID-19 and influenza vaccination coverage among the parents of the student participants compared to the study population.

Regarding nutritional issues, further research is needed to understand better the BMI and weight increase by evaluating additional anthropometrics measures, improving food intake, and translating our findings into actual policies that benefit these vulnerable populations.

Some caveats in our study are worth noting. First, although we had the Indigenous student population represented in this cohort, it is not necessarily representative of all Indigenous university students from other institutions or people with an Indigenous background in this region of Mexico. Second, the participants provided the weight and height measurements at their discretion. On the other hand, our study's high response rate (71.6%) is a strength. Although the students were asked to participate voluntarily in the survey, the high response rate was probably influenced by the weekly reminders that the Academic Coordinator emailed to the students. In addition, studies examining the impact, attitudes, and prevention strategies surrounding COVID-19 in Indigenous populations are scarce. Our study is especially salient in that the percentage of students with Indigenous backgrounds is significant (41.2%). To the best of our knowledge, this is the first study in Mexico and among a few studies globally that have examined the public health effects of the COVID-19 pandemic among Indigenous university students.

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Author contributions Conceptualization: EJD, GC, SEM. Data curation: EJD, GC, SD. Formal Analysis: EJD, GC, SD. Investigation: EJD, SEM, GC. Methodology: EJD, SEM, GC. Project administration: EJD, GC. Resources: EJD, SEM, GC. Supervision: EJD, GC. Validation: EJD, GC. Visualization: EJD, SD, GC. Writing- original draft: EJD, GC. Writing- review and editing: EJD, AGRA, SD, JGM, LS, SEM, GC.

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Data availability The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Code availability Not applicable.

Declarations

Ethics approval and consent to participate Our study followed ethical standards, institutional regulations, national laws, and the Helsinki declaration. This study was based on data with no personal identifiers. Informed consent was obtained from all subjects. The voluntary submission of a completed survey by the participants was considered as consent to participate in the study. This study was approved by the Institutional Review Committee of the Universidad Tecnológica de la Huasteca Hidalguense.

Consent for publication Not applicable.

Competing interests All authors have read and approved the submitted version of the manuscript. We confirm that our manuscript is not under consideration elsewhere and declare no competing/conflicts of interest relating to this study.

References

1. Park M, Cook AR, Lim JT, Sun Y, Dickens BL. A systematic review of covid-19 epidemiology based on current evidence. J Clin Med. 2020;9:967.
2. United Nations. COVID-19 and indigenous peoples. Department of economic and social affairs. 2022. https://www.un.org/development/desa/indigenouspeoples/covid-19.html. Accessed 7 Jun 2022.
3. de León-Martínez LD, Palacios-Ramírez A, Rodriguez-Aguilar M, Flores-Ramírez R. Critical review of social, environmental and health risk factors in the Mexican indigenous population and their capacity to respond to the COVID-19. Sci Total Environ. 2020;733:139357.
4. Dahal S, Mamelund SE, Luo R, Sattenspiel L, Self-Brown S, Chowell G. Investigating COVID-19 transmission and mortality differences between indigenous and non-indigenous populations in Mexico. Int J Infect Dis. 2022;122:910–20.

5. Cohen JH, Mata-Sánchez ND. Challenges, inequalities and COVID-19: examples from indigenous Oaxaca, Mexico. Glob Public Health. 2021;16:639–49.
6. Dwyer J, O'Donnell K, Willis E, Kelly J. Equitable care for indigenous people: every health service can do it. Asia Pac J Health Manag. 2016;11:11–7.
7. Banco Mundial. Pueblos Indígenas. Banco Mundial. 2021. https://www.bancomundial.org/es/topic/indigenouspeoples. Accessed 7 Jun 2022.
8. Consejo Nacional Para Prevenir la Discriminación (CONAPRED), Gobierno de la Ciudad de Mexico. Pronunciamiento del 21 de febrero de 2021: Día Internacional de la Lengua Materna. Discriminación en contra de la población indígena en México. 2021. https://copred.cdmx.gob.mx/comunicacion/nota/pronunciamiento-del-21-de-febrero-de-2021-dia-internacional-de-la-lengua-materna. Accessed 13 Sep 2022.
9. Food and Agriculture Organization (FAO), International Found for Agriculture Development (IFAD), United Nations, World Health Organization, World Food Programme. El estado de la seguridad alimentaria y la nutrición en el mundo 2021. FAO; 2021.
10. Chatterjee P, Nirgude A, Chatterjee PK. Healthy eating – a modifiable contributor to optimize healthy living in the COVID-19 pandemic: a review. J Sci Food Agric. 2022;102:1751–8.
11. Lugo-Morin DR. Looking into the past to build the future: food, memory, and identity in the indigenous societies of Puebla, Mexico. J Ethnic Foods. 2022;9:7.
12. Instituto Nacional de Lenguas Indígenas, Cámara de Diputados. Catálogo de las lenguas indígenas nacionales: variantes lingüísticas de México con sus autodenominaciones y referencias geoestadísticas. Ciudad de México; 2018.
13. Instituto Nacional de Lenguas Indígenas, Gobierno de México. Contigo en la distancia. Mapa de la diversidad cultural de México, lenguas indígenas nacionales. 2012. https://site.inali.gob.mx/descargas/mapa_diversidad_cultural_mexico.pdf. Accessed 5 Aug 2022.
14. Instituto Nacional de Estadistica y Geografía. En México somos126 014 024 habitantes: Censo de población y vivienda 2020. Ciudad de México; 2021.
15. Consejo Nacional de Población. Proyecciones de la Población de México y de las Entidades Federativas, 2016–2050 y Conciliación Demográfica de México, 1950 -2015. Gobierno de México. 2018. https://www.gob.mx/conapo/acciones-y-programas/conciliacion-demografica-de-mexico-1950-2015-y-proyecciones-de-la-poblacion-de-mexico-y-de-las-entidades-federativas-2016-2050. Accessed 7 Jun 2022.
16. Instituto Nacional de Pueblos Indígenas. Indicadores Socioeconómicos de los Pueblos Indígenas de México, 2015. Gobierno de México. 2017. https://www.gob.mx/inpi/articulos/indicadores-socioeconomicos-de-los-pueblos-indigenas-de-mexico-2015-116128. Accessed 7 Jun 2022.
17. Instituto Nacional de Estadística y Geografía. Censo de población y vivienda 2022: Presentación de resultados del Estado de Hidalgo. Instituto Nacional de Estadística y Geografía. 2020. https://www.inegi.org.mx/contenidos/programas/ccpv/2020/doc/cpv2020_pres_res_hgo.pdf. Accessed 7 Jun 2022.
18. Instituto Nacional de Estadística y Geografía. Panorama sociodemográfico de Hidalgo: Censo de Población y Vivienda 2020. Aguascalientes, Aguascalientes; 2021.
19. Alves DE, Mamelund SE, Dimka J, Simonsen L, Mølbak M, Ørskov S, et al. Indigenous peoples and pandemics. Scand J Public Health. 2022;50:662–7.
20. Instituto Nacional de Estadística y Geografía. Encuesta Intercensal 2015. Ciudad de México; 2015.
21. Fernández Ham P. Indígenas de sociedades contemporáneas: retos estadísticos. Ciudad de México; 2010.
22. Cámara de Diputados, Secretaría General, Secretaría de los Servicios Parlamentarios. Constitución Política de los Estados Unidos Mexicanos . México; 1917.
23. United Nations. The concept of indigenous peoples. New York; 2004.
24. Muñoz-Torres V, Bravo-García E, Magis-Rodríguez C. Letalidad por COVID-19 en la población indígena de México. Ciudad de México; 2020.
25. Romero S, Caryn Rabin R, Walker M. How the Pandemic Shortened Life Expectancy in Indigenous Communities. The Coronavirus Pandemic. 2022.
26. Diaz E, Dimka J, Mamelund S-EM. Disparities in the offer of COVID-19 vaccination to migrants and non-migrants in Norway: a cross sectional survey study. Res Sq. 2022;22:1–12.
27. Alberto Rascón-Pacheco R, del Carmen Candia-Plata M, Margarita Rivera-Icedo B, Elena Romero-Arredondo M, Rosa Brito-Zurita O, Guerrero-Romero F. Codificación geométrica y análisis de conglomerados para evaluar el control metabólico de pacientes con diabetes mellitus tipo 2.
28. Cámara de Diputados. La definición de indígena en el ámbito internacional. Ciudad de México; 2003.
29. González Hermida AE, Villa Diaz J, Guerra Cabrera CE, Quintero Rodríguez O, Dorta Figueroa M, Danilo Pacheco J. Nutritional condition of school age children. Clinic, anthropo-medical and alimentary assessment. Rev Electrón Cienc Méd Cienfuegos. 2010;8:15–22.
30. Lozada-Tequeanes AL, García-Guerr A, Mejía-Rodrígue F, Arenas AB. Stunting and overweight in children under 5y who inhabit the Sierra Tarahumara in northern Mexico. Arch Latinoam Nutr. 2021;71:252–60.
31. Rivera JA, Monterrubio E, González-Cossío T, García-Feregrino R, García-Guerra A, Sepúlveda-Amor J. Estado nutricional de los niños indígenas menores de cinco años de edad enMéxico: resultados de una encuesta nacional probabilística. Salud Publica Mex. 2003;4:S466–76.
32. Madueño Paulette R. La Huasteca hidalguense: pobreza y marginación social acumulada.
33. Gomashie GA. Bilingual youth's language choices and attitudes towards Nahuatl in Santiago Tlaxco, Mexico. J Multiling Multicult Dev. 2022;43:182–93.
34. Yang S, Guo B, Ao L, Yang C, Zhang L, Zhou J, et al. Obesity and activity patterns before and during COVID -19 lockdown among youths in China. Clin Obes. 2020;10: e12416.
35. Caroppo E, Mazza M, Sannella A, Marano G, Avallone C, Claro AE, et al. Will nothing be the same again?: Changes in lifestyle during COVID-19 pandemic and consequences on mental health. Int J Environ Res Public Health. 2021;18:8433.
36. Paciera Di Zoppolo Y, Melo Freyle J, Niño Restrepo JD, Quintero Brito L, Vázquez Martinez AA. Behavioral changes in the practice of physical activity and nutritional consumption in the population of the colombian Guajira in the cotext of the Covid-19 pandemic. 1st ed. Colombia: EDUFISADRED; 2020.

37. Panciera-Di-Zoppola Y, Niño-Restrepo J, Melo-Freile J, Ortiz-Moncada R. Levels of physical activity in the adult population of La Guajira, Colombia: a focus on ethnicity. Front Public Health. 2021;8:610679.
38. Secretaria de Salud, Gobierno de México. Sana distancia COVID-19. Jornada Nacional de Sana Distancia. 2020. https://www.gob.mx/salud/documentos/sana-distancia. Accessed 10 Aug 2022.
39. Instituto Nacional de Estadística y Geografía. Censo 2020: Característica de los hogares. Instituto Nacional de Estadística y Geografía. 2020. https://www.inegi.org.mx/temas/hogares/. Accessed 8 Jun 2022.
40. Instituto Nacional de Estadística y Geografía. Hogares: vivimos en hogares diferentes. Instituto Nacional de Estadística y Geografía. 2020. https://cuentame.inegi.org.mx/poblacion/hogares.aspx?tema=P. Accessed 8 Jun 2022.
41. Suárez Domínguez JL, Vazquez Feria AG. Cultural capital and internal migration trajectories of recently enrolled students at the Universidad Veracruzana. Apuntes. 2021;48:115–39.
42. Ahmad K, Erqou S, Shah N, Nazir U, Morrison AR, Choudhary G, et al. Association of poor housing conditions with COVID-19 incidence and mortality across US counties. PLoS ONE. 2020;15(11): e0241327.
43. Dahal S, Luo R, Swahn MH, Chowell G. Geospatial variability in excess death rates during the COVID-19 pandemic in Mexico: examining socio demographic, climate and population health characteristics. Int J Infect Dis. 2021;113:347–54.
44. Hu M, Roberts JD, Azevedo GP, Milner D. The role of built and social environmental factors in Covid-19 transmission: a look at America's capital city. Sustain Cities Soc. 2021;65:102580.
45. Lan FY, Wei CF, Hsu YT, Christiani DC, Kales SN. Work-related COVID-19 transmission in six Asian countries/areas: a follow-up study. PLoS ONE. 2020;15: e0233588.
46. Baker MG, Peckham TK, Seixas NS. Estimating the burden of United States workers exposed to infection or disease: a key factor in containing risk of COVID-19 infection. PLoS ONE. 2020;15: e0232452.
47. World Health Organization. Coronavirus disease (COVID-19). World Health Organization. 2022. https://www.who.int/health-topics/coronavirus#tab=tab_1. Accessed 8 Jun 2022.
48. Sharma A, Ahmad Farouk I, Lal SK. Covid-19: A review on the novel coronavirus disease evolution, transmission, detection, control and prevention. Viruses. 2021;13:202.
49. Shen J, Duan H, Zhang B, Wang J, Ji JS, Wang J, et al. Prevention and control of COVID-19 in public transportation: Experience from China. Environ Pollut. 2020;266:115291.
50. Shukla N, Pradhan B, Dikshit A, Chakraborty S, Alamri AM. A review of models used for investigating barriers to healthcare access in Australia. Int J Environ Res Public Health. 2020;17:1–19.
51. Pammer K, Freire M, Gauld C, Towney N. Keeping safe on australian roads: overview of key determinants of risky driving, passenger injury and fatalities for indigenous populations. Int J Environ Res Public Health. 2021;18:1–16.
52. Jordan M, Tiako N, Stokes DC. Who is biking for? Urban bikeshare networks' responses to the COVID-19 pandemic, disparities in bikeshare access, and a way forward. Yale J Biol Med. 2021;94:159.
53. Shamah-Levy T, Rivera-Dommarco J, Cuevas-Nasu L, Romero-Martínez M, Gaona-Pineda EB, Gómez-Acosta LM, et al. Encuesta Nacional de Salud y Nutrición 2020 sobre Covid-19 Resultados nacionales. Cuernavaca, Morelos, México; 2020.
54. Enriquez-Martinez OG, Martins MCT, Pereira TSS, Pacheco SOS, Pacheco FJ, Lopez K, v, et al. Diet and lifestyle changes during the COVID-19 pandemic in Ibero-American Countries: Argentina, Brazil, Mexico, Peru, and Spain. Front Nutr. 2021;8:671004.
55. Espinoza-Ortega A, Martínez-García CG, Rojas-Rivas E, Fernández-Sánchez Y, Escobar-López SY, Sánchez-Vegas L. Consumer and food changes in Mexican households during maximal contingency in the COVID-19 pandemic. Int J Gastron Food Sci. 2021;24:100357.
56. Martínez-Vázquez SE, Ceballos-Rasgado M, Posada-Velázquez R, Hunot-Alexander C, Nava-González EJ, Ramírez-Silva I, et al. (2021) Perceived diet quality, eating behaviour, and lifestyle changes in a mexican population with internet access during confinement for the covid-19 pandemic: Escan-covid19mx survey. Nutrients. 2021;13:4256.
57. Cámara de Diputados, Secretaría de Educación Pública, Secretaría de Gobernación. ACUERDO número 02/03/20 por el que se suspenden las clases en las escuelas de educación preescolar, primaria, secundaria, normal y demás para la formación de maestros de educación básica del Sistema Educativo Nacional, así como aquellas de los tipos medio superior y superior dependientes de la Secretaría de Educación Pública. Ciudad de México; 2022.
58. Pye C, Sutherland S, Martín PS. Fruit, vegetable and legume consumption among adult residents of eastern Santiago, Chile: effects of the covid-19 confinement? Rev Chil Nutr. 2021;48:374–80.
59. Terrones Cordero A, Sánchez Torres Y, Vázquez Rojas AM. Estrategias de desarrollo participativas para Huejutla de Reyes Hidalgo, México. Rev Cimexus. 2019;14:213–34.
60. Czerny M, Macowsky J. Estudio de caso: Huejutla de Reyes Hidalgo. Gac Mex Adm Pública Estatal Munic. 1986;22–23:141–50.
61. Centro de Investigación en Nutrición y Salud IN de SPPM de A. Estudio sobre el efecto de la contingencia por COVID-19 en el consumo y compra de alimentos. Instituto Nacional de Salud Pública. 2020. https://www.insp.mx/dieta-covid. Accessed 20 Jun 2022.
62. Ravasco P, Anderson H, Mardones F, Ravasco P. Methods of valuation of the nutritional condition. Nutr Hosp Supl. 2010;3:57–66.
63. Pereira M, Oliveira AM. Poverty and food insecurity may increase as the threat of COVID-19 spreads. Public Health Nutr. 2020;23:3236–40.
64. Organización de las Naciones Unidas para la Alimentación y la Agricultura (FAO), Organización Panamericana de la Salud (OPS), el Fondo Internacional de Desarrollo Agrícola (FIDA), Programa Mundial de Alimentos (WFP), Fondo de las Naciones Unidas para la Infancia (UNICEF), Organización Mundial de la Salud Oficina Regional de las Américas (OMS). América Latina y el Caribe - Panorama regional de la seguridad alimentaria y nutricional 2021: Estadísticas y tendencias. FAO, FIDA, OPS, WFP y UNICEF; 2021.
65. Castillo C, Marinho ML. Los impactos de la pandemia sobre la salud y el bienestar de niños y niñas en América Latina y el Caribe: La urgencia de avanzar hacia sistemas de protección social sensibles a los derechos de la niñez. Santiago de Chile; 2022.
66. Comisión Económica para América Latina y el Caribe (CEPAL). El impacto del COVID-19 en los pueblos indígenas de América Latina-Abya Yala: Entre la invisibilización y la resistencia colectiva. Santiago de Chile; 2020.
67. de Faria C-R, Corgosinho FC, Sanches FLFZ, Prado CMM, Laviano A, Mota JF. Dietary recommendations during the COVID-19 pandemic. Nutr Rev. 2021;79:382–93.
68. Shakoor H, Feehan J, Al Dhaheri AS, Ali HI, Platat C, Ismail LC, Apostolopoulos V, Stojanovska L, et al. Immune-boosting role of vitamins D, C, E, zinc, selenium and omega-3 fatty acids: could they help against COVID-19? Maturitas. 2021;143:1–9.

69. Secretaría del Trabajo y Previsión Social, Gobierno de México. Entra en vigor incremento al salario mínimo del 22%: Comunicado 001/2022. Secretaría del Trabajo y Previsión Social. 2022. https://www.gob.mx/stps/prensa/entra-en-vigor-incremento-al-salario-minimo-del-22?idiom=es. Accessed 21 Jun 2022.
70. CHOPO laboratorios. Detección COVID-19 por PCR. Detección de SARS COV-2 RNA (COVID-19) por PT-PCR. 2022. https://www.chopo.com.mx/metro/deteccion-covid-19-por-pcr. Accessed 6 Sep 2022.
71. Nicola M, Alsafi Z, Sohrabi C, Kerwan A, Al-Jabir A, Iosifidis C, et al. The socio-economic implications of the coronavirus pandemic (COVID-19): A review. Int J Surg. 2020;78:185–93.
72. World Heatlh Organization. Preventing and mitigating COVID-19 at work: policy brief. 2021.
73. Bazan IS, Akgün KM. COVID-19 Healthcare Inequity: Lessons Learned from Annual Influenza Vaccination Rates to Mitigate COVID-19 Vaccine Disparities. 2021.
74. Parra-Torres NM, Bautista-Hernández G, Techalotzi-Amador A, Almonte-Becerril M. Vaccination against COVID-19 and its coping from the perspective of three native peoples from the northeastern highlands of Puebla. Mexico Aten Primaria. 2022;54:102316.
75. González-Espinosa JF. Native's vaccinations in front of Covid-19. Logos Bol Cient Esc Prep. 2022;2(8):4–6.
76. Das S, Anu KR, Birangal SR, Nikam AN, Pandey A, Mutalik S, et al. Role of comorbidities like diabetes on severe acute respiratory syndrome coronavirus-2: a review. Life Sci. 2020;258:118202.
77. Lima-Martínez MM, Carrera Boada C, Madera-Silva MD, Marín W, Contreras M. COVID-19 and diabetes: a bidirectional relationship. Clin Investig Arterioscler. 2021;33:151–7.
78. Fang X, Li S, Yu H, Wang P, Zhang Y, Chen Z, et al. Epidemiological, comorbidity factors with severity and prognosis of COVID-19: a systematic review and meta-analysis. Aging. 2020;12:12493–503.
79. Ejaz H, Alsrhani A, Zafar A, Javed H, Junaid K, Abdalla AE, et al. COVID-19 and comorbidities: deleterious impact on infected patients. J Infect Public Health. 2020;13:1833–9.
80. Venegas-Vera AV, Colbert GB, Lerma EV. Positive and negative impact of social media in theCOVID-19 era. Rev Cardiovasc Med. 2020;21:489–92.
81. Llano Guibarra NI, Aguila Sánchez JC. Conferencias de prensa y COVID-19: explorando la respuesta gubernamental mexicana desde la comunicación en salud. Rev Esp Comun Salud. 2020. https://doi.org/10.20318/recs.2020.5451.
82. Cortés Alcalá R, Gómez Torres R, Alba Ricaño X, López-Gatell Ramírez H, Alcocer Varela JC. Política nacional de vacunación contra el virus SARS-CoV-2 para la prevención de la COVID-19 en México. Documento rector. Ciudad de México: Constitución Política de los Estados Unidos Mexicanos; 2021.
83. Instituto Nacional de Estadística y Geografía, Instituto Federal de Telecomunicaciones. En México hay 84.1 millones de usuarios de internet y 88.2 millones de usuarios de teléfonos celulares: ENDUTIH 2020. Ciudad de México; 2021.
84. Gómez Navarro DA, Martínez Domínguez M. Brechas digitales en indígenas en tiempos de COVID-19. Ichan Tecolotl. 2020. https://ichan.ciesas.edu.mx/brechas-digitales-indigenas-en-tiempos-de-covid-19-2/. Accessed 27 Jun 2022.
85. Amerio A, Brambilla A, Morganti A, Aguglia A, Bianchi D, Santi F, et al. Covid-19 lockdown: housing built environment's effects on mental health. Int J Environ Res Public Health. 2020;17:1–10.
86. Brotto LA, Chankasingh K, Baaske A, Albert A, Booth A, Kaida A, et al. The influence of sex, gender, age, and ethnicity on psychosocial factors and substance use throughout phases of the COVID-19 pandemic. PLoS ONE. 2021;22:1–22.
87. Arriagada P, Hahmann T, O'Donnell V. Indigenous people and mental health during the COVID-19 pandemic. STATCAN COVID-19: Data to Insights for a Better Ca. 2022. https://www150.statcan.gc.ca/n1/pub/45-28-0001/2020001/article/00035-eng.pdf. Accessed 17 Jul 2022.
88. Newby JM, O'Moore K, Tag S, Christensen H, Faasse K. Acute mental health responses during the COVID-19 pandemic in Australia. PLoS One. 2020;15: e0236562.
89. Medina-Mora M. La epidemiología de la salud mental en México. CONADIC. 2001. Pp. 6–9.
90. Salgado de Snyder VN, de Díaz-Pérez Ma J. Los trastornos afectivos en la población rural. Salud Mental. 1999;22:68.
91. Adhena G, Hidru HD. Knowledge, attitude, and practice of high-risk age groups to coronavirus disease-19 prevention and control in korem district, tigray, Ethiopia: Cross-sectional study. Infect Drug Resist. 2020;13:3801–9.
92. Altayb Mousa KNA, Saad MMY, Tayseer Bashir Abdelghafor M. Knowledge, attitudes, and practices surrounding COVID-19 among Sudan citizens during the pandemic: an online cross-sectional study. Sudan J Med Sci. 2020;15:32–45.
93. Nwagbara UI, Osual EC, Chireshe R, Bolarinwa OA, Saeed BQ, Khuzwayo N, et al. Knowledge, attitude, perception, and preventative practices towards COVID-19 in sub-Saharan Africa: A scoping review. PLoS ONE. 2021;16: e0249853.
94. Instituto Nacional de Estadística y Geografía. Clasificación de religiones 2020. 2020.
95. Instituto Nacional de Estadística y Geografía. Población católioca en México. INEGI. 2020. https://www.inegi.org.mx/temas/religion/. Accessed 28 Jun 2022.
96. Trujillo Ríos JE. Accompany in times of pandemic. Med Rev. 2021;8:79–89.
97. Comisión Económica para América Latina y el Caribe (CEPAL), Fondo para el Desarrollo de los Pueblos Indígenas de América Latina y el Caribe (FILAC). Los pueblos indígenas de América Latina-Abya Yala y la Agenda 2030 para el Desarrollo Sostenible Tensiones y desafíos desde una perspectiva territorial. Santiago de Chile; 2020.
98. Instituto Nacional de las Mujeres. Indigenous people. Ciudad de México; 2021.
99. Keller JJ, Kim JH, Lau JCH, Wong AH, Griffiths SM. Intention to engage in preventive behaviors in response to the A/H1N1 pandemic among university entrants in four Chinese cities. Asia Pac J Public Health. 2014;26:42–7.