Introduction

The COVID-19 pandemic has highlighted the serious social inequities that exist between countries and societies. Among the groups most vulnerable to this disease are the Indigenous populations around the world (Power et al., 2020). Although Indigenous peoples represent 6.2% of the world’s population, they make up about 15% of people living in extreme poverty, and their life expectancy is up to 20 years lower than that of non-Indigenous people (Grupo Banco Mundial, 2015; International Labour Organization, 2019). In Latin America, where some 58 million Indigenous people live, this same pattern of inequality is reproduced (Comisión Económica para América Latina y el Caribe, 2020).

During the first year of the pandemic, Latin American governments focused their interventions on urban populations, who speak the dominant languages, showing little interest in designing strategies aimed at the Indigenous and rural populations (Meneses-Navarro et al., 2020). In Mexico, the population that speaks an Indigenous language constitutes 6.1% of the total population. However, 19.4% of the population self-identifies as Indigenous (Instituto Nacional de los Pueblos Indígenas, 2017). This sector of the Mexican population, as in all of Latin America, is characterized by high levels of poverty, lack of access to basic services, and poor health and living conditions and has historically faced barriers to accessing health services.

The Mexican Indigenous population is concentrated, to a greater extent, in the central and southern regions of the country, mainly in rural areas with less than 2,500 inhabitants. This population group has the highest levels of poverty and social deprivation in the country. According to the Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL), in 2018, 74.9% of the Indigenous language-speaking population was in poverty, while in the rest of the population this percentage was 39.4%. The same agency points out that the proportion of people living in extreme poverty is five times higher among the Indigenous population than among the non-Indigenous population (CONEVAL, 2019).
Social deprivation is accentuated among the Mexico’s Indigenous population in almost all of its dimensions. In 2018, the percentage of the Indigenous population with educational backwardness was 31.1%, while in the non-Indigenous population it was 15.4%. In terms of housing conditions, deprivations related to quality and space affected 28.5% of the Indigenous population, compared with 9.2% of the non-Indigenous population. Similarly, while 57.5% of the Indigenous population lacked access to basic services, only 15.7% of the non-Indigenous population did not have access to these services. Finally, the percentage of the Indigenous population without access to food was 31.5%, compared with 19.2% for the non-Indigenous population (CONEVAL, 2019).

The pattern of isolation and dispersion that characterizes the Indigenous communities determines, among other factors, the type of health services to which this sector has access. Within the Mexican health care system, health care consumers are classified into three main categories: (a) The uninsured, who are covered by the services of the Ministry of Health. These services are offered to the uninsured in urban and rural areas throughout the country; (b) Those with social security. Under Mexican law, all formal sector workers must belong to a social security institution; and (c) Those covered by the private sector (Organización Panamericana de la Salud [OPS], 2002). The majority of the Indigenous population is not affiliated with any of the state social security institutions such as the Mexican Social Security Institute or the Social Security and Services Institute for State Workers. While the former is a tripartite organization financed partly by the federal government and partly by employers and workers, the latter is a public institution with its own legal personality and assets that is financed by the federal government, as well as by workers (OPS, 2002). These institutions provide their beneficiaries with medical care and health facilities at all levels of health care (Instituto Nacional de Estadística y Geografía [INEGI], 2012; Programa de Naciones Unidas para el Desarrollo [PNUD], 2010). The hospitals, clinics, and health centers to which most of this sector of the population has access depend on the Ministry of Health, state services, or some government programs (Leyva-Flores et al., 2014). In general, the care offered by these agencies is of lower quality and does not cover the full spectrum of treatments and interventions. This situation is especially worrisome considering the double burden of disease and inequity that affects the Indigenous population (Pelcastre-Villafuerte et al., 2020).

In general, there are differences between the Indigenous and non-Indigenous populations in terms of access, availability, timeliness, and quality of health services provided (CONEVAL, 2019). In addition, the Mexican health care system has several structural deficiencies, in particular, its lack of adaptation to the country’s linguistic diversity, the ethnic discrimination to which the Indigenous population is often subjected, and the concentration of specialty hospitals and national health institutes in metropolitan areas and large cities (Cortez-Gómez et al., 2020).

Several studies have shown that Mexico has been affected by excess mortality due to the COVID-19 pandemic (Dahal et al., 2021). Obesity, particularly when combined with other comorbidities, was found to be a strong risk factor for short-term mortality and severe disease in Mexican patients with COVID-19 (Vera-Zertuche et al., 2021). The interaction between comorbidities and age shapes the diversity of the risk of severe COVID-19 outcomes (Clark et al., 2020). The high prevalence of multimorbidity, the presence of two or more chronic conditions simultaneously, in the Mexican population is a serious mortality risk for those infected with severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) (Carrillo-Vega et al., 2020). The high prevalence of metabolic syndrome, characterized by low high-density lipoprotein-cholesterol levels, central obesity, hypertension, and elevated triglycerides, among the Mexican Indigenous population is well documented (Mendoza-Caamal et al., 2020). The Indigenous population is exposed to social, environmental, and health factors that hinder the application of preventive health measures or aggravate the development of the disease in the event of contagion (Díaz de León-Martínez et al., 2020).

Previous research shows that the COVID-19 fatality rate (proportion of deaths due to COVID-19 among infected individuals) is higher among the Mexican Indigenous population than among non-Indigenous Mexicans (Argoty-Pantoja et al., 2021). Among Mexicans with COVID-19, not only are the odds of dying higher among Indigenous than among non-Indigenous people, but also Indigenous deaths from COVID-19 were mostly associated with outpatient care, even adjusting for health care sector, suggesting poor access to health care services (Ibarra-Nava et al., 2021).

There are three criteria to determine who is considered an Indigenous person in Mexico: (a) speak an Indigenous language; (b) self-identify as Indigenous; and (c) living in a household in which one of the members speaks an Indigenous language. The first criterion is the one traditionally used. However, it excludes people with Indigenous traditions who have lost the use of the Indigenous language. The National Institute of Statistics and Geography considers the first two criteria as valid. The third one is used by the National Commission for the Development of Indigenous People (Consejo para Prevenir y Eliminar la Discriminación en la Ciudad de México, 2021).

Previous studies on the mortality risk of the Mexican Indigenous population only consider a person to be Indigenous if he or she speaks an Indigenous language (Argoty-Pantoja et al., 2021; Horbath Corredor, 2021; Ibarra-Nava et al., 2021; Serván-Mori et al., 2022), thus limiting the number of Indigenous people analyzed (Horbath Corredor, 2021) and losing information from those who do not speak an Indigenous language but consider themselves Indigenous.

Unlike previous studies, this study used a broader definition of what is considered an Indigenous person according to which the Indigenous population is composed of both speakers of an Indigenous language and those who
do not speak an Indigenous language but consider themselves Indigenous. Thus, using the broader definition of Indigenous population, the objective of this study is to compare the risk of COVID-19-related mortality among the Indigenous and non-Indigenous Mexican population one and a half years after the onset of the pandemic.

**Data and methods**

This study used open access data compiled and published by the General Directorate of Epidemiology of the Ministry of Health of the Federal Government of Mexico (Ministry of Health, 2021). The database used in this study contains information collected between March 18, 2020, and September 16, 2021.

The information in the database generated by the Ministry of Health comes from two different sources: (a) the Epidemiological Surveillance System for Viral Respiratory Disease. This system retrieves information on hospitalizations, laboratory tests, and deaths from 5,186 units which include 475 units of monitoring respiratory diseases across the country; and (b) the information of suspected or confirmed COVID-19 cases reported by any medical facility (Ministry of Health, 2022). The information provided by the system includes sociodemographic data, such as age, sex, area of residence, health services used, and information on whether the individual speaks an Indigenous language, as well as whether he or she considers himself or herself to be Indigenous. The system also provides information on hospitalizations, intensive care units use, and seven chronic conditions: asthma, cardiovascular disease, chronic kidney disease, chronic obstructive pulmonary disease, diabetes, hypertension, and immunosuppression, as well as whether or not the individual was considered obese. It also includes information on the date of symptoms onset, date of entry into the system, laboratory test results, and date of death if applicable (Ministry of Health, 2022).

The persons registered in the database generated by the Ministry of Health are classified as follows: (a) case of COVID-19 confirmed by clinical-epidemiological association (the case is a direct contact of a person registered in the system as positive to COVID-19); (b) case of COVID-19 confirmed by an evaluation committee—applies to deaths in which the case was not sampled for a reverse transcription-polymerase chain reaction (RT-PCR) laboratory test or an antigenic test or the case was sampled, but the sample was found to be invalid; (c) case of COVID-19 confirmed by an RT-PCR laboratory test or an antigenic test that was positive for severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), the coronavirus causing COVID-19; (d) case with invalid laboratory results—the case has neither clinical-epidemiological association nor COVID-19 evaluation and an RT-PCR laboratory sample that was found to be invalid; (e) case not analyzed by a laboratory—the case has neither clinical-epidemiological association nor COVID-19 evaluation, and a laboratory sample was obtained but not analyzed; (f) suspected case—the case has neither clinical-epidemiological association nor COVID-19 evaluation, and an RT-PCR laboratory sample was not obtained or the laboratory sample is still being analyzed; and (g) SARS-CoV-2-negative case confirmed by an RT-PCR laboratory test or antigenic test (Ministry of Health, 2022).

Between March 18, 2020, and September 16, 2021, the database generated by the Ministry of Health recorded information on 10,294,713 persons, of whom 95.1% (9,790,141) were classified as either being a confirmed COVID-19 case by clinical-epidemiological association, by an evaluation committee, or by an RT-PCR or antigen test or being a confirmed negative COVID-19 case by an RT-PCR or antigen test; the remainder were cases with invalid laboratory results, cases not analyzed by laboratory or suspected cases. Among those who were confirmed as positive or negative COVID-19 cases, according to the definitions cited above, 3,548,724 individuals (36.2%) were diagnosed with COVID-19. Of those diagnosed with COVID-19, 1.0% (36,217) were Indigenous according to our broader definition. Of those who identified themselves as Indigenous, 42.5% do not speak an Indigenous language, and 19.3% of those who speak an Indigenous language do not identify themselves as Indigenous. Henceforth, when reference is made to Indigenous status, it is understood that the broadest definition is used.

**Study design and population**

The study population is composed of those individuals who, between March 18, 2020, and September 16, 2021, were registered in the database and were diagnosed with COVID-19—confirmed by clinical-epidemiological association, by an evaluation committee, or by an RT-PCR or antigen test. We conducted a longitudinal analysis using parametric methods to assess the effect of being Indigenous on the risk of COVID-19-related death. We defined COVID-19-related deaths as those who had a positive diagnosis for SARS-CoV-2 and died on or before September 16, 2021.

**Covariates**

The variables of interest were: Indigenous (dichotomous: yes, no); age (continuous); sex (dichotomous: male, female); area of residence (dichotomous: metropolitan, non-metropolitan); health service (three categories: Ministry of Health, social security, private); obesity (dichotomous: obese, non-obese); and number of chronic conditions (three categories: 0 chronic conditions, 1 chronic condition, and 2 or more chronic conditions—multimorbidity). This last covariate was constructed using information provided by the database on the seven chronic conditions mentioned above. To avoid missing cases, we added a missing data category for the variables number of chronic conditions and obesity status. Since we only consider individuals with a positive diagnosis for COVID-19, we also defined, for a given part of the analysis, a variable determining the type of patient (dichotomous: outpatient, hospitalized), and for those who were hospitalized, an indicator of whether they were admitted to an intensive care unit (dichotomous: yes, no).
Statistical analysis

Descriptive statistics were performed stratifying by Indigenous and non-Indigenous status. We used Student’s t-tests for equality of proportions. Kaplan–Meier survival estimates were calculated for Indigenous and non-Indigenous individuals. We used a set of three nested Gompertz proportional hazards regression models (A, B, and C) to estimate the risk of COVID-19-related mortality in the Indigenous population compared with the non-Indigenous population. Model A only adjusts for the main variable, the Indigenous status. Model B adds sociodemographic variables of age, sex, area of residence, and type of health services to Model A. Finally, Model C adds, to Model B, health variables and health-related variables with information on known mortality risk factors for COVID-19—number of chronic conditions, and obesity status. For Kaplan–Meier and Gompertz analyses, time to death was calculated as the days between the date of symptom onset and the date of death. For censored cases, time was calculated from the date of symptom onset to the date of the last update of the data used, September 16, 2021. All analyses were performed using Stata 16.1. All p values were two-tailed; p values < .05 were considered statistically significant.

Results

The analytical sample used in this study comprises 3,545,952 Mexicans who, according to the General Directorate of Epidemiology, were diagnosed as being infected with SARS-CoV-2 between March 18, 2020 and September 16, 2021, and have information on all variables of interest. This cohort represents 99.99% of those originally diagnosed with COVID-19, of which 1.0% (36,195) are Indigenous.

Characteristics of individuals in the analytical sample are shown in Table 1. In our sample, Indigenous individuals are older than their non-Indigenous counterparts, and in both groups, individuals in the sample are more likely to be female than male. However, the proportion of males is higher among the non-Indigenous population than among the Indigenous population. The majority of Indigenous people reside in a non-metropolitan area. In addition, Indigenous people are more likely to be beneficiaries of health services provided by the Ministry of Health than non-Indigenous people. The opposite is true for health services provided by social security and the private sector. The proportion of individuals with obesity and suffering from one chronic condition is higher among the Indigenous population, as is the prevalence of multimorbidity. A higher proportion of Indigenous people than non-Indigenous people were hospitalized and, once hospitalized, a higher proportion of Indigenous individuals were admitted to an intensive care unit. The proportion of Indigenous deaths was higher than that of the non-Indigenous population. A similar result was found among outpatients. However, among those who were hospitalized, there was no difference between Indigenous and non-Indigenous people in the proportion of deaths, with a same result for those admitted to an intensive care unit (Table 1).

| Table 1. Characteristics of the Mexican Indigenous and non-Indigenous populations diagnosed with COVID-19 between March 18, 2020, and September 16, 2021. |
|----------------------------------|------------------|------------------|------------------|------------------|
| Age, M (SD)                      | Indigenous (n = 36,195) | Non-Indigenous (n = 3,509,757) | p value       | Total (n = 3,545,952) |
| Sex                              | 45.16 (18.46)                  | 41.37 (17.13)                  | <.001       | 41.40 (17.16)                  |
| Male (%)                        | 49.93                          | 52.24                          | <.001       | 49.96                          |
| Female (%)                      | 50.07                          | 47.76                          | <.001       | 50.04                          |
| Area of residence               |                                |                                |             |                               |
| Non-metropolitan (%)            | 63.66                          | 18.88                          | <.001       | 19.33                          |
| Metropolitan (%)                | 36.34                          | 81.12                          | <.001       | 80.67                          |
| Health service                  |                                |                                |             |                               |
| Ministry of Health (%)          | 77.43                          | 54.61                          | <.001       | 54.84                          |
| Social security (%)             | 21.06                          | 42.60                          | <.001       | 42.38                          |
| Private insurance (%)           | 1.51                           | 2.79                           | <.001       | 2.77                           |
| Obesity                         |                                |                                |             |                               |
| Yes (%)                         | 15.78                          | 12.41                          | <.001       | 12.44                          |
| No (%)                          | 84.08                          | 87.59                          | <.001       | 87.36                          |
| Missing (%)                     | 0.14                           | 0.20                           | .019        | 0.20                           |
| Number of CC                    |                                |                                |             |                               |
| 0 CC (%)                        | 70.63                          | 77.22                          | <.001       | 77.36                          |
| 1 CC (%)                        | 18.89                          | 14.78                          | <.001       | 14.83                          |
| 2+ CC (multimorbidity) (%)      | 10.12                          | 7.67                           | <.001       | 7.70                           |
| Missing (%)                     | 0.36                           | 0.33                           | .202        | 0.32                           |
| Deaths                          |                                |                                |             |                               |
| Yes (%)                         | 12.46                          | 7.51                           | <.001       | 7.56                           |
| No (%)                          | 87.54                          | 92.49                          | <.001       | 92.44                          |

(Continued)
Between March 18, 2020 and September 16, 2021, there were 268,121 deaths of persons diagnosed with COVID-19, among which 12.5% (4,511) were Indigenous compared with 7.5% (263,610) of individuals of non-Indigenous origin (Table 1). These figures point to a disproportionate number of COVID-19-related deaths among the Indigenous population. As expected, Kaplan–Meier curves show that the probability of dying was at all times higher among the Indigenous population than among their non-Indigenous counterparts, with a steep slope particularly in the first month of symptom onset when the bulk of the deaths occurred. On the contrary, the flat tail in the Kaplan–Meier curves responds to the fact that after the first months of symptoms onset deaths were very rare (Figure 1).

**Table 1.** (Continued)

|                  | Indigenous | Non-Indigenous | p value | Total           |
|------------------|------------|----------------|---------|-----------------|
| **Patient**      |            |                |         |                 |
| Outpatient (%)   | 74.65      | 84.31          | <.001   | 84.21           |
| Hospitalized (%) | 25.35      | 15.69          | <.001   | 15.79           |
| Outpatients      |            |                |         |                 |
| (n = 27,018)     | (n = 2,959,047) |            |         | (n = 2,986,065) |
| **Deaths**       |            |                |         |                 |
| Yes (%)          | 1.71       | 0.78           | <.001   | 0.71            |
| No (%)           | 98.29      | 99.22          | <.001   | 99.29           |
| Hospitalized     |            |                |         |                 |
| (n = 9,177)      | (n = 550,710) |            |         | (n = 559,887)   |
| **Deaths**       |            |                |         |                 |
| Yes (%)          | 44.11      | 44.11          | 1.000   | 44.11           |
| No (%)           | 55.89      | 55.89          | 1.000   | 55.89           |
| Intensive care unit |       |                |         |                 |
| Yes (%)          | 9.82       | 7.75           | <.001   | 7.78            |
| No (%)           | 89.18      | 91.36          | <.001   | 91.32           |
| Missing (%)      | 1.00       | 0.89           | .266    | 0.90            |
| Intensive care unit |       |                |         |                 |
| (n = 901)        | (n = 42,685) |            |         | (n = 43,586)    |
| **Deaths**       |            |                |         |                 |
| Yes (%)          | 57.49      | 55.82          | .318    | 55.85           |
| No (%)           | 42.51      | 44.18          | .318    | 44.15           |

SD: standard deviation; CC: chronic conditions.

*p value: Student’s t-test for the difference in percentages, or means, between Indigenous and non-Indigenous individuals.

Table 2 shows that among Indigenous people the risk of dying is about 73.0% higher compared with non-Indigenous people (Model A). Adjusting the model for sociodemographic characteristics (age, sex, area of residence, type of health service) decreases the risk of death among individuals in the Indigenous population by 22.0% (Model B). However, further adjustment of the model for pre-existing health conditions, shown to worsen COVID-19 outcomes (number of chronic conditions and obesity), does not change the risk of death among individuals in the Indigenous population which remains about 52.0% higher than among individual in the non-Indigenous population (Model C).

In addition, the analysis shows that, as expected, being male and being obese independently increase the COVID-19-related mortality risk by 63.0% and 50.0%, respectively. Furthermore, also as expected, having multimorbidity doubles the risk of COVID-19-related death.

Results also show the effect of living in a metropolitan area compared with living in a non-metropolitan area (Table 2). The reduction in mortality risk associated with living in a metropolitan area, between 11.0% and 14.0%, according to the model, could be considered a counterintuitive result, since it was precisely in large cities that the pandemic broke out most strongly and then spread to other regions of the country. However, although the concentration of the population in metropolitan areas implies a higher risk of contagion, they also have the best health infrastructures and the best access to medical institutions.

The fact that the use of health services provided by social security more than doubles the risk of COVID-19-related...
death deserves a detailed explanation. Early in pandemic, a national hospital conversion strategy was put in place to meet the demand for medical services in a timely manner. This strategy considered all public sector medical units, including social security institutions, which were obligated to receive patients with COVID-19 symptoms, regardless of their insurance status (Cisneros & González, 2021). Social Security institutions as a whole have a greater number not only of hospital beds, but also of beds in intensive care units, so that during the most intense phases of the pandemic they attended the most severe patients (PNUD, 2020). In this sense, the differences in mortality risk can be attributed more to the fact that the social security health services attended to the most severe patients than to the quality of care provided in the different sectors (Sánchez-Talanquer, 2020).

To further analyze the disparity in mortality risks between Indigenous and non-Indigenous populations we estimated the complete model stratifying by type of patient. Our results show that, among outpatients, the mortality risk of Indigenous individuals is more than double that of non-Indigenous individuals, and that among hospitalized patients, the mortality risk of Indigenous people is 3.0% higher than that of non-Indigenous people (Table 3). Although the risk of death among inpatients is substantially lower than among outpatients, this risk is still significantly higher for Indigenous individuals than for their non-Indigenous counterparts. This finding may indicate that access to poor health care services is partly responsible for the higher mortality risk found among Indigenous patients, both outpatients and inpatients. However, it has been widely documented how the conditions of discrimination and isolation faced by the Indigenous population have an impact on the delay of timely medical care, which can aggravate the medical condition of Indigenous persons infected by COVID-19.

To find out whether differential access to health care services is responsible for the difference in COVID-19-related mortality risk between Indigenous and non-Indigenous individuals, we estimated the full model stratifying by health service sector (Table 4).
Table 3. Gompertz models: risk of death among Mexicans who were diagnosed with COVID-19 between March 18, 2020, and September 16, 2021, by patient type.

|                     | Outpatients (n = 2,986,065) | Hospitalized (n = 559,887) |
|---------------------|-----------------------------|-----------------------------|
|                     | RR 95% CI                   | RR 95% CI                   |
| Indigenous          |                             |                             |
| No (Ref.)           | 1.00                        | 1.00                        |
| Yes                 | 2.20*** [2.00, 2.41]        | 1.03* [1.00, 1.07]          |
| Age                 | 1.08*** [1.08, 1.08]        | 1.03*** [1.03, 1.03]        |
| Sex                 |                             |                             |
| Female (Ref.)       | 1.00                        | 1.00                        |
| Male                | 2.03*** [1.97, 2.09]        | 1.22*** [1.21, 1.23]        |
| Area of residence   |                             |                             |
| Non-metropolitan (Ref.) | 1.00                    | 1.00                        |
| Metropolitan        | 0.91*** [0.88, 0.94]        | 1.01 [0.99, 1.02]           |
| Health service      |                             |                             |
| Ministry of Health (Ref.) | 1.00                    | 1.00                        |
| Social security     | 3.07*** [2.98, 3.15]        | 1.17*** [1.16, 1.18]        |
| Private insurance   | 1.24*** [1.13, 1.34]        | 0.44*** [0.43, 0.45]        |
| Number of CC        |                             |                             |
| 0 CC (Ref.)         | 1.00                        | 1.00                        |
| 1 CC                | 1.66*** [1.60, 1.72]        | 1.14*** [1.13, 1.15]        |
| 2+ CC (multimorbidity) | 2.55*** [2.46, 2.64]      | 1.27*** [1.25, 1.28]        |
| Missing             | 3.97*** [3.22, 4.90]        | 1.27*** [1.19, 1.35]        |
| Obesity             |                             |                             |
| Non-obese (Ref.)   | 1.00                        | 1.00                        |
| Obese              | 1.76*** [1.70, 1.82]        | 1.13*** [1.12, 1.15]        |
| Missing             | 2.18*** [1.85, 3.00]        | 1.12* [1.03, 1.23]          |
| Constant            | 0.00*** [0.00, 0.00]        | 0.00*** [0.00, 0.00]        |
| Gamma               | −0.06*** [−0.06, −0.06]     | −0.05*** [−0.05, −0.05]     |

RR: relative risk; 95% CI: 95% confidence interval; Ref.: reference category; CC: chronic conditions.

*p < .05; **p < .001.

Table 4. Gompertz models: risk of death among Mexicans who were diagnosed with COVID-19 between March 18, 2020, and September 16, 2021, by health service.

|                     | Ministry of Health (n = 1,944,768) | Social Security (n = 1,502,833) | Private (n = 98,301) |
|---------------------|------------------------------------|---------------------------------|----------------------|
|                     | RR 95% CI                          | RR 95% CI                       | RR 95% CI            |
| Indigenous          |                                    |                                 |                      |
| No (Ref.)           | 1.00                               | 1.00                            | 1.00                 |
| Yes                 | 1.61*** [1.55, 1.67]               | 1.12*** [1.06, 1.18]            | 1.17                 |
| Age                 | 1.06*** [1.06, 1.06]               | 1.07*** [1.07, 1.07]            | 1.06*** [1.05, 1.06] |
| Sex                 |                                    |                                 |                      |
| Female (Ref.)       | 1.00                               | 1.00                            | 1.00                 |
| Male                | 1.87*** [1.84, 1.90]               | 1.51*** [1.50, 1.53]            | 1.78*** [1.68, 1.89] |
| Area of residence   |                                    |                                 |                      |
| Non-metropolitan (Ref.) | 1.00                  | 1.00                           | 1.00                 |
| Metropolitan        | 0.66*** [0.65, 0.67]               | 1.1*** [1.09, 1.12]            | 0.67*** [0.62, 0.72] |
| Number of CC        |                                    |                                 |                      |
| 0 CC (Ref.)         | 1.00                               | 1.00                            | 1.00                 |
| 1 CC                | 1.81*** [1.78, 1.84]               | 1.56*** [1.54, 1.58]            | 2.13*** [1.99, 2.29] |
| 2+ CC (multimorbidity) | 2.54*** [2.50, 2.59]       | 2.03*** [2.00, 2.05]            | 2.88*** [2.67, 3.40] |
| Missing             | 2.57*** [2.34, 2.82]               | 2.31*** [2.10, 2.54]            | 2.18*** [1.64, 2.89] |
| Obesity             |                                    |                                 |                      |
| Non-obese (Ref.)   | 1.00                               | 1.00                            | 1.00                 |
| Obese              | 1.89*** [1.86, 1.92]               | 1.33*** [1.32, 1.35]            | 1.46*** [1.36, 1.57] |
| Missing             | 2.55*** [2.28, 2.86]               | 0.72*** [0.63, 0.82]            | 0.51*** [0.35, 0.73] |
| Constant            | 0.00*** [0.00, 0.00]               | 0.00*** [0.00, 0.00]            | 0.00*** [0.00, 0.00] |
| Gamma               | −0.06*** [−0.06, −0.06]            | −0.06*** [−0.06, −0.06]         | −0.04*** [−0.04, −0.04] |

RR: relative risk; 95% CI: 95% confidence interval; Ref.: reference category; CC: chronic conditions.

***p < .001.
Table 4 shows that, among those who received medical care offered by the Ministry of Health, the risk of death is 61.0% higher among Indigenous individuals than among their non-Indigenous counterparts. This risk is 49.0% higher than that of those Indigenous people who have access to social security services. Although among those served by the private health sector there is no difference in the risk of COVID-19 mortality between Indigenous and non-Indigenous people, the regression coefficient has the same direction than for the other health care sectors (Table 4). These results could support the hypothesis that much of the difference in the risk of COVID-19-related death between Indigenous and non-Indigenous populations is due to the fact that the Indigenous population mostly does not have health insurance or is only affiliated to the public sector, which offers a lower quality service than the health care service offered by the private sector. When receiving adequate medical care, for example, having access to an intensive care unit, if necessary, there is no difference in the risk of COVID-19 mortality between Indigenous and non-Indigenous individuals, even considering other risk factors (Table 4), as is the case with the private health sector.

**Table 5.** Gompertz models: risk of death among Mexicans who were diagnosed with COVID-19 between March 18, 2020, and September 16, 2021, and were hospitalized, by ICU admission.

| No ICU (n = 511,289) | ICU (n = 43,586) |
|---------------------|------------------|
| RR                  | 95% CI           | RR              | 95% CI          |
| Indigenous          |                  |                 |
| No (Ref.)           | 1.00             | 1.00            |
| Yes                 | 1.05*** [1.01, 1.08] | 1.01 [0.93, 1.11] |
| Age                 | 1.03*** [1.03, 1.03] | 1.02*** [1.02, 1.02] |
| Sex                 |                  |                 |
| Female (Ref.)       | 1.00             | 1.00            |
| Male                | 1.22*** [1.21, 1.23] | 1.15*** [1.12, 1.18] |
| Area of residence   |                  |                 |
| Non-metropolitan (Ref.) | 1.00          | 1.00            |
| Metropolitan        | 1.01* [1.00, 1.02] | 0.98 [0.95, 1.01] |
| Health service      |                  |                 |
| Ministry of Health (Ref.) | 1.00      | 1.00            |
| Social security     | 1.26*** [1.25, 1.27] | 0.91*** [0.88, 0.93] |
| Private insurance   | 0.31*** [0.29, 0.32] | 0.49*** [0.47, 0.51] |
| Number of CC        |                  |                 |
| 0 CC (Ref.)         | 1.00             | 1.00            |
| 1 CC                | 1.13*** [1.12, 1.15] | 1.10*** [1.06, 1.13] |
| 2+ CC (multimorbidity) | 1.27***       | 1.19*** [1.15, 1.23] |
| Missing             | 1.28*** [1.19, 1.38] | 1.07 [0.92, 1.24] |
| Obesity             |                  |                 |
| Non-obese (Ref.)   | 1.00             | 1.00            |
| Obese               | 1.12*** [1.11, 1.13] | 1.10*** [1.07, 1.13] |
| Missing             | 1.14*** [1.03, 1.26] | 0.95 [0.78, 1.16] |
| Cons                | 0.00*** [0.00, 0.00] | 0.01*** [0.01, 0.01] |
| Gamma               | −0.06*** [−0.06, −0.06] | −0.04*** [−0.04, −0.04] |

ICU: intensive care unit; RR: relative risk; 95% CI: 95% confidence interval; Ref.: reference category; CC: chronic conditions.
*p < .05; **p < .01; ***p < .001.

**Discussion and conclusion**

As seen in the statistical analysis, the risk of COVID-19-related mortality is disproportionately higher among the Indigenous population than among the non-Indigenous population. This result is consistent with other studies using data from Latin America and elsewhere that show that the Indigenous population is more vulnerable to COVID-19 infection and mortality (Mendes et al., 2021; Millalen et al., 2020; Raifman & Raifman, 2020; Santos et al., 2020). Our results show that Indigenous individuals have a higher risk of COVID-19-related mortality than their non-Indigenous counterparts, regardless of age, sex, area of residence, health service, number of chronic diseases, and obesity status, characteristics noted in the literature as risk factors associated with COVID-19 mortality (Caramelo et al., 2020; Gutiérrez & Bertozzi, 2020; Peña et al., 2021; Rashedi et al., 2020; Wolff et al., 2021).

These results suggest that there are certain characteristics of Indigenous people that are not included in the set of risk factors commonly associated with COVID-19 mortality. These include: the structural poverty and lack of infrastructure that prevail in Indigenous communities; the linguistic and cultural barriers that hinder interaction with the rest of the population; and the settlement and mobility
patterns typical of some ethnic groups (Díaz de León-Martínez et al., 2020). All these aspects, historically rooted in Mexican society, increase the vulnerability of the Indigenous population to the pandemic.

However, our results identify some factors that explain the differences in mortality risk between both populations. Such is the case of the type of access to the health care system and the type of care the patient receives. In Mexico, most of the Indigenous population is not affiliated to the social security system, so most of them are treated in public institutions that provide health services to the general population (Pelcastre-Villafuerte et al., 2020). In general, these institutions suffer from serious deficiencies in terms of infrastructure and equipment, in addition to not covering the full spectrum of treatments and interventions.

The difference in the risk of death between the Indigenous population that received care in clinics or hospitals under the Ministry of Health and those treated in social security services shows the impact that the particular conditions of each institution have on the quality of care. The fact that the risk of death in Indigenous and non-Indigenous populations is the same when using private health services reinforces this conclusion. However, due to the magnitude and sign of the regression coefficient, this result may be a statistical artifact due to the small percentage of Indigenous people with access to the private health sector.

Deficiencies in the health services to which the majority of the Indigenous population has access probably explain the differences in mortality risk associated with both outpatient and inpatient care. The conditions of dispersion and isolation that characterize Indigenous localities limit timely access to health services offered by first level medical units, where ambulatory services are provided. In addition, it is worth mentioning the linguistic and cultural barriers that, together with the mobility restrictions that prevailed during the first phase of the pandemic, affected the adequate delivery of health services.

Several reports show that the public health measures issued by the federal government to the entire population in the context of the COVID-19 emergency lacked a culturally relevant approach. Information was not translated into Indigenous languages and was not disseminated through appropriate channels. Limited access to the Internet and mass media prevented the Indigenous population in isolated rural areas from learning about infection prevention and epidemic control measures (Cortez-Gómez et al., 2020).

In addition, it is important to consider that Mexican second and third level hospital units are concentrated in the urban areas of the country’s main cities. For example, the 33 hospital units that during the first phase of the pandemic were designated as COVID hospitals, that is, dedicated exclusively to the care of infected persons, and the 5 national institutes of medical specialties that adapted special areas to care for the seriously ill were located in cities belonging to a metropolitan area. However, it should be considered that people living in semi-urban or rural municipalities with high poverty rates, in addition to difficulties in timely access to health services, are exposed to critical situations in terms of social deprivation, nutritional status, and incidence of multimorbidities so that in case of infection their probability of dying is higher (Hernández, 2020). This result suggests that metropolitan areas, despite higher infection rates, are less vulnerable than municipalities far from large urban centers, where social deprivations are greater and health infrastructure is scarce (Suárez-Lastra et al., 2020). Moreover, this result may also indicate that, in the event of health complications, the Indigenous population residing in rural areas has greater difficulty in accessing a hospital bed or intensive care unit care unit in a timely manner (Campos & Balam, 2020).

On the one hand, the strengths of this study lies in the database used. Unlike previous studies on the difference in mortality risk associated with COVID-19 between Indigenous and non-Indigenous populations in Mexico, which analyzed data from the beginning of the pandemic, this study uses data collected during one and a half years into the pandemic. This same fact allowed us to broaden the definition of what is considered an Indigenous person as those who speak an Indigenous language or consider themselves to be Indigenous, given that it was until the end of October 2020 that the information on self-definition as an Indigenous person was released (Horbath Corredor, 2021). With this definition we avoid losing information of those who do not speak an Indigenous language but consider themselves Indigenous, as well as those who, trying to avoid stigmatization, do not identify themselves as Indigenous.

On the other hand, the limitations of this study are also related to the database used. The data were collected primarily through the Mexican sentinel surveillance system to identify and record possible cases of pulmonary infectious diseases, so it only provides information on individuals seeking medical care. Consequently, asymptomatic and mildly symptomatic individuals may not be part of the data set. The data set does not provide information on economic status, for example, level of education, which limits the scope of the statistical analysis. Furthermore, there is evidence that the number of deaths may be underreported (Lozano, 2021). These limitations probably imply that our results are underestimating the risk of COVID-19-related mortality among Indigenous peoples.

Despite these limitations, our results add new evidence that the difference in the risk of COVID-19-related mortality between the Indigenous and the non-Indigenous population is associated with structural factors related to inequity independently of the risk factors reported in the medical literature. Our results underscore the need to design public policies that guarantee the Indigenous population access to and availability of quality and culturally appropriate medical services. The COVID-19 pandemic only highlights the accumulated inequalities that the Indigenous populations historically faced.

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