Distribution of COVID-19 related deaths in municipalities from Sonora, Mexico, 2020

Distribución de las muertes por COVID-19 en municipios de Sonora, México, 2020

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Abstract

Introduction: The COVID-19 pandemic has challenged societies, not only because of its magnitude and impact, but also because it has deepened health inequalities and inequities. Socially disadvantaged groups show a higher frequency of adverse health events due to COVID-19, particularly in Latin America. With that in mind, we describe the distribution of deaths in COVID-19 patients stratified by sociodemographic characteristics and medical comorbidities, and explore perceptions related to disease-care, in selected rural and urban localities from Sonora, Mexico. **Methods:** We conducted a cross-sectional study on 160 deaths attributed to COVID-19, from the period April 1st and July 31st 2020, using death certificates as a data source. Furthermore, to explore the variables of interest, a verbal autopsy was applied to a relative caregiver for the patient's health. Data collected was analyzed by descriptive statistics and qualitative technique. **Results:** We did not find significant differences in sociodemographic conditions among the COVID-19 deaths. Interestingly, 85.6% of the deceased had a chronic medical condition and 74.4% of all deaths took place in an urban locality. Caregivers frequently consigned deficiencies from medical services over the disease-care process of COVID-19 deaths.

Keywords: Mortality; COVID-19; Post-mortem examination; Verbal examination; Mexico.

Resumen

Introducción: la pandemia de COVID-19 ha desafiado a las sociedades, no solo por su magnitud e impacto, sino también porque ha profundizado las desigualdades e inequidades en salud. Los grupos socialmente desfavorecidos muestran una mayor frecuencia de eventos de salud adversos debido a COVID-19, particularmente en América Latina. Con eso en mente, describimos la distribución de muertes en pacientes con COVID-19 estratificadas por características sociodemográficas, comorbilidades médicas y exploramos percepciones relacionadas con la atención

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de la enfermedad en localidades rurales y urbanas seleccionadas de Sonora, México. **Métodos:** realizamos un estudio transversal de 160 muertes atribuidas a COVID-19, correspondientes al periodo Abril 1-Julio 31, 2020, usando como fuente de datos los certificados de defunción. Además, para explorar las variables de interés, se aplicó una autopsia verbal a un familiar cuidador de la salud del paciente. Los datos recolectados fueron analizados por estadística descriptiva y técnica cualitativa. **Resultados**: no encontramos diferencias significativas en las condiciones sociodemográficas entre las muertes por COVID-19. Se observó que 85.6 % de los fallecidos padecían una enfermedad crónica y 74.4 % de todas las muertes ocurrieron en una localidad urbana. Los cuidadores frecuentemente atribuyeron deficiencias de los servicios médicos al proceso de atención de las muertes por COVID-19.

Palabras clave: Mortalidad; COVID-19; Examen post mortem; Autopsia verbal; México.

Introduction

Since its emergence in 2019 in Wuhan, China, the coronavirus disease 2019 (COVID-19) rapidly became a pandemic. The World Health Organization (WHO) has reported globally, up to August 31, 2023, over 770.1 million cases and 6.97 million deaths due to COVID-19. Although these numbers are spread along all over the six WHO regions, the Americas have been one of the most affected, accounting for 25.1% and 42.5% of the world's confirmed cases and deaths registered, respectively[1].

From the beginning of the pandemic, several individual characteristics have been outlined as determinants related with higher mortality in COVID-19 patients, such as older age (>60 years old), diabetes, hypertension, cardiovascular disease, obesity, and chronic respiratory disease[2-3]. However, as the pandemic has followed its course, individual features cannot solely explain the differences observed between populations in terms of COVID-19 mortality. Social determinants, such as access to health care, work status, education level, housing density, and cultural beliefs undoubtedly have influenced COVID-19 incidence and adverse health outcomes in vulnerable populations[4-5].

Examining social disparities in the context of the pandemic may be valuable for Latin American countries, where economic gaps between communities are commonly observed. Mexico, a country with a high prevalence of chronic diseases[6], has been severely affected by COVID-19, ranking fifteenth and fifth place worldwide in cumulative cases and deaths, respectively. As expected, individual biological characteristics for adverse outcomes seems not to differ from those observed in other countries[7-8]. Nevertheless, still is not completely understood the role that sociodemographic conditions played in the clinical evolution of Mexican patients deceased due to COVID-19. Although it is not an easy task, there are certain approaches that can help us recognize such factors.

A retrospective methodology known as verbal autopsy (VA) can help to elucidate some factors related with the health care process, clinical evolution, and risk perception of a deceased individual's relative or caregiver[9]. The approach of VA has shown its utility in many low- and middle-income countries (LMICs), where determination of causes of death (CoD) and death registration systems are likely inaccurate[10]. Even in contexts where medical certification of death occurs, VA can be useful in filling out in some gaps around specific CoD[11]. Due to its low cost and practicality, the VA-method has been widely used in developing countries for ascertaining multiple CoD, including chronic noncommunicable and infectious diseases[12-13]. VA in the context of the COVID-19 pandemic can identify barriers related with the medical care process experienced by the deceased. Recognizing key elements surrounding COVID-19 can help us in the understanding of mortality-wise differences between populations. The aim of this study is to describe the distribution of deaths in COVID-19 patients stratified by sociodemographic characteristics and medical comorbidities, as well as exploring perceptions related to disease-care, in selected rural and urban localities from Sonora, Mexico.

Methods

Study setting

This cross-sectional study was performed in the state of Sonora, Mexico, placed at the northwestern region of the country, sharing most of its northern border with the state of Arizona, United States. According to the latest Mexican census in 2020 its population is 2,944,840[14]. All study procedures were approved by the Sonora Health Secretariat, who authorized their execution as part of the routine epidemiological surveillance activities of the COVID-19 pandemic and waived ethical evaluation due to use of public health information.

Study design and population

We conducted a cross-sectional assessment on a non-probabilistic series of death certificates in which the basic cause-of-death (COD) was certified as COVID-19, either U07.1 or U07.2 in accordance with the WHO recommendations[15]. We included deaths occurred between April 1st and July 31st, 2020, across the 11 most populated (2,530,653 inhabitants) municipalities of Sonora[14]. Deaths were compared according to their place of residence, either rural or urban, and stratified by sex of deceased. All deaths must have occurred in an adult aged 18 years or more, who had his/her habitual residence in one of the 11 eligible municipalities and who had been a confirmed case a COVID-19, defined as a positive result on a real-time reverse-transcriptase PCR (RT-PCR) assay of nasal or pharyngeal swab specimens. Only a single positive test was necessary for the patient to be included.

All analyzed death certificates were retrieved from the national platform known as Statistical and Epidemiological System of Deaths (SEED) to abstract official data, such as the patient's age, residency, marital status, occupation, date and time of death, place of death and medical causes of death, which were coded using the 10th revision of the International Classification of Diseases (ICD-10) (World Health Organization, 2010)[15].

Data collection

To examine characteristics related with the disease care process, we developed a semi structured questionnaire as a verbal autopsy (VA) tool, based on a literature review; the VA was organized into seven different sections. Additionally, we included open questions regarding sociodemographic data of the deceased, comorbidities, lifestyle, circumstances of death, a checklist of signs and symptoms experienced before death, comprising disease duration, and health care access. Furthermore, we designed an open section in which the interviewee's perceptions regarding COVID-19 and the death of its relative were described. The questionnaire was not piloted because the pandemic hindered many field procedures at the time of its application. The VA was applied at the residence of the interviewees who had to be a relative adult older than 18 years directly involved in providing care to the deceased individual. The informants were contacted by the local department of epidemiology once a COVID-19 death was identified in the SEED. All the informants signed a consent form previously reviewed by the head of the state department of epidemiology, blinded to the purposes of the study. A team of in-state health workers (physicians and nurses) blinded to the study goals, was previously trained by the leading researcher (who has prior experience in conducting verbal autopsies) to standardize data collection; to warrant confidentiality of responses once the questionnaire was applied, personal identifiers were deleted, then it was sealed in an envelope and sent to the principal investigator. All the interviews were conducted during July-August 2020.

Sociodemographic characteristics

Sociodemographic characteristics (age, sex, marital status, educational level, medical care insurance, and employment status) and information on household conditions were collected. Given the mechanism of transmission of COVID-19, we asked if the deceased individual shared a bedroom with more than one person, and we used this criterion to determine if he/she lived in overcrowded conditions. For comparison purposes, the place of residence of the deceased was dichotomized in urban or rural; an urban locality was considered as an agglomeration of 15,000 inhabitants or more, meanwhile a rural locality has less than 15,000 inhabitants in accordance with national criteria[16].

Data analysis

We described our series by estimating simple proportions of selected demographic, behavioral, medical, and clinical characteristics among the deceased individuals. We used the chi-square test to detect differences in proportions among study subjects, considering their sex and place of residence (urban/rural locality) as comparison characteristics. Moreover, we also used Student t-test for age and time intervals of interest in the health care process. We used NCSS 11.0.24 ® (Number Cruncher Statistical System, Utah, USA, 2020) to enter, validate and analyze quantitative data. A double-tail hypothesis was used to detect statistical significance, with p-values <0.05 being considered as significant.

An exploratory qualitative analysis was performed using the open questions of the questionnaire. In this part, the original narratives were transcribed into Microsoft Word. Subsequently, these transcripts were imported into NVivo 12 Pro ® (QSR International, Melbourne, Australia, 2020). Based on concepts provided by the scientific literature, as well as those arising from the interviewee's speeches, a codebook was generated. Once the coding was completed, a code scheme was generated to visualize the information by topics. A pair of experts in socio-anthropological data performed the analysis.

Results

Descriptive statistics

Overall, 174 informants were contacted, although only 160 (91.9%) COVID-19-related deaths were analyzed because acceptance of interviewees and completeness of data. One-hundred nineteen (74.4%) and 41 (25.6%) of these deaths occurred in urban and rural localities, respectively. Gender distribution was not statistically different in both types of communities, although men accounted for 58% (n=69) and 59% (n=24) of deaths in urban and rural localities, correspondingly. No age differences were observed between genders. Overall, 61 out of 93 (65.6%) men, and 13 out of 67 (19.4%) women were active employees two-weeks prior to death, such differences were statistically significant for both urban (p<0.0001) and rural (p=0.0065) localities. Before death occurred, a larger proportion of women (n=41, 82.0%) residing in urban communities attended routine medical checkups than men (n=41, 59.4%) (p=0.0086). According to the informants, 38 of the 160 (23.8%) deceased had recent prior exposure to a suspicious or confirmed COVID-19 case. Table 1.

Table 1. Sociodemographic characteristics and behavioral factors of the study subjects.

Variable	Urban (n=119)		Rural (n=41)	
	N (%)		N (%)	
	Male (n=69)	Female (n=50)	Male (n=24)	Female (n=17)
Age (Geometric mean ± SD)	62.5 ± 13.6	64.9 ± 14.2	63.1 ± 16.4	64.0 ± 9.4
In-state geographic zone of residency				
−North	25 (36.2)	17 (34.0)	2 (8.3)	1 (5.9)
−Central	11 (15.9)	10 (20.0)	9 (37.5)	5 (29.4)
−South	33 (47.8)	23 (46.0)	13 (54.2)	11 (64.7)
Medical care insurance (Yes)	43 (62.3)	31 (62.0)	15 (62.5)	8 (47.1)
Currently employed (Yes)	45 (65.2)	9 (18.0) ***	16 (66.7)	4 (23.5) ***
Marital status (lived without a partner)	21 (30.4) *	25 (50.0)	4 (16.7) *	9 (52.9)
Education level				
−Elementary or middle school	43 (62.3)	30 (60.0)	17 (70.8)	11 (64.7)
−High school	11 (15.9)	8 (16.0)	2 (8.3)	1 (5.9)
−Graduated and/or post graduated	10 (14.5)	5 (10.0)	2 (8.3)	1 (5.9)
−None	5 (7.2)	7 (14.0)	3 (12.5)	4 (23.5)
He/she had contact with a suspicious COVID-19 case	17 (24.6)	14(28.0)	5 (20.8)	2 (11.8)
The patient shared bedroom with more than one person	26 (37.7)	26 (52.0)	16 (66.7)	11 (64.7)
Used public transportation	7 (10.1)	7 (14.0)	3 (12.5)	2 (11.8)
The patient engaged in regular physical exercise	26 (37.7)	14(28.0)	1 (4.2)	4 (23.5)
The patient attended medical examinations to monitor his/her disease	41 (59.4) **	41 (82.0)	13 (54.2)	11 (64.7)
The patient had adequate glycemic and blood pressure control	48 (69.6)	39 (78.0)	19 (79.2)	8 (47.1) *
He/she took medication on a regular basis	45 (65.2)	38 (76.0)	14 (58.3)	16 (94.1) *

Note: a) for categorical variables P-value is based on a Chi-squared two-tailed test for equality of proportions.

b) for the continuous variable p-value is based on a T two-tailed test.

*Statistically significant difference between male and female at the 0.05 level. ** Statistically significant at the 0.01 level.
***Statistically significant at the 0.001 level

On the other hand, the more common symptoms reported by the proxies were shortness of breath (61.9%), fever (59.4%) and cough (54.4%). Among the 160 deceased individuals, 137 (85.6%) of them had a chronic medical condition, being high blood pressure (63.8%) and type 2 diabetes (38.1%) the most frequently reported. Interestingly, all 17 women that resided in rural localities had a known history of high blood pressure prior to their death. Although no significant differences (p=0.5443) were observed between both types of localities, only a low proportion of the population was recommended to return to their health care facility if symptoms worsened, in urban communities it was 39.5% and in rural communities 34.1%. **Table 2**.

Table 2. Health-related characteristics in the study subjects.

Variable	Urban (n=119)		Rural (n=41)	
	N (%)		N (%)	
	Male (n=69)	Female (n=50)	Male (n=24)	Female (n=17)
Initial symptoms that he/she presented.				
−Fever	40 (58.0)	28 (56.0)	15 (62.5)	12 (70.6)
−Cough	35 (50.7)	30 (60.0)	14 (58.3)	8 (47.1)
−Headache	26 (37.7)	22 (44.0)	13 (54.2)	10 (58.8)
−Shortness of breath	39 (56.5)	31 (62.0)	17 (70.8)	12 (70.6)
−Fatigue	35 (50.7)	21 (42.0)	15 (62.5)	9 (52.9)
He/she had any chronic medical condition (Yes)	57 (82.6)	42 (84.0)	21 (87.5)	17 (100)
−High blood pressure	44 (63.8)	27 (54.0)	14 (58.3) *	17 (100)
−Type 2 diabetes	23 (33.3)	22 (44.0)	6 (25.0) *	10 (58.8)
−Obesity	18 (26.1)	22 (44.0) *	9 (37.5)	6 (35.3)
−Cardiovascular disease	14 (20.3)	6 (12.0)	7 (29.2)	0 (0.0)
−Chronic Obstructive Pulmonary Disease	3 (4.3)	1 (2.0)	4 (16.7)	1 (5.9)
Did the physician inform him/her about symptoms of aggravation? (Yes)	29 (42.0)	18 (36.0)	9 (37.5)	5 (29.4)
Was she/he prescribed medication at the first visit to physician? (Yes)	43 (62.3)	29 (58.0)	16 (66.7)	11 (64.7)
Did she/he take remedies or other medications not indicated by a physician? (Yes)	26 (37.7)	23 (46.0)	12 (50)	10 (58.8)
−Natural/home remedies	19 (73.1)	16 (69.6)	11 (91.7)	9 (90.0)
−Drugs	4 (15.4)	5 (21.7)	1 (8.3)	0 (0.0)
−Both	3 (11.5)	2 (8.7)	0 (0.0)	1 (10.0)
Type of healthcare facility attended after onset of symptoms				
−Primary care clinic	2/58 (3.4)	2/47 (4.2)	7/24 (29.2)	1/16 (6.3)
−Pharmacy	15/58 (25.9)	6/47 (12.8)	6/24 (25.0)	4/16 (25.0)
−Emergency room	20/58 (34.5)	22/47 (46.8)	2/24 (8.3)	3/16 (18.7)
−Private physician	21/58 (36.2)	17/47 (36.2)	9/24 (37.5)	8/16 (50.0)
Time (minutes) from home to nearest health facility, Mean ± SD	14.0 ± 10.1	12.3 ± 9.0	17.0± 28.6	14.2 ± 14.7

Note: a) for categorical variables P-value is based on a Chi-squared two-tailed test for equality of proportions.

b) for the continuous variable p-value is based on a T two-tailed test.

*Statistically significant difference between male and female at the 0.05 level.

Regarding the medical care of their disease, two thirds of the study subjects received pharmacological treatment, with no significant differences between urban and rural localities (p=0.5443). After onset of symptoms, first medical contact for individuals living in urban communities most commonly took place in an emergency room (n=42, 40%), whereas for those living in rural communities, attention was initially given by a private primary care physician (doctor's office, domiciliary medical care, pharmacy, etc.) in most cases (n=17, 42.5%) **Table 2**.

Moreover, for the empirical care of the disease, unprescribed natural remedies to treat early respiratory symptoms were taken by 35 (29.4%) and 20 (48.8%) patients that resided in an urban and rural locality, respectively. Some of the domestic remedies most mentioned in the proxies' narratives were hot lemon tea, valerian tea, eucalyptus tea, garlic, and cinnamon, boiled acetylsalicylic acid, among others. **(Table 3)**.

Results from qualitative narratives

According to the interviewees' narratives, the following signs/symptoms were the most perceived as severe and urged the patients or their caregivers to seek for medical attention: having trouble breathing (33.1%), a high fever (8.3%), chest pain/tightness (5.6%), difficulty speaking (4.2%) and 'lack of strength' (4.2%). Of notice, 10.6% of the proxies considered a low oxygen saturation as a sign of severity and explicitly included it in their narratives. Furthermore, some of the interviewees described a misinterpretation, by both caregivers and physicians, of the early clinical picture, which led to a delay in the definite diagnosis of COVID-19. Table 3. Common misdiagnosis included other respiratory diseases, as well as allergic and gastroenterological conditions, as commented in several narratives:

Table 3. Perceptions and attitudes regarding COVID-19 among relatives of study subjects.

Topic		Testimonials
Signs/ symptoms most observed	At home	Cough (68.8%), difficulty breathing (33.1%), fever (31.9%), headache (19.4%), high temperature (18.8%), throat discomfort (16.9%), diarrhea (11.3%), runny nose (6.9%), impaired smell (6.9%), vomit (6.2%), tiredness (5%), taste impairment (3.1%), dehydration (2.5%), nausea (1.9%),
	Before visiting the hospital	Difficulty breathing (33.1%), oxygen saturation levels below normal (10.6%), high fever (8.3%), chest pain (5.6%), difficulty speaking (4.2%), weakness (4.2%)
Confusion with other diseases	Flu	"He just got the flu and isolated himself; he had a high temperature and was taking acetaminophen. He said he wasn´t sick, so he continued to look after his store."
	Allergies	"She was working in Somerton […] since she is allergic, she thought that her initial symptoms were due to her allergies, so she waited a week before she sought for medical attention."
	Gastrointestinal diseases	"She started off with diarrhea, nausea and vomit; she was taken to a private doctor's office, where she was prescribed fluids and gastritis drugs. I took care of her and didn't notice any improvement."
Common self-treatment practices	Alternative treatments	Turning off the air conditioning, warm head rags, hot lemon tea, baths, valerian tea, serums, eucalyptus sprays, mullein tea, garlic, and cinnamon, 3 boiled aspirin with 3 lemons, mullein puffs with eucalyptus, eucalyptus, chamomile or cinnamon teas, massages, sodium bicarbonate/antacid, squash smoothie with cucumber and lemon drops.
	Self-medication	Oxygen use, acetaminophen, tramadol, amoxicillin, ibuprofen, nifedipine, ampicillin, benzonatate, intravenous anti-inflammatory drugs, nebulization, aspirin, metamizole, diclofenac, ambroxol, bonadoxin.
Disbelief regarding COVID-19 as cause of death		"He needed oxygen, but they didn't give it to him. He shouldn't have died, he only had diarrhea; what he was feeling in his throat was just an infection, but it wasn't COVID."

"He just got the flu and isolated himself; he had a high temperature and was taking acetaminophen. He said he wasn´t sick, so he continued to look after his store."
"She started off with diarrhea, nausea and vomit; she was taken to a private doctor's office, where she was prescribed fluids and gastritis drugs. I took care of her and didn't notice any improvement".

Additionally, some people denied the existence of COVID-19 and/or the severity of the disease. Therefore, when it came to explaining the causative factors for their relative's death, they discarded SARS-CoV-2 as one of them:

"It's just that my dad already had issues with his lungs. I believe the cause of death was a respiratory arrest".
"He needed oxygen, but they didn't give it to him. He shouldn't have died, he only had diarrhea; what he was feeling in his throat was just an infection, but it wasn't COVID".

Moreover, deficiencies in the health care system and medical services were frequently addressed in the descriptions provided by the proxies. Unfortunately, some of these limitations derived in troublesome situations:

"He woke up feeling fatigued […] and I called my dad so we could take him to the health care unit […] they didn't want to assist him because there weren't any oxygen masks available at the center. His oxygen was at 45%, so I began to give him mouth to mouth breathing, and his oxygen went up to 72%. Everyone just looked at me, but nobody did a thing. The nurses pulled me off from him because they said he was going to infect me with COVID. I asked them to transfer him to a hospital, but they said they couldn't do that because the only ambulance available was reserved for pregnant women. We had to take off in our car […] when we reached the hospital, they said that it was too late. This all happened because the health care unit workers didn't do anything".

Discussion

The COVID-19 pandemic has been an emphatic reminder of health disparities found all over the world. In Latin American countries, social gaps result in differences regarding health outcomes[17-18]. Our findings showed that COVID-19 deaths were differentially distributed in Sonora, with a higher proportion in people who lived in urban locations, were male, or had a chronic medical condition, particularly high blood pressure (HBP) or type 2 diabetes (T2D). Such characteristics could be linked with perceptions related to disease-care from caregivers and patients themselves, which could delay both medical attendance and reinforce reluctance to fulfill preventive measures.

Moreover, we found that the presence of a chronic medical condition, mainly HBP or T2D, could explain the high impact that the COVID-19 pandemic had over Mexican adults. Our finding could be explained by the fact that key medical risk factors for mortality in COVID-19, such as diabetes, obesity, and hypertension, are equally distributed across Mexican communities. According to the 2018 National Health and Nutrition Survey, 3 out of 10 Mexican adults have a known diagnosis of high blood pressure (33% and 35% in rural and urban localities, respectively), and 7 out of 10 have some degree of overweight or obesity in rural (70%) and urban (77%) areas, respectively[6].

Although there were no substantial differences between rural and urban localities, some of the narratives included in the interviews do suggest the existence of social disparities in the patient care process, including less access to educative interventions to accomplish with preventive measures such as wearing a mask, sanitized their home, and keeping safe social distance, which has been associated with the occurrence of COVID-19 cases and deaths[19]. Furthermore, during the pandemic, rural places were more vulnerable, as their communities tend to have a higher percentage of elderly people and they have constraint in access to medical facilities, particularly at more advanced stages of illness[20].

On the other hand, prior to their decease, a significantly larger proportion of men attended a workplace when compared to women. Local and national health authorities encouraged businesses to keep their workers at home, especially those with risk factors. However, according to official statistics, 56% of the economic active population (EAP) in Mexico has an informal employment[21], in which neither worker benefits nor social protection are guaranteed. Moreover, 71% of Mexican families have a male figure as head of the household[22]. Given such a context, it is likely that a large proportion of men had to continue working outside of their homes, regardless of the COVID-19 situation. This by itself represents a risk factor for infection, as common workplaces are usually overcrowded (i.e., food markets, flea markets) or require interaction with many strangers (i.e., taxi driver, food deliveryman). Furthermore, 8 out 10 men included in our study had at least one medical condition considered as a risk factor

for mortality in the context of a SARS-CoV-2 infection, which may increase the risk for fatal outcomes. Overall, it has been already documented than men are more vulnerable to the clinical severity of COVID-19 than women[23-24].

A complex interaction between biomedical and environmental characteristics exacerbates vulnerability of certain groups of workers living in socioeconomic lag, which may turn them out medically underserved; such interaction should be routinely addressed in local public health strategies to cope COVID-19[25-26]. Larochelle[27] proposed a framework for counseling patients about working during the pandemic, suggesting that both individual and occupational characteristics contribute to the risk of death from SARS-CoV-2. Our findings indicate that, during the COVID-19 pandemic, Mexican men have faced challenges that encompass medical, social, cultural, and economic aspects, all which might help explain the higher mortality rate for this gender in the study setting.

From another point of view, behaviors and attitudes regarding COVID-19 have differed in our study between genders. Compared to men, a larger proportion of women approached the disease as a serious health problem. Across the world, the range of agreement with restraining measures, as well as the compliance of sanitary recommendations, have also been higher in females[28]. Differences in risk perception are critical to succeed in agreeing public health policies, understanding such differences can help to overcome barriers imposed by regional disparities in education, personal and collective income, and geographic location[29].

It is important to recognize that community perceptions and beliefs regarding COVID-19 are not limited to the disease itself and can be a consequence of the way in which the health system responded to the pandemic. Popular opinion seems to display a degree of distrust in health institutions and the quality of the services they provide. This perception may explain why some patients delayed seeking care. Other attitudes mainly based on misinformation were denial of the pandemic, reluctance to comply with preventive measures, refusal to take certain medications and to receive in-hospital treatment when needed, all of which could be related to the observed differences in the distribution of mortality from COVID-19 that occurred in the study setting.

In Mexico, the discontent towards health services has grown substantially over the last few years. A recent study showed that 3 out of every 4 Mexicans are unsatisfied with the quality and access to health services, which often leads them to seek for alternatives, such as home remedies and self-medication[30], these attitudes were also frequently observed in our study subjects. This perception is not exclusive of low-and middle- income countries. As exhibited by public-opinion data, only 23% and 34% of the American population have trust in the United States health system and their physicians, respectively[31]. Undoubtfully, the COVID-19 pandemic enhanced public distrust, which was boosted by the emergence of myths, misinformation and conspiracy theories surrounding the disease, all of that fueled by the wide use of social media[32].

Our study has some limitations. First, due to the retrospective assessment obtained by VA, our study may be prone to recall bias. Secondly, although interviewers received training prior to the conduction of VA, differences between their individual skills and capacities could have resulted in a nondifferential misclassification in data collection and registration. Moreover, the study only represents a small piece of the 10,366 registered deaths up to August 31st, 2023, in 63 out of the 72 municipalities of Sonora, and other locations may have different results. Thirdly, our study design may have an information bias due to an under-analysis of qualitative data. Finally, because the non-probabilistic selection of the study subjects we are not able to generalize our findings.

Conclusions

Our study on a series of COVID-19 deaths, exposed unequal distribution of chronic diseases, gender and occupational differences, as well as socioeconomic gaps in Sonora, Mexico. The COVID-19 pandemic has challenged social and cultural structures, scientific knowledge, public policies, and a myriad of daily live aspects. However, a disproportionate burden of morbidity and mortality has fallen over vulnerable populations, deepening inequalities in healthcare and challenging health systems to address the epidemiological and social impact of the disease.

Author contribution

Conceptualization: GAH, DIAL. Investigation: GAH, DIAL, MPEM. Supervision: GAH, BJMC, PAG. Writing-original draft: GAH, DIAL, MPEM. Writing-review & editing: GAH, DIAL, MPEM, PAG, MCCP.

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Ethical considerations

The Sonora Health Secretariat exempted the study from ethical evaluation. However, because public data were used, procedures to ensure anonimity and confidentiality were performed.

Conflict of interests

The authors declare that there is not any conflict of interest.

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The authors report that they did not use Artificial Intelligence, language models, machine learning or similar technologies to create or assist with the elaboration or editing of any of the contents of this document.

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