Hospitalisation and mortality from COVID-19 in Mexican indigenous people: a cross-sectional observational study

Edson Serván-Mori,[1] Jacqueline A Seiglie,[2] Octavio Gómez-Dantés,[1] Veronika J Wirtz [3]

[1]Center for Health Systems Research, National Institute of Public Health Mexico, Cuernavaca, Morelos, Mexico
[2]Diabetes Unit, Massachusetts General Hospital, Boston, Massachusetts, USA
[3]Department of Global Health, Boston University, Boston, Massachusetts, USA

Correspondence to
Professor Veronika J Wirtz, Department of Global Health, Boston University, Boston, MA 02215, USA; vwirtz@bu.edu

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ABSTRACT

Background Despite having a large indigenous population, little is known about the differences in COVID-19-related health outcomes between indigenous and non-indigenous patients in Mexico. The aim of this study is to analyse the variation in hospitalisation and death between indigenous and non-indigenous patients with COVID-19 to guide future policies and clinical practice.

Methods We used data from the Mexican Ministry of Health (MoH) to study the hospitalisation and death of adults with laboratory-confirmed SARS-CoV-2 in MoH facilities between 1 March 2020 and 28 February 2021. Predicted probabilities of hospitalisation and death were adjusted for sociodemographic and presentation to care characteristics as well as municipal social deprivation index and health jurisdiction-level index of human resource and hospital equipment availability.

Results Of 465 676 hospitalised adults with COVID-19, 5873 (1.3%) were identified as indigenous. Indigenous patients had higher odds of hospitalisation (adjusted OR (aOR)=1.9, 95% CI 1.8 to 2.0), death (aOR=1.3, 95% CI 1.1 to 1. 3) and early mortality (aOR=1.2, 95% CI 1.0 to 1.4), compared with non-indigenous patients. Living in municipalities with high social deprivation was associated with a higher risk of hospitalisation and early death. Living in areas with low healthcare resources was associated with a higher risk of hospitalisation but not death. Being male, aged 51 years or older, having diabetes, hypertension and obesity were associated with an incremental probability of hospitalisation and death among indigenous patients.

Conclusions Indigenous patients with COVID-19 in Mexico have a higher risk of hospitalisation and death than non-indigenous individuals. Our findings can guide future efforts to protect this population from SARS-CoV-2 infection and associated outcomes.

INTRODUCTION

In Mexico, over 2 100 000 cases and 194 000 deaths have been reported due to COVID-19 (as of March 2021),[1] with official figures likely to underestimate the true mortality attributed to this disease.[2] Mexico has one of the highest case fatality rates (9.0%) worldwide and the ninth highest mortality per capita (154.1 reported deaths per 100 000 inhabitants).[3] While numerous studies conducted in Mexico have described individual-level characteristics associated with heightened COVID-19 severity and mortality,[4–6] few studies have focused on Mexico's indigenous population.[7]

There are approximately 476 million indigenous peoples worldwide, and although they make up over 6% of the global population, they account for about 15% of the extreme poor.[8] In addition to poverty, many indigenous peoples live in remote communities, where healthcare services are difficult to access, have limited capacities or simply do not exist.[9 10] In addition to geographical and financial barriers, indigenous populations also often face widespread discrimination and confront organisational and cultural barriers in the process of utilisation of healthcare services.[11 12] In 2015, out of 126 million Mexicans,[13] around 10% self-identified as indigenous. Half of them lived in households where an indigenous language was spoken, and one-third spoke an indigenous language. Eight out of 32 states in Mexico are home to 60%–85% of all indigenous people in the country. Since the large majority of indigenous people live in poor communities and were subject to health vulnerabilities prior to COVID-19, this pandemic has represented a particular hardship for this population.[14] Indigenous population health needs are largely managed in Mexican Ministry of Health (MoH) units, which are tax funded,[15 16] and belong to one of the 243 health jurisdictions responsible for providing health services for the population without social security. They execute, coordinate and monitor health programmes and services at the substate level.

Disparities in the context of social vulnerability have been at the forefront of the COVID-19 pandemic. High infection risk[17] and poor health outcomes are common in racial and ethnic minorities.[18–20] While there are numerous studies on ethnic disparities and COVID-19 outcomes in high-income countries, there is a gap in our understanding of health inequities related to ethnicity in low and middle-income countries, including Mexico. A recent study showed that adults with COVID-19 who spoke an indigenous language were at a much higher risk of dying from COVID-19 than those who did not speak an indigenous language.[7] However, previous studies did not address the difference in hospitalisation and early mortality, nor account for differences in healthcare resources and characteristics related to presentation to care. In this study, we analyse the variation in hospitalisation and death between indigenous and non-indigenous patients with laboratory-confirmed

COVID-19 treated in MoH institutions according to demographic characteristics, comorbidities, healthcare resources and presentation to care characteristics.

METHODS

Study design and population

We performed an observational and cross-sectional study using public data from the General Directorate of Epidemiology of the MoH, an open-source data set that provides data on individuals tested for COVID-19 in Mexico.[21] The data analysed in this study cover the period between 1 March 2020 and 28 February 2021. COVID-19 reporting follows two procedures: (1) hospital surveillance keeps track of all deaths and hospitalisations, providing a census of confirmed COVID-19 cases; (2) sentinel surveillance is carried out through a system of 475 selected health units that monitor respiratory diseases, which includes medical units from the first, second or third level of care distributed across the country. COVID-19 cases were confirmed based on laboratory confirmation of SARS-CoV-2 with either RT-PCR or antigen testing and by either the laboratory from the Mexican Institute of Epidemiological Diagnosis and Reference (InDRE for its Spanish acronym) or by any other public or private laboratory in Mexico.

There are two main public providers of health services in Mexico: (1) social security institutions, which offer health services to individuals working in the formal sector of the economy and their families, and (2) the MoH, which provides primary and secondary health services to the non-salaried population and includes the most socially vulnerable populations in the country.[22] In order to analyse a more homogeneous group of individuals in terms of their socioeconomic profile and to increase comparability according to the ethnic status of the study population, our analysis included only adults aged 18–85 years with complete basic sociodemographic information who received care in the MoH care units for diagnosed COVID-19 (n=795 878). Individuals treated in social security facilities and Mexicans with COVID-19 symptoms who never received a confirmed diagnosis via a laboratory test are not included in the study data set, and hence did not form part of the study sample.

Main variables

The main outcome variables were hospitalisation and confirmed death (ICD-10/International Classification of Diseases 10th Revision: U07.1) certified by a medical professional or other qualified healthcare worker.[23] Death was additionally subcategorised as early death, defined according to previous studies and using a distributional-based criteria,[24] as death occurring within the first 5 days from hospitalisation (the median time to death of those who died).

We classified users of MoH care units as indigenous or not indigenous according to the official definition in Mexico,[25] whereby a person is considered indigenous if she/he speaks an indigenous language. Following this definition, we created a binary variable (yes=1/no=0). Out of 795 878 individuals included in our study, 8022 (1.01%) were indigenous people.

Covariates included individual and contextual characteristics of the participants. *Individual*: sex (female=1, male=0); age (18–35, 36–50, 51–65, 66 years and over); the self-reported diagnosis of any of the following chronic conditions: diabetes, hypertension (HTN), obesity, cardiovascular disease, chronic kidney disease (CKD), chronic obstructive pulmonary disease (COPD) or asthma; health problem during pregnancy or during childbirth (yes=1/no=0); the month of presentation to care (March to April, May, June, etc), and the timing of presentation to care from initial symptom onset, defined as follows: 0–3, 4–7, 8 or more days. Information on these variables was provided by patients upon receiving care. *Contextual*: given lack of individual-level data on socioeconomic status, which can influence one's main outcomes, we included two indices with information on the social context and health system capacity according to the municipality of residence of each individual in the data set. The first index was a factor municipality-level social deprivation index, which is considered a reliable measure of an individual's socioeconomic context in Mexico. This index is based on access to basic public services, housing conditions and wage earnings in 2015.[26] The calculation of this index was carried out using data from the 2015 intercensal survey and was limited to the Mexican population without social security.[27] We also included a health jurisdiction-level index of human resource and hospital equipment availability with data available prior to the COVID-19 outbreak. This index was constructed using factor analysis[28] using the last official health resources database available (2018).[29] The index incorporated availability of human resources and hospital equipment prior to the COVID-19 pandemic, which corresponded to the state in which SARS-CoV-2 testing was conducted, and followed the official guidelines for the organisation and execution of the Hospital Conversion COVID-19 for the Mexican National Health System Institutions.[30]

Analysis

Analyses were performed using the statistical package Stata MP V.15.1. First, we quantified the sociodemographic, clinical, healthcare resource and presentation to care characteristics of the study population (column percentages with 95% CI) according to indigenous ethnicity. Differences between them were evaluated using χ^2 tests. Next, we calculated the percentage (and their 95% CI) of individuals who were hospitalised, who died and who died within 5 days of hospitalisation (early mortality), according to indigenous ethnicity. Differences between them were also evaluated using χ^2 tests. We then conducted three separate multiple logistic regression analyses, a model for each of the outcomes of interest. Regression models were adjusted for all covariates mentioned above (except for ambulatory/hospitalised setting for the hospitalisation outcome), including a binary variable for each state (ie, state fixed effect). Adjusted ORs (aORs) with their 95% CIs were estimated. We then estimated the incremental predicted probability of hospitalisation and death (global and early) among indigenous people according to sex, age groups, comorbidities (diabetes, obesity and HTN), lowest and highest healthcare resources at the health jurisdictional level and high and low municipality social deprivation. Incremental predicted probabilities were calculated with respect to the adjusted probability of hospitalisation and death (global and early) among the indigenous population and were expressed in ORs.

RESULTS

The baseline characteristics of the study population, according to indigenous status, are presented in table 1. A total of 795 878 adults diagnosed with COVID-19 were included in the analysis, of whom 8022 (1.01%) self-identified as indigenous (table 1). A higher percentage of indigenous patients (compared with non-indigenous) were male (56.1%, p<0.001), aged 51 years or over (27.6%, p<0.001), self-reported diabetes (20.6% vs 12.6%, p<0.001), obesity (18.3% vs 15.9%), HTN (20.3% vs 16.0%,

Table 1 Main characteristics of Mexicans with COVID-19, users of any MoH care unit, by indigenous status. Mexico, 1 March 2020 to 28 February 2021

	Total 795 878 (100)	Non-indigenous 787 856 (98.99)	Indigenous 8022 (1.01)	
n (%)	Column % or mean (95% CI)			P value
Individual				
Sex				
Male	48.9 (48.8 to 49.0)	48.8 (48.7 to 48.9)	56.1 (55.0 to 57.2)	<0.001
Female	51.1 (51.0 to 51.2)	51.2 (51.1 to 51.3)	43.9 (42.8 to 45.0)	
Age (years)				
18–35	34.7 (34.6 to 34.8)	34.8 (34.7 to 34.9)	24.1 (23.2 to 25.1)	<0.001
36–50	33.0 (32.9 to 33.1)	33.0 (32.9 to 33.1)	29.2 (28.2 to 30.2)	
51–65	23.0 (22.9 to 23.1)	22.9 (22.8 to 23.0)	27.6 (26.7 to 28.6)	
>66	9.3 (9.3 to 9.4)	9.2 (9.2 to 9.3)	19.0 (18.2 to 19.9)	
Self-reported morbidity				
Diabetes	12.7 (12.6 to 12.8)	12.6 (12.5 to 12.7)	20.6 (19.8 to 21.5)	<0.001
Obesity	15.9 (15.9 to 16.0)	15.9 (15.8 to 16.0)	18.3 (17.4 to 19.1)	<0.001
Hypertension	16.1 (16.0 to 16.1)	16.0 (15.9 to 16.1)	20.3 (19.5 to 21.2)	<0.001
Cardiovascular disease	1.4 (1.3 to 1.4)	1.4 (1.3 to 1.4)	1.5 (1.3 to 1.8)	0.183
Chronic kidney disease	1.0 (1.0 to 1.0)	1.0 (1.0 to 1.0)	1.8 (1.6 to 2.2)	<0.001
COPD	0.9 (0.9 to 0.9)	0.9 (0.9 to 0.9)	2.9 (2.6 to 3.3)	<0.001
Asthma	2.3 (2.3 to 2.4)	2.3 (2.3 to 2.4)	2.5 (2.2 to 2.8)	0.341
Smoking	7.7 (7.7 to 7.8)	7.7 (7.7 to 7.8)	5.6 (5.1 to 6.1)	<0.001
Month of presentation to care				
March to April 2020	1.9 (1.9 to 2.0)	1.9 (1.9 to 2.0)	3.7 (3.3 to 4.1)	<0.001
May	6.1 (6.1 to 6.2)	6.1 (6.0 to 6.1)	9.6 (9.0 to 10.3)	
June	10.5 (10.4 to 10.5)	10.4 (10.4 to 10.5)	13.8 (13.0 to 14.5)	
July	13.2 (13.1 to 13.2)	13.1 (13.0 to 13.2)	19.7 (18.9 to 20.6)	
August	10.9 (10.9 to 11.0)	10.9 (10.9 to 11.0)	13.3 (12.6 to 14.0)	
September	8.8 (8.7 to 8.8)	8.8 (8.7 to 8.8)	8.1 (7.5 to 8.7)	
October	11.1 (11.0 to 11.2)	11.2 (11.1 to 11.2)	6.3 (5.7 to 6.8)	
November	12.3 (12.2 to 12.3)	12.3 (12.2 to 12.4)	6.4 (5.9 to 7.0)	
December	10.8 (10.8 to 10.9)	10.9 (10.8 to 10.9)	6.6 (6.1 to 7.2)	
January	11.0 (11.0 to 11.1)	11.0 (11.0 to 11.1)	9.5 (8.9 to 10.1)	
28 February 2021	3.3 (3.3 to 3.4)	3.3 (3.3 to 3.4)	3.0 (2.7 to 3.4)	
Days from symptom onset to presentation to care				
0–3	46.6 (46.5 to 46.7)	46.6 (46.5 to 46.7)	45.5 (44.4 to 46.6)	0.293
4–7	40.9 (40.8 to 41.1)	40.9 (40.8 to 41.0)	41.9 (40.8 to 42.9)	
>8	12.5 (12.4 to 12.5)	12.5 (12.4 to 12.5)	12.7 (12.0 to 13.4)	
Contextual				
Social deprivation*				
Low	33.4 (33.3 to 33.5)	33.6 (33.5 to 33.7)	10.3 (9.7 to 11.0)	<0.001
Middle	33.4 (33.3 to 33.5)	33.6 (33.5 to 33.7)	10.2 (9.5 to 10.9)	
High	33.2 (33.1 to 33.3)	32.8 (32.7 to 32.9)	79.5 (78.6 to 80.4)	
Human resources and hospital equipment†				
Low	23.9 (23.8 to 24.0)	23.8 (23.7 to 23.9)	34.9 (33.9 to 36.0)	<0.001
Middle	32.3 (32.2 to 32.4)	32.2 (32.1 to 32.3)	36.5 (35.4 to 37.5)	
High	43.8 (43.7 to 44.0)	44.0 (43.9 to 44.1)	28.6 (27.6 to 29.6)	

*At municipality level.
†At health jurisdiction level.
COPD, chronic obstructive pulmonary disease; MoH, Ministry of Health.

p<0.001) and CKD (1.8% vs 1.0%, p<0.001). Although a lower proportion of indigenous individuals self-reported smoking than non-indigenous individuals, COPD was also the most commonly reported among indigenous patients (2.9% vs 0.9%, p<0.001), compared with non-indigenous patients. A higher proportion of indigenous patients lived in a municipality with high social deprivation (79.5% vs 32.8%, p<0.001), and in a state with

Table 2 Hospitalisation and death of Mexicans with COVID-19, users of any MoH care unit, by indigenous status. Mexico, 1 March 2020 to 28 February 2021

	Total 795 878 (100)	Non-indigenous 787 856 (98.99)	Indigenous 8002 (1.01)	
	% (95% CI)			P value
Hospitalised	12.4 (12.3 to 12.5)	12.6 (12.5 to 12.6)	30.9 (29.9 to 31.9)	<0.001
Death	4.8 (4.8 to 4.9)	4.9 (4.9 to 5.0)	14.5 (13.7 to 15.2)	<0.001
Early mortality (in <5 days*)	45.0 (44.5 to 45.5)	45.2 (44.7 to 45.7)	50.3 (47.5 to 53.2)	<0.001

*Median of the number of days from presentation to care until death.
MoH, Ministry of Health.

low healthcare resources (34.9% vs 23.8%, p<0.001) than non-indigenous individuals.

Table 2 presents the predicted probability of hospitalisation, mortality and early mortality of Mexican adults with COVID-19, according to indigenous status. Patients who self-identified as indigenous had a higher predicted probability of hospitalisation compared with non-indigenous patients (30.9%, 95% CI 29.9% to 31.9% vs 12.6%, 95% CI 12.5% to 12.6%, p<0.001). Indigenous patients also had a higher predicted probability of death compared with non-indigenous patients (14.5%, 95% CI 11.4% to 13.1% vs 4.9%, 95% CI 4.9% to 5.0%, p<0.001) as well as of early mortality (50.3%, 95% CI 47.5% to 53.2% vs 45.2%, 95% CI 44.7% to 45.7%, p<0.001).

Table 3 presents the aORs and their 95% CI for the association between indigenous status and hospitalisation, mortality and early mortality among Mexican adults with COVID-19. Indigenous patients had higher odds of hospitalisation (aOR=1.94, 95% CI 1.82 to 2.06, p<0.001), death (aOR=1.27, 95% CI 1.17 to 1.39, p<0.001) and early mortality (aOR=1.20, 95% CI 1.06 to 1.36, p<0.01), compared with non-indigenous patients. Compared with ages 18–35, age 36 and over was associated with higher odds of hospitalisation and death, with the effect size increasing substantially with increasing age group. Medical comorbidities, including diabetes, obesity, HTN and CKD, were associated with higher odds of hospitalisation, death and early mortality. COPD was associated with higher odds of hospitalisation and early mortality and cardiovascular disease with higher odds of hospitalisation. Presenting to care in the months of May 2020 to December 2021 was associated with lower odds of hospitalisation, death and early mortality, compared with presenting in March or April. Early mortality increased in January 2021. Presenting to care 4 or more days after symptom onset was associated with higher odds of hospitalisation (4–7 days aOR=1.46, 95% CI 1.43 to 1.48, p<0.001; 8 or more days aOR=2.74, 95% CI 2.68 to 2.80, p<0.001) and a small but significant odds of death (8 or more days aOR=1.07, 95% CI 1.04 to 1.10, p<0.001). Hospitalisation, intensive care unit (ICU) admission or mechanical ventilation were associated with higher odds of death (aOR=34.11, 95% CI 32.94 to 35.31, p<0.001) and early mortality (aOR=1.51, 95% CI 1.42 to 1.61, p<0.001). Living in a municipality with high social deprivation was associated with higher odds of hospitalisation (aOR=1.54, 95% CI 1.50 to 1.58, p<0.001) and early mortality (aOR=1.33, 95% CI 1.23 to 1.44, p<0.001), compared with living in a municipality with low social deprivation. Residence in a state with high healthcare resources was associated with lower odds of death (aOR=0.92, 95% CI 0.89 to 0.96, p<0.001) and early death (aOR=0.93, 95% CI 0.88 to 0.99, p<0.05).

Figure 1 presents the characteristics associated with an incremental predicted probability of hospitalisation or death among indigenous compared with non-indigenous patients. Being male, aged 51 years or older, having diabetes, HTN and obesity were associated with an incremental probability of hospitalisation and death among indigenous patients. Living in a municipality with the highest level of social deprivation was associated with a higher probability of hospitalisation (incremental predicted probabilities=1.14, 95% CI 1.13 to 1.15), as was presenting to care 4–7 days (incremental predicted probabilities=1.04, 95% CI 1.03 to 1.04), and 8 or more days after symptom onset (incremental predicted probabilities=1.48, 95% CI 1.47 to 1.50).

DISCUSSION

Research on ethnic disparities in health outcomes in Mexico is scant and large gaps remain, particularly as we continue to face the challenges of the COVID-19 pandemic. In this large retrospective cross-sectional study of individuals with laboratory-confirmed SARS-CoV-2, we show that indigenous people with COVID-19 in Mexico, who carry a disproportionate burden of non-communicable diseases (NCDs), are more likely to be hospitalised and die than non-indigenous individuals with COVID-19. Furthermore, the greater odds of poor COVID-19 outcomes seen among indigenous individuals hold even after adjustment for demographic characteristics, comorbidities, presentation to care characteristics and healthcare resources. These findings underscore the urgent need to implement risk mitigation strategies to prevent SARS-CoV-2 infection in this vulnerable population.

We also found that out of those who died, nearly half of non-indigenous individuals and more than half of all indigenous individuals died within the first 5 days of hospitalisation. Mortality data from higher resource contexts such as the USA, where the median time between hospitalisation and death is 13 days, suggest important shortcomings in the Mexican health system's ability to mitigate the risk of death among indigenous peoples.[31] Healthcare workers in Mexican hospitals have reported low quality of care for patients with COVID-19 as a result of acute understaffing and a decade-long underinvestment in hospital infrastructure.[32] As such, it is possible that limited healthcare resources both in hospital infrastructure and human resources may have exacerbated existing disparities in the care of indigenous peoples[33] and contributed to the higher early mortality documented in our study.

Two important aspects about the burden of NCDs on the indigenous population in our study should be noted. First, although there was a lower percentage of indigenous people who reported smoking, there was a higher prevalence of COPD in this population compared with non-indigenous individuals, which is consistent with prior literature.[34] This finding highlights the importance of considering differences in the risk factors associated with respiratory NCDs, which in this instance could be attributed to indoor cooking in open fires—a practice

Table 3 Association between indigenous status and hospitalisation and death among Mexicans with COVID-19, users of MoH care unit. Mexico, 1 March 2020 to 28 February 2021

	Hospitalisation	Death	Early mortality‡
	aOR (robust 95% CI)		
Individual			
Indigenous status			
Non-indigenous	1	1	1
Indigenous	1.94*** (1.82 to 2.06)	1.27*** (1.17 to 1.39)	1.20** (1.06 to 1.36)
Sex			
Male	1	1	1
Female	0.61*** (0.61 to 0.62)	0.66*** (0.65 to 0.68)	1.06** (1.01 to 1.11)
Age (years)			
18–35	1	1	1
36–50	2.16*** (2.11 to 2.22)	2.71*** (2.56 to 2.88)	0.85** (0.76 to 0.95)
51–65	4.50*** (4.39 to 4.62)	5.72*** (5.40 to 6.06)	0.78*** (0.70 to 0.87)
>66	9.74*** (9.46 to 10.02)	11.05*** (10.40 to 11.74)	0.88* (0.79 to 0.98)
Self-reported morbidity (No=1)			
Diabetes	2.11*** (2.07 to 2.16)	1.29*** (1.25 to 1.33)	1.20*** (1.15 to 1.25)
Obesity	1.53*** (1.50 to 1.56)	1.37*** (1.33 to 1.41)	1.10*** (1.05 to 1.15)
Hypertension	1.26*** (1.24 to 1.29)	1.16*** (1.12 to 1.19)	1.07** (1.03 to 1.12)
Cardiovascular disease	1.20*** (1.14 to 1.27)	1.05 (0.97 to 1.13)	1.15** (1.04 to 1.27)
Chronic kidney disease	2.98*** (2.81 to 3.17)	1.82*** (1.69 to 1.97)	1.51*** (1.37 to 1.67)
COPD	1.81*** (1.70 to 1.92)	1.02 (0.94 to 1.10)	1.21*** (1.08 to 1.35)
Asthma	0.93** (0.88 to 0.98)	0.91* (0.83 to 1.00)	0.98 (0.84 to 1.13)
Smoking	0.96* (0.94 to 0.99)	0.87*** (0.82 to 0.91)	1.00 (0.92 to 1.08)
Month of presentation to care			
March to April	1	1	1
May	0.55*** (0.53 to 0.58)	0.81*** (0.76 to 0.88)	1.06 (0.96 to 1.18)
June	0.41*** (0.39 to 0.44)	0.65*** (0.61 to 0.70)	0.89* (0.80 to 0.98)
July	0.36*** (0.34 to 0.37)	0.56*** (0.52 to 0.60)	0.75*** (0.68 to 0.83)
August	0.28*** (0.27 to 0.30)	0.47*** (0.44 to 0.51)	0.63*** (0.56 to 0.71)
September	0.25*** (0.24 to 0.26)	0.41*** (0.38 to 0.44)	0.54*** (0.47 to 0.61)
October	0.24*** (0.23 to 0.25)	0.43*** (0.40 to 0.46)	0.55*** (0.49 to 0.63)
November	0.25*** (0.24 to 0.26)	0.46*** (0.43 to 0.50)	0.63*** (0.56 to 0.71)
December	0.38*** (0.36 to 0.40)	0.55*** (0.51 to 0.59)	0.64*** (0.57 to 0.71)
January	0.47*** (0.45 to 0.50)	0.43*** (0.40 to 0.46)	0.80*** (0.72 to 0.88)
14 February 2021	0.53*** (0.50 to 0.56)	0.19*** (0.17 to 0.21)	1.24* (1.05 to 1.47)
Days from symptom onset to presentation to care			
0–3	1	1	1
4–7	1.46*** (1.43 to 1.48)	1.07*** (1.04 to 1.10)	0.99 (0.95 to 1.04)
>8	2.74*** (2.68 to 2.80)	1.13*** (1.09 to 1.17)	1.00 (0.95 to 1.06)
Ambulatory/hospitalised setting			
Ambulatory		1	1
Hospitalisation, ICU admission or mechanical ventilation		34.11*** (32.94 to 35.31)	1.51*** (1.42 to 1.61)
Contextual			
Social deprivation*			
Low	1	1	1
Middle	1.11*** (1.08 to 1.14)	1.02 (0.97 to 1.07)	1.12** (1.03 to 1.21)
High	1.54*** (1.50 to 1.58)	0.93** (0.89 to 0.98)	1.33*** (1.23 to 1.44)
Human resources and hospital equipment†			
Low	1	1	1
Middle	1.21*** (1.18 to 1.24)	0.96* (0.93 to 1.00)	0.91** (0.86 to 0.97)
High	0.99 (0.96 to 1.01)	0.92*** (0.89 to 0.96)	0.93* (0.88 to 0.99)
Fixed effects at state	Yes	Yes	Yes

Continued

Table 3 Continued

	Hospitalisation	Death	Early mortality‡
	aOR (robust 95% CI)		
n	795 878	795 878	39 034
Area under ROC curve	0.843	0.948	0.609
Pseudo-R^2	0.251	0.449	0.027
Probability > χ^2	<0.001	<0.001	<0.001

Significance levels: ***p<0.001; **p<0.01; *p<0.05.
*At municipality level.
†At health jurisdiction level.
‡Median of the number of days from presentation to care until death.
aOR, adjusted OR; COPD, chronic obstructive pulmonary disease; ICU, intensive care unit; MoH, Ministry of Health; ROC, receiver operating characteristic.

actively used by about half of indigenous groups in Mexico—which creates high levels of indoor pollution.[35] More research is needed to identify whether the differences in risk factors (eg, smoking vs indoor pollution) for respiratory NCDs also explain the difference in the risk of COVID-19 morbidity and mortality. Given the association between COPD and severe COVID-19,[36] policies and educational programmes that help mitigate the exposure to these risk factors could help lower the risk of COPD in groups already vulnerable to poor COVID-19 outcomes. Second, the burden of cardiometabolic NCDs was significantly higher in the indigenous compared with the non-indigenous group in this study. While cardiometabolic NCDs, particularly obesity and diabetes, have emerged as strong risk factors for heightened illness severity with COVID-19, the increased hospitalisation and mortality risk seen among the indigenous population was observed even after adjustment for these comorbidities. However, given that these comorbidities were self-reported and metabolic disease is highly prevalent among indigenous communities in Mexico,[37] it is possible that the higher risk of hospitalisation and death observed could be partly attributed to either undiagnosed or unaccounted metabolic disease owing to self-report. This may also explain why we observed an incremental risk of hospitalisation when presenting later in the course of illness among indigenous compared with non-indigenous individuals.

Our findings that show indigenous people are subject to poorer health outcomes when compared with non-indigenous individuals are not unique to COVID-19. For instance, disparities in maternal health and child health outcomes between indigenous compared with non-indigenous individuals have been well documented in Mexico.[38 39] Our study adds to the current literature on health disparities seen in the care of indigenous peoples and sheds light to the fact that poor COVID-19 outcomes are associated with higher social deprivation, low healthcare resources and organisational and cultural barriers faced by indigenous individuals in the process of accessing and using healthcare services. Although the Mexican government has increased ICU and hospital capacity,[40] these efforts have not been targeted at regions with a high percentage of indigenous peoples. Previous studies have highlighted the disparities in healthcare resources in states with a large indigenous population.[17] Other explanations for higher death and earlier mortality may be that indigenous people tend to identify alarm signs later in the process of disease due to a lack of information and their different perception of need. Moreover, deprivation effects such as lack of paid sick leave may result in indigenous people postponing seeking care. Additionally, indigenous peoples may hesitate to seek conventional healthcare, in part due to a conflicting relationship with the providers of conventional health services. Finally, indigenous peoples tend to receive lower quality of care, due in part to organisational and cultural barriers, which may help explain some of the disparities that we document in our study.[41]

Our study has several limitations. First, this study makes use of a nationwide administrative database that was not designed for clinical research and does not include people who died outside of the hospital setting. Second, all comorbidities included were self-reported. Third, we do not have data on quality of care, which means we do not know whether differences in clinical care or individual factors contributed to the higher predicted probability of death in indigenous people. Fourth, considering that many indigenous peoples live in remote communities where healthcare services are difficult to reach and have limited capacity, our estimates of the prevalence of death, especially in the indigenous population, could be underestimated. Future studies should explore the distance to the nearest hospital and time from symptom onset to hospitalisation, adjusting for mode of transportation. Fifth, we lacked socioeconomic information at the individual level (ie, schooling, work condition, health insurance, etc). To account for this limitation, we (A) limited our analysis to adults who received care in an MoH care unit, thus creating a study sample that is more homogenous in terms of their socioeconomic profile, and (B) we adjusted our estimations by the municipality social deprivation index, which is considered a reliable measure of an individual's socioeconomic context in Mexico.[26] Sixth, we also lacked information on healthcare resources (physical and human) currently available to combat the epidemic, which in our model could be underestimating this effect.

Reducing preventable inequalities is a worldwide concern and one of the main goals of social justice. However, indigenous peoples experience a high degree of marginalisation, which includes lack of access to water, sanitation and other key services, including healthcare services. The COVID-19 pandemic poses a grave health threat to indigenous peoples around the world. Our study suggests that Mexican indigenous people with COVID-19 and users of a public MoH care unit have a higher risk of hospitalisation and death than non-indigenous individuals. Better protecting indigenous people will require a concerted effort, including promoting better access to healthcare and improving quality of existing health services for this population. There is also a need for better information technology and other infrastructure to ensure that indigenous peoples have access to timely and reliable information that could reduce their risk of infection. The improvement of the relationship between these communities and local health authorities is crucial because indigenous populations will seek and use conventional health services only if they trust these authorities and the conventional healthcare providers.

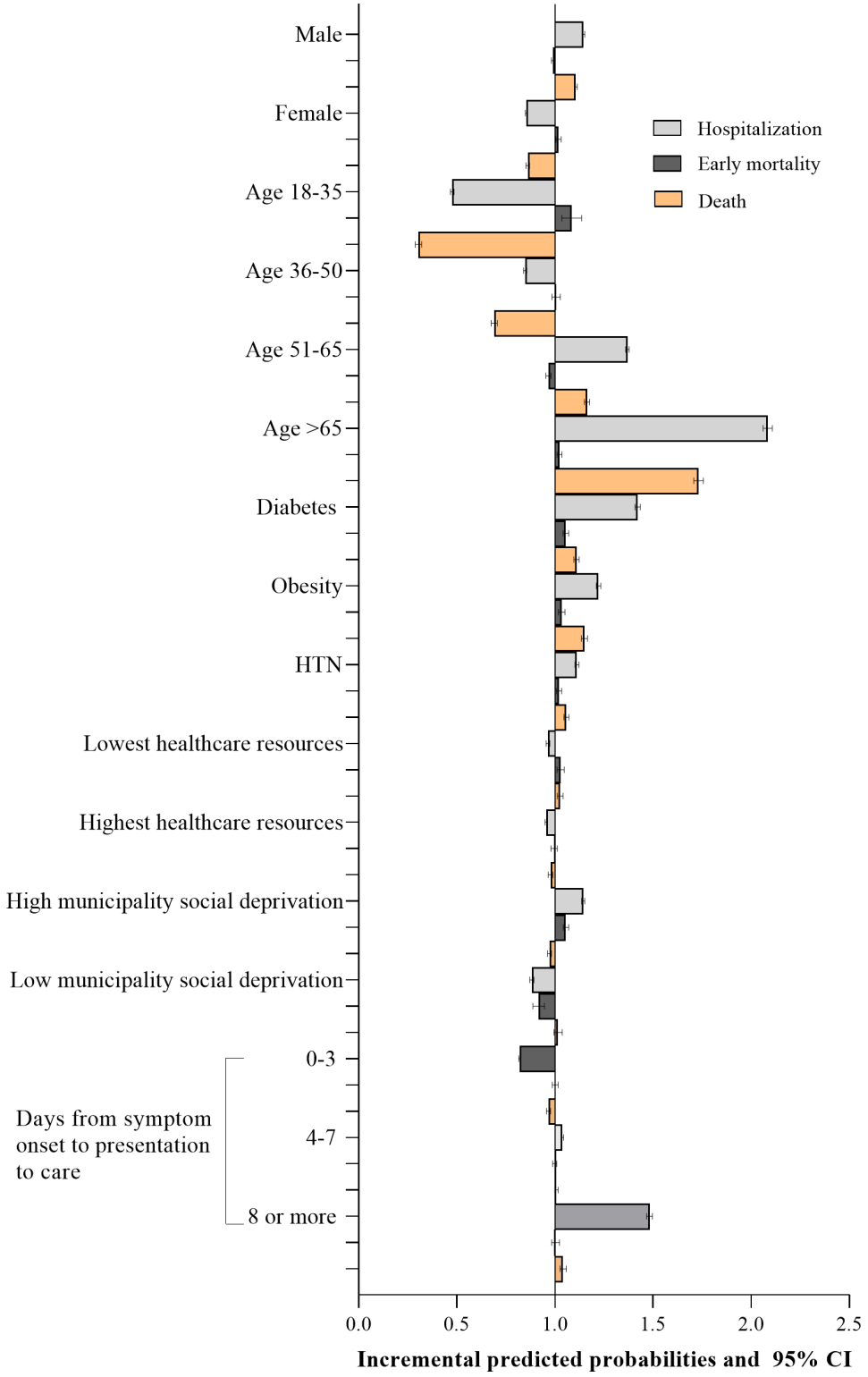

Figure 1 Incremental probability of hospitalisation and death among Mexican indigenous patients with COVID-19. Mexico, 1 March 2020 to 28 February 2021. HTN, hypertension.

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What is already known on this subject

- While there are numerous studies on ethnic disparities and COVID-19 outcomes in high-income countries, there is a gap in our understanding of health inequities related to ethnicity in many low and middle-income countries, including Mexico.
- A recent study showed that adults with COVID-19 who spoke an indigenous language were at a much higher risk of dying from COVID-19 than those who did not speak an indigenous language.

What this study adds

- Indigenous patients with COVID-19 in Mexico have nearly a twofold increase in the risk of hospitalisation and a 20% increase in the odds of death and early mortality from COVID-19 than non-indigenous individuals. Our findings can guide future efforts to protect this population from SARS-CoV-2 infection and associated outcomes, and similar pandemics.

ORCID iD
Veronika J Wirtz http://orcid.org/0000-0002-0863-8768

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