Social inequalities in COVID-19 lethality among Indigenous peoples in Mexico

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Abstract *This study aimed to estimate the COVID-19 lethality in the Mexican Indigenous population from 2020 to 2022, considering clinical characteristics and social conditions. Data were retrieved from the Epidemiological Surveillance System of Respiratory Diseases, identifying the COVID-19-positive cases among the Indigenous population. Lethality was evaluated per clinical conditions and vulnerability due to social deprivation. The number of COVID-19-positive cases in the Indigenous population represented 0.7% of the total number of cases. The case fatality rate in the Indigenous population was 9.8% against 4.6% in the non-Indigenous population. Lethality was higher in men. However, the association with diabetes, hypertension, chronic kidney disease, obesity, and smoking was lower in the Indigenous population than in the non-Indigenous population. A greater vulnerability to social conditions was identified among the Indigenous population than the non-Indigenous population, mainly regarding income, education, and access to health services.*
Key words *COVID-19, Indigenous Peoples, Fatality Rate, Social Determinants of Health*

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Introduction

Approximately 476 million indigenous people are estimated worldwide, representing 6% of the world's population. In Latin American countries, approximately 50 million people are Indigenous, corresponding to 8% of the population, distributed mainly in countries such as Mexico, Guatemala, Peru, and Bolivia. Most of them live in extreme poverty and social marginalization[1-3].

According to Mexico's 2020 National Population Census, the Indigenous population, identified as those who descend from native or ancestral populations or preserve Indigenous peoples' traditions or customs, totals 11,800,247 individuals, equivalent to 9.4% of the country's total population; 50.5% are distributed in the states of Oaxaca, Chiapas, Yucatán, and Guerrero. Around 52% of the Indigenous population lives in rural communities (less than 2,500 inhabitants)[4].

Indigenous populations often bear social and economic conditions that increase their vulnerability to diseases[5,6]. They tend to live in isolated or poorly connected communities, with limited and poor-quality access to health services, which, in the context of a pandemic such as that caused by COVID-19, leads to a delay in seeking medical care, complicating timely diagnosis and treatment and increasing the risk of complications and mortality.

During the COVID-19 pandemic in Mexico, prevention strategies were implemented to break transmission chains. A vaccination plan was implemented, prioritizing older adults, healthcare staff, and people with comorbidities. However, no specific actions were aimed at the Indigenous population beyond disseminating health promotion and prevention information in native languages. This population was not considered a priority group for vaccination against COVID-19, besides an increase in access barriers to health services that led to higher mortality from other conditions[7].

Several studies have analyzed mortality due to COVID-19[8-15]. However, no studies have been conducted in Mexico determining the disease's lethality, especially in this specific social group. This is important because mortality refers to the number of people who die due to a disease in the general population. In contrast, lethality refers to the proportion of people who die among confirmed cases of disease and provides a measure of the severity of the disease among diagnosed cases, which allows assessing the risk of severe or fatal complications associated with the disease and reflects the detection capacity, availability, accessibility, and quality of medical care and not only by the disease prevalence.

COVID-19 fatality rates varied widely across countries in the Americas. In Peru, the reported fatality rate was 9.1%, while in Bolivia, it reached 6.2% at the onset of the pandemic. In Brazil, the fatality rate in 2022 was 15.4%, the highest in the region. Among the Indigenous population, some studies report that the fatality rate was 53.3% at the hospital level and up to 4.03% in the community in Brazil, while in Colombia, it reached 3.41%[16-19].

For this reason, this study aimed to estimate the lethality due to COVID-19 in the Indigenous population in Mexico from 2020 to 2022, considering the clinical characteristics and their social conditions.

Methods

A cross-sectional study was conducted considering the COVID-19-positive cases and the deaths that occurred due to this disease in the Indigenous population reported in the 2020-2022 period by the General Directorate of Epidemiology of the Mexican Ministry of Health[20].

People whose final classification issued by health authorities was confirmed by epidemiological association were classified as COVID-19-positive cases; that is, when the case reported being a contact of a COVID-19 positive case (and is registered in the Epidemiological Surveillance System for Respiratory Diseases) even when the case did not have a sample or the sample was invalid; those confirmed by ruling in deaths where the case did or did not have a sample taken, or a sample was taken, but was invalid; or when a laboratory sample or antigen test was available, and it was positive for SARS-CoV-2.

The number of deaths from COVID-19 was calculated considering all people who tested positive for the disease as the denominator to assess the lethality of the disease. The study population was classified per their Indigenous status. Age was classified into two groups (up to 60 years, 60 years and above), considering those over 60 as the most vulnerable population. Clinical characteristics such as pneumonia, diabetes, hypertension, asthma, chronic obstructive pulmonary disease (COPD), immunosuppression, cardiovascular diseases, obesity, chronic kidney disease, and obesity were studied. The type of institution of

the National Health System that provided the care was not considered since care in the services was provided regardless of whether or not people were assigned to any public service where they were treated during the pandemic.

Regarding the social conditions associated with COVID-19 lethality in the Indigenous population, the economic and social deprivations defined by the National Council for the Evaluation of Social Development Policy (CONEVAL) were considered per the federal entity of habitual residence[21]. The deprivations studied included vulnerability due to economic deprivation, educational backwardness, access to health services, access to social security, housing quality and space, and lack of access to fundamental housing services, such as access to water, drainage service, electricity, and type of fuel used for cooking. Finally, access to nutritious and quality food was analyzed and identified when households have moderate or severe food insecurity.

The percentage values of the population with these conditions at the state level were obtained from the latest report published by CONEVAL (2020) and were subsequently classified into quintiles.

The statistical analysis performed for the clinical variables consisted of a descriptive analysis, the prevalence odds ratio (POR) was calculated, contrasting the deaths among Indigenous and non-Indigenous people. Subsequently, logistic regression was performed considering the statistically significant variables and those with biological plausibility concerning the disease regardless of the p-value. Regarding social deprivation conditions, the odds ratio was estimated using a Poisson regression considering the number of deaths in the Indigenous population as the dependent variable, while the independent variables were each of the social deprivations studied, taking quintile 1 as a reference, which represents the group with the lowest deprivation. The statistical package Stata version 16 was employed for the statistical analysis.

This study analyzed secondary sources of information available to the public. No primary data were collected for this analysis, so prior submission to an ethics committee was not required.

Results

A total of 7,285,192 COVID-19-positive cases were reported during the period analyzed, of which 0.7% occurred in the Indigenous popula-

tion. In both groups, a higher number of cases occurred in men.

The most frequent clinical conditions in positive cases were hypertension (11.9%), obesity (9.6%), and diabetes (8.8%). These conditions were even more frequent among the Indigenous population. Deaths from COVID-19 among Indigenous and non-Indigenous people showed no differences regarding gender (p=0.633) or diabetes (p=0.650). Deaths in Indigenous people aged 65 and above were higher than in non-Indigenous people (p<0.001), as was obesity (p<0.0001). However, hypertension (p<0.001), cardiovascular diseases (p=0.020), and chronic kidney disease were more frequent among non-Indigenous people. The clinical conditions in Indigenous and non-Indigenous groups are shown in Table 1.

The fatality rate in the general population was 4.6%, and 9.8% in the Indigenous population. By gender, men were more likely to die than women in the Indigenous and non-Indigenous populations, 74% and 88%, respectively. Case fatality from COVID-19 associated with diabetes was higher among non-Indigenous people (ORp=7.31; 95%CI=7.26-7.37) than among Indigenous people (ORp=4.68; 95%CI=4.39-4.98). The same situation occurred with hypertension, chronic kidney disease, obesity, and cardiovascular disease (Table 2).

The analysis of social deprivations showed a gradient with a higher lethality due to COVID-19 as educational backwardness increases among the population, which is more evident among Indigenous people, where the most vulnerable quintile is three times more likely to die from COVID-19 than the least vulnerable group.

On the other hand, higher mortality from COVID-19 was associated with vulnerability due to lack of income, mainly among quintiles 3 and 4. Lack of access to health services affected all strata. However, it increased in the most vulnerable sectors. Security access did not show significant differences between the groups, except in the most vulnerable quintile, where it was a protective factor. No significant association was found regarding reported deaths with deprivations in the quality of housing or fundamental services (Table 3).

Discussion

During the COVID-19 pandemic, the most vulnerable social groups had limitations in performing disease containment actions, such as rein-

Table 1. Characteristics associated with COVID-19 positivity and death by Indigenous status in Mexico, 2020-2022.

Characteristics	COVID-19-positive			Deaths by COVID-19		
	Non-Indigenous N (%)	Indigenous N (%)	P-value*	Non-Indigenous N (%)	Indigenous N (%)	P-value*
Sex						
Female	3,860,259 (53.37)	26,771 (51.14)	<0.001	125,734 (38.5)	1,985 (38.8)	0.633
Male	3,372,586 (46.63)	25,576 (48.86)		201,140 (61.5)	3,131 (61.2)	
Age group						
Up to 60 years	6,283,457 (86.9)	41,619 (79.5)	<0.001	205,126 (62.8)	3,336 (65.2)	<0.001
60 years and above	949,389 (13.1)	10,728 (20.5)		121,748 (37.2)	1,780 (34.8)	
Pneumonia						
Yes	513,258 (7.1)	7,923 (15.1)	<0.001	232,938 (71.3)	4,008 (21.7)	<0.001
No	6690788 (92.9)	44,419 (84.9)		93,914 (28.7)	1,108 (21.7)	
Diabetes						
Yes	629,251 (8.7)	7,189 (13.8)	<0.001	119,914 (36.9)	1,894 (37.2)	0.650
No	6580905 (91.3)	45033 (86.2)		205,282 (63.1)	3,199 (62.8)	
COPD						
Yes	48,342 (0.7)	949 (1.8)	<0.001	14,288 (4,4)	337 (6.6)	<0.001
No	7,162,734 (99.3)	51,294 (98.2)		310,942 (95,6)	4,759 (93.4)	
Asthma						
Yes	135,343 (1,9)	1,020 (2,0)	0.206	5,550 (1.7)	130 (2.5)	<0.001
No	7,075,930 (98,1)	51,230 (98,0)		319,730 (98.3)	4,970 (97.5)	
Immunosuppression						
Yes	40,625 (0.6)	428 (0,8)	<0.001	7,597 (2.3)	105 (2.1)	0.194
No	7,170,422 (99.4)	51,813 (99,2)		317,642 (97.7)	4,994 (97.9)	
Hypertension						
Yes	854,813 (11.9)	79,35 (15.2)	<0.001	144,892 (44.5)	1,981 (38.8)	<0.001
No	6,356,277 (88.1)	44,311 (84.8)		180,381 (55.5)	3,119 (61.2)	
Cardiovascular disease						
Yes	71,712 (1.0)	707 (1.4)	<0.001	16,590 (5.1)	223 (4.4)	0.020
No	7,139,351 (99.0)	51,536 (98.6)		308,603 (94.9)	4,870 (95.6)	
Obesity						
Yes	690,607 (9.6)	6,907 (13.2)	<0.001	33,867 (20.5)	1,133 (22.5)	0.004
No	6,521,644 (90.4)	45,349 (86.8)		258,582 (79.5)	3,969 (77.8)	
Chronic Kidney Disease						
Yes	67,943 (0.9)	734 (1.4)	<0.001	23,651 (7.3)	269 (5.3)	<0.001
No	7,143,217 (99.1)	51,506 (98.6)		301,593 (92.7)	4,824 (94.7)	

*Chi-square.

Source: Authors.

forcing hygiene measures and home isolation[22,23], which increased inequality in income, employment, and access to health services, affecting mortality and lethality in Indigenous groups in several countries in the region[24-28].

COVID-19 had a significant impact on the Brazilian Indigenous population. Santos *et al.*[29] reported a case fatality rate of 1.8% in the In-digenous population. However, the case fatality rate in this group was 3.2% for those living in the Midwest region of the country, which is lower than what was found in our study, where the case fatality rate in the Indigenous population reached 9.8%. This study identified that the COVID-19 case fatality rates among Indigenous peoples are higher than those observed in the

Table 2. Characteristics associated with COVID-19 mortality according to Indigenous status in Mexico, 2020-2022.

Characteristics	Indigenous					Non-Indigenous				
	Yes	No	OR*	95%CI**	p	Yes	No	OR	95%CI	p
Gender										
Female	1,985 (38.8)	24.786 (52.5)				125,734 (38.5)	3,734,525 (54.1)			
Male	3,131 (61.2)	22.445 (47.5)	1.74	1.64-1.85	<0.001	201,140 (61.5)	3,171,446 (45.9)	1.88	1.87-1.90	<0.001
Age group										
60 years and above	3,336 (65.2)	7.392 (15.6)	10.10	9.49-10.75	<0.001	205,126 (62.7)	744,262 (10.8)	13.95	13.84-14.05	<0.001
Up to 60 years	1,780 (34.8)	39.839 (84.4)				121,748 (37.3)	6,161,709 (89.2)			
Pneumonia										
Yes	4,008 (78.3)	3.915 (8.3)	40.02	37.16-43.10	<0.001	232,938 (71.3)	280,320 (4.1)	58.84	57.85-58.84	<0.001
No	1,108 (21.7)	43.311 (91.7)				93,914 (28.7)	6,596,874 (95.9)			
Diabetes										
Yes	1,894 (37.2)	5,295 (11.2)	4.68	4.39-4.98	<0.001	119,914 (36.9)	509,337 (7.4)	7.31	7.26-7.37	<0.001
No	3,199 (62.8)	41,834 (88.8)				205,282 (63.1)	6,375,623 (92.6)			
COPD										
Yes	337 (6.6)	612 (1.3)	5.38	4.70-6.17	<0.001	14,288 (4.4)	34,054 (0.5)	9.25	9.06-9.43	<0.001
No	4,759 (93.4)	46,535 (98.7)				310,942 (95.6)	6,851,792 (99.5)			
Asthma										
Yes	130 (2.5)	890 (1.9)	1.36	1.13-1.64	0.002	5,550 (1.7)	129,793 (1.9)	0.9	0.88-0.93	<0.001
No	4.970 (97.5)	46,260 (98.1)				319,730 (98.3)	6,756,200 (98.1)			
Immunosuppression										
Yes	105 (2.1)	323 (0.7)	3.05	2.44-3.81	<0.001	7,597 (2.3)	33,028 (0.5)	4.96	4.84-5.09	<0.001
No	4,994 (97.9)	46,819 (99.3)				317,642 (97.7)	6,852,780 (99.5)			
Hypertension										
Yes	1,981 (38.8)	5,954 (12.6)	4.39	4.13-4.68	<0.001	141,515 (44.6)	682,033 (10.36)	6.96	6.90-7.01	<0.001
No	3,119 (61.2)	41,192 (83.4)				175,995 (55.4)	5,900,113 (89.64)			
Cardiovascular disease										
Yes	223 (4.4)	484 (1.0)	4.41	3.76-5.19	<0.001	16,590 (5.1)	55,122 (0.8)	6.66	6.54-6.78	<0.001
No	4,870 (95.6)	46,666 (99.0)				308,603 (94.9)	6,830,748 (99.2)			
Obesity										
Yes	1,133 (22.2)	5,774 (12.2)	2.05	1.90-2.20	<0.001	66,867 (20.5)	623,740 (9.1)	2.6	2.57-2.62	<0.001
No	39.69 (77.8)	41,380 (87.8)				258,582 (79.5)	6,263,062 (90.9)			
Chronic Kidney Disease										
Yes	269 (5.3)	465 (1.0)	5.6	4.80-6.52	<0.001	23,651 (7.3)	44,292 (0.6)	12.11	11.92-12.31	<0.001
No	4,824 (94.7)	46,682 (99.0)				301,593 (92.7)	6,841,624 (99.4)			

*Prevalence odds ratio. **95% Confidence Interval.

Source: Authors.

Table 3. Association of COVID-19 fatality in the Indigenous population by type of economic and social deprivation in Mexico, 2020-2022.

Type of deprivation	RR*	Standard Error	P-value	95%CI**
Income				
Quintile 2	1.19	0.06	0.001	1.08-1.32
3	1.43	0.10	<0.001	1.25-1.63
4	1.55	0.13	<0.001	1.31-1.82
5	1.34	0.11	<0.001	1.14-1.57
Educational backwardness				
Quintile 2	1.17	0.16	0.248	0.90-1.52
3	1.79	0.23	<0.001	1.40-2.29
4	2.33	0.30	<0.001	1.81-2.98
5	2.91	0.37	<0.001	2.27-3.74
Health services				
Quintile 2	1.13	0.06	0.011	1.03-1.25
3	1.06	0.06	0.260	0.96-1.18
4	1.16	0.06	0.004	1.05-1.28
5	1.45	0.05	<0.001	1.34-1.56
Social Security				
Quintile 2	1.03	0.10	0.765	0.85-1.25
3	0.99	0.09	0.880	0.82-1.19
4	0.95	0.09	0.587	0.79-1.14
5	0.91	0.08	0.291	0.76-1.08
Housing quality				
Quintile 2	0.98	0.11	0.834	0.77-1.23
3	1.03	0.12	0.797	0.81-1.31
4	0.89	0.11	0.330	0.70-1.12
5	1.09	0.13	0.476	0.86-1.38
Basic housing services				
Quintile 2	0.86	0.10	0.193	0.69-1.07
3	0.79	0.10	0.050	0.62-1.00
4	1.07	0.12	0.559	0.86-1.32
5	0.89	0.10	0.333	0.71-1.12
Food				
Quintile 2	0.81	0.06	0.010	0.69-0.95
3	0.91	0.07	0.204	0.78-1.05
4	0.77	0.06	<0.001	0.67-0.89
5	0.99	0.06	0.914	0.87-1.13

*Risk ratio. **95% Confidence Interval.

Source: Authors.

general population, without considering possible underreported cases, which is common in these social groups[30].

Argoty-Pantoja et al.[31] point out that the factors associated with higher mortality rates among non-Indigenous and Indigenous outpatients were gender and comorbidities, which is similar to what was found in our study where chron-ic kidney disease, hypertension, diabetes, and obesity were associated with higher COVID-19 mortality. However, this association was higher among non-Indigenous people.

The lethality in men was higher than in women in Indigenous and non-Indigenous people. The same results were published by several authors[31-33], which can be explained by the occu-

pational exposure to which men were subjected during the pandemic, making them more vulnerable to contracting the disease and dying[34].

Social and economic deprivations are determinants in increasing the risk of infectious diseases, such as COVID-19. They are prevalent among Indigenous groups, who lack access to health centers and basic sanitation and live under substandard health conditions[22]. Our results show that the lack of access to education was significantly associated in all quintiles regarding death from COVID-19, which is more evident among Indigenous people even in the most vulnerable quintile, while the results obtained for the lack of access to health services in the Indigenous group, mainly in the most vulnerable population quintile, reveal barriers to care and timely diagnosis similar to those faced at the pandemic onset[35].

Contrary to what has been reported in other studies[35], the results did not show any association regarding the lack of public services and housing quality concerning COVID-19 lethality, the results of which are similar to those reported by Khan *et al.*[36], which may result from the implementation of some measures, such as the use of alcohol gel, which could have alleviated the lack of water for hand hygiene and influenced the transmission of the disease.

On the other hand, the dimension of access to food security was not relevant regarding the mortality rate in the Indigenous and non-Indigenous populations, which the food collection and delivery to vulnerable populations can explain. This fact shows the importance of community strengthening to increase and maintain food resilience and the public policies implemented during the COVID-19 pandemic[37,38].

It is necessary to build dialogue and active participation of communities in the design and implementation of strategies for the promotion, prevention, care, and rehabilitation adapted to different contexts based on autonomy and integrating each community's knowledge systems in order to address the health problems of minorities, including the Indigenous population, which allows for building a health system with a community-based approach and strengthening of support networks to produce more effective strategies[39-41].

As a result, health must be considered as a cohesive element to include development and progress proposals under multi-sectoral work in Indigenous communities in order to reduce the social, environmental, and health inequality gaps, given the vulnerability to which they were exposed to the COVID-19 pandemic[42], as shown in the final report "Monitoring MDGs through an Indigenous Peoples' Perspective", which presents the results of 47 programs implemented in Africa, Latin America, and Asia[43].

Finally, we should underscore the limitations of using secondary sources to analyze the social determinants of health because they were created for specific purposes other than the objectives of this research. So, the information retrieved from records and databases does not always respond to the needs for which they are used, and the record's quality cannot be fully guaranteed[44,45].

Furthermore, the results obtained consider the pandemic outlook during the years studied. However, we should recognize that they may vary if we consider our country's different waves, affecting lethality at different intensities among the several social groups.

Collaborations

O Medina-Gómez and JJ Medina-Villegas worked on the conception and design, drafted and critically revised the article, and approved the final version. O Medina-Gómez performed the statistical analysis.

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