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Analysis of Fatality of Cases by the New Coronavirus, in the Mexican State of Guanajuato: A Cross-sectional Study

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Authors' contributions

This work was carried out in collaboration among all authors. Author NPR designed the protocol, analyzed the data and wrote the first draft of the manuscript. Author GFV participated in the analysis of data and writing of the first draft of the manuscript. Author ENO participated in the analysis of data and writing of the first draft of the manuscript. Author MJGL participated in the writing of the protocol, reviewing the database and writing of the first draft of the manuscript. Author FJMV obtained the database and participated in analysis of data and writing of the first draft of the manuscript. Author DADM reviewed the protocol, searched the literature and participated in the writing of the first draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: COVID-19 has been a big public health challenge around the world in the past several months. The aim of this study is to describe the epidemic and report of fatality of confirmed cases of COVID-19 in the Mexican state of Guanajuato, until October 2, 2020.

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Study Design: Cross-sectional, quantitative, analytical study.
Place and Duration of Study: Registries of confirmed cases for COVID-19 in Mexican population from January until October 2, 2020, from National System of Epidemiological Surveillance/ General Direction of Epidemiology/ Secretary of Health, Mexico.
Methodology: Based on the National Epidemiological Surveillance System Database from Mexico was used in this study. Data were collected on age, sex, comorbidities (i.e., diabetes, chronic obstructive pulmonary disease, asthma, hypertension, cardiovascular disease, immunosuppression, chronic kidney disease, obesity, and smoking), date of death, and real-time reverse transcription polymerase test results. Statistical analyses used were Case Fatality Ratio, Chi- squared test and P-value to show relationships among variables. Odds Ratio and confidence intervals at 95% were reported to show the effect of comorbidities on death due to COVID-19. Also, a Bayesian network model was fitted to assess the statistical dependence among risk factors, comorbidities, and death.
Results: There were 100,109 suspected cases, of which 41.69% were positive for SARS-CoV-2. Being older than 60 and male had a higher effect on fatality by COVID-19. In Guanajuato state, 1,457 (48.68%) of deaths occurred in Mexican Institute of Social Security, with a case fatality ratio of 15.63%; meanwhile, in the Ministry of Health from Guanajuato State occurred 1,260 (42.10%) of the deaths with a case fatality ratio of 4.14%. Diabetes (OR 5.16, CI95% 4.77–5.59), chronic obstructive pulmonary disease (OR 6.34, CI95% 5.37–7.49), immunosuppression (OR 2.85, CI95% 2.17–3.76), cardiovascular disease (OR 4.20, CI95% 3.51–5.02), hypertension (OR 4.74, CI95% 4.39–5.11), chronic kidney disease (OR 6.27, CI95% 5.30–7.42), obesity (OR 1.87, CI95% 1.72–2.03), and smoking (OR 1.60, CI95% 1.41–1.81) had effect on death by COVID-19. Asthma had a preventive effect on death (OR=0.72, CI95% 0.54–0.97), but this effect is diluted after adjusting by sex and age. In all cases, age and sex, acted as confounder.
Conclusion: Among the Guanajuato population with COVID-19, the main risk factor for dying were age and sex. However, diabetes, chronic obstructive pulmonary disease, immunosuppression, cardiovascular disease, chronic kidney disease, obesity, and smoking are risk factors for dying. Although, comorbidities and risk factors are highly correlated. HIV/AIDS has no effect on fatality from SARS-CoV-2 disease and whereas asthma shows to be a protective factor.

Keywords: Clinical data; COVID-19; fatality; population; SARS-CoV-2.

1. INTRODUCTION

In November 2019, an outbreak of pneumonia of unknown cause was reported in Wuhan, China [1]. Shortly afterwards, it was announced that the cases were due to a new coronavirus firstly called the new coronavirus and later re-named as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [2], and that it caused a disease now known as coronavirus disease 2019 (COVID-19) [3].

In Mexico, the first confirmed case was reported on February 20, 2020 and the first deaths were reported on March 18, 2020 [4]. In Guanajuato state, which is in the center of Mexico, the first confirmed case of COVID-19 was reported at the beginning of clinical data on March 10, 2020 and two deaths were registered on April 5, 2020 [5,6].

Up to June 30, 2020, in Mexico 226,089 confirmed cases of COVID-19 and 27,769 deaths due to this disease were reported. In Guanajuato state, by the same date, 7,336 confirmed cases and 359 deaths were reported [7]. According to the 2010 census [8], Guanajuato had 5,486,372 inhabitants, which represented 4.88% of the Mexican population.

While the fatality ratio in Mexico was high (12.28%), worldwide it was 4.9%, and geographically it was as follow: 2.0% in Africa, 4.8% in America, 2.3 % in Eastern Mediterranean, 7.3% in Europe, 2.8% in South-East Asia and 3.5% in Western Pacific, as reported by World Health Organization (WHO) for June 30, 2020 [9].

Faced with the arrival of the pandemic to Guanajuato, in March 2020, the state civil authorities initiated preventive actions such as social isolation, staying at home; closure of educational institutions of all levels as of March 20, 2020. A week later, restaurants, gyms, public parks were all closed and the cancellation of massive events and meetings with more than 10 participants occurred. These actions slowed the spread of the infection in the state.

Nevertheless, the numbers of confirmed cases increased, and it was decided on March 27 to open a hospital to exclusively serve COVID-19 patients, being the first state in Mexico to have an exclusive hospital for patients with COVID-19. At the same time, several hospitals were converted to COVID-19 reference hospitals at the state level. Additionally, on June 22, the COVID Mobile Hospital began operations in Guanajuato state, also dedicated to treat the same type of patients. These actions: preparation, equipment, supplies, human resources for the care of hospitalized COVID-19 patients, and the on-time hospitalization, are likely the reasons behind the low Case Fatality Ratios (CFR) observed in previous reports [10] compared to that reported throughout Mexico.

The objective of this study was to analyze the fatality rate and the effect of comorbidities on it, among confirmed cases of COVID-19 in Guanajuato State from Mexico, up to October 2, 2020.

2. METHODOLOGY

This is a cross-sectional analytical study of fatality in confirmed cases due to COVID-19, in the Mexican state of Guanajuato. Information on confirmed and discarded cases of COVID-19 comes from the database of the National System of Epidemiological Surveillance (NSES) from the General Directorate of Epidemiology (GDE) [11].

The considered registries included the confirmed cases and deaths registered as caused by COVID-19 in Guanajuato state up to October 2, 2020. The database from NSES is the registry of all the suspected, confirmed, and discarded cases of COVID-19, from the Secretary of Health in Mexico.

The selected records in the analysis were those registries with complete data. There were no exclusion criteria. The records with missing data were eliminated for the analysis.

According to the guidelines of NSES/GDE, a suspected case was one with a clinical finding considered primary (cough, fever, headache, or dyspnea), accompanied by at least one of the following: myalgia, arthralgia, odynophagia, chills, chest pain, rhinorrhea, anosmia, dysgeusia or conjunctivitis [12].

A confirmed case of COVID-19 is a person with a positive result to a rRT-PCR test for SARS-CoV-2, regardless of the clinical data presented [12].

The institutions that registered cases of COVID-19 in Guanajuato state were the Mexican Institute of Social Security (MISS), Ministry of Health of Guanajuato State (MHGS), Institute of Social Security and Services for the State Workers (ISSSSW), Mexican Oil (MO), Ministry of National Defense (MND), Ministry of Marine (MM), private institutions and MISS-Opportunities.

The sociodemographic variables, age and sex, were included and the independent variables, the presence of comorbidities (i.e., diabetes, chronic obstructive pulmonary disease, asthma, immunosuppression, hypertension, cardiovascular disease, renal chronic disease, obesity, smoking), health system where the patient was attended, if the patient was in an Intensive Care Unit (ICU) and result positive to rRT-PCR test.

The dependent variables were the date of death and COVID-19 as cause of death, registered in the NSES/GDE database [11].

2.1 Procedures

After approval by the Research Ethics Committee of the Campus Celaya-Salvatierra of the University of Guanajuato, the Excel ® (Microsoft Corp.), database was reviewed and it was copied to the STATA 13.0 ® database (Stata Corp., College Station, TX, USA). All procedures were according to the General Law of Health (Mexico) and Declaration of Helsinki.

2.2 Statistical Analysis

Descriptive statistics were performed for all variables and an epidemiological curve was designed for confirmed cases with a date of death. Case Fatality Ratio was computed, by health institution, with the number of deaths over total of confirmed cases of COVID-19. Tabulation of comorbidities for confirmed cases and death was performed. To show associations of comorbidities and deaths between confirmed and discarded cases, the Chi-squared statistic test was calculated, and the degrees of freedom and P-value are presented; in cases where the Chi-squared test was not performed, the Z test for two proportions was calculated. To show the effect of the comorbidities on deaths in confirmed cases, Odds Ratio (OR) and 95% confidence intervals (95% CI) were calculated.

Logistic regression models were generated, and it was determined whether age group and sex acted as confounders, with the Likelihood Ratio Test (LRT) and P-value.

A Bayesian network model was fitted to study the conditional probabilities of comorbidities and death. For this purpose, the implementation in the package bnlearn in R 3.6.3 was used [13]. The structure learning of the network was performed applying the function hc taking the edges departing from the variable Death as blacklisted. The function bn.fit was used to fit the model by the maximum likelihood estimators. The R code is available under request.

In all cases, to demonstrate statistical significance, the alpha value was set at 0.05.

Statistical analysis was performed in STATA 13.0 (Stata Corp., College Station, TX, USA) and R 3.6.3.

3. RESULTS AND DISCUSSION

A total of 100,919 records were obtained from the NSES/GDE database up to October 2, 2020 [11] but 810 records (0.8%) were eliminated due the absence of the rRT-PCR test result. As a result, 100,109 records were used as suspected cases.

From the 100,109 suspected cases, 41,734 (41.69%) tested positive to SARS-CoV-2.

Table 1 shows that among those who died due to COVID-19, those over 60 years old predominated with 61.75% and men with 64.62%. Among the confirmed cases that did not die, those aged between 12 and 49 (67.45%%) years and female (52.62%) predominated.

The number of deaths stayed at relatively low levels from March to May 2020, with fewer than 10 deaths per day, but they increased notably as of June 2020, reaching more than 50 deaths in a single day in July 2020 (Fig. 1).

72.89% of the confirmed cases in the state were treated by the MHGS, 22.33% by the MISS. 2.52% by ISSSSW, 1.66% by private institutions, 0.88% by MO. Regarding the confirmed death cases, those attended by the MISS of the state of Guanajuato (48.68%) predominated, followed by those attended by the MHGS (42.10%) (Table 2).

Most of the confirmed cases to COVID-19, 35,289 (84.56%), received an ambulatory treatment; the remaining, 6,445 (15.44%), were hospitalized. Among those hospitalized, 2,348 (78.45%) died, and 645 (21.55%) of those who received ambulatory treatment died (OR 30.78 con 95%CI 28.05 -33.78).

Only 12.90% of the confirmed cases who died were accessed to the ICU (Table 3).

Following the elimination criteria, the percentage of deleted records is small (less than 0.5% per comorbidity and risk factor), which does not affect the result of the statistical analyses.

Table 1. Distribution of deaths due to COVID-19, by age group and sex

Variable	Deaths		No deaths		X^2 (df) P-value	Z for two proportions (P-value)
	n	%	n	%		
Age group (years)					NA	
0 a 2	7	0.23	266	0.69		-3.00 (.003)
3 a 5	1	0.03	261	0.67		-4.28 (.00001)
6 a 11	0	0.00	553	1.43		-6.59 (.00001)
12 a 49	485	16.20	26,129	67.45		-56.20 (.00001)
50 a 59	652	21.78	6,063	15.65		8.79 (.00001)
60 to 69	1,225	40.93	4,279	11.05		46.54 (.00001)
70 or higher	623	20.82	1,190	3.07		45.90 (.00001)
Sex					330.41 (1) .0001	
Male	1,934	64.62	18,356	47.38		
Female	1,059	35.38	20,385	52.62		

Source: NSES/GDE [11]

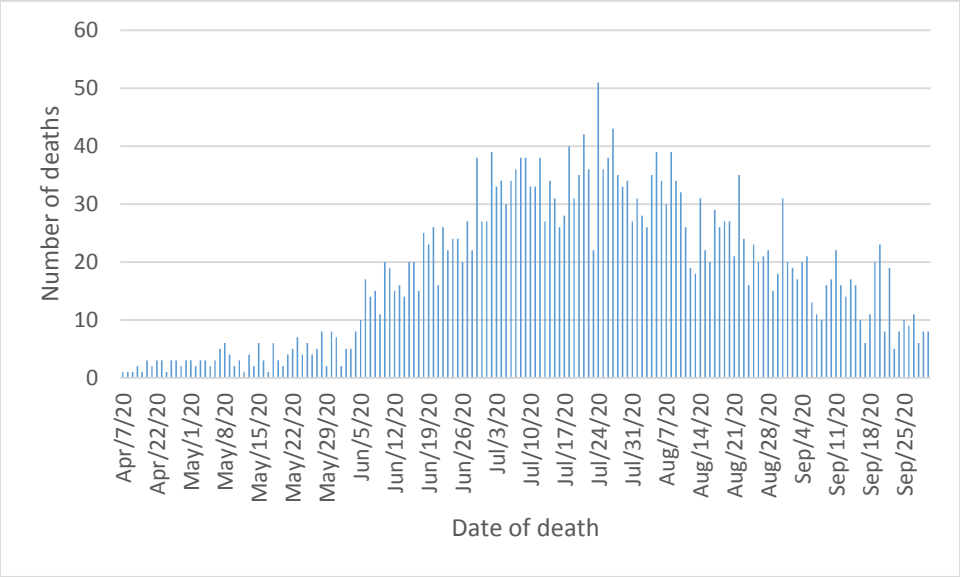

Fig. 1. Epidemiological curve of deaths by COVID-19 until October 2, 2020 (n=3,728)
Source: NSES/GDE [11]

Table 2. Distribution of deaths due to COVID-19 by health care system in the state of Guanajuato

System	Deaths		No deaths		Case Fatality Ratio
	n	%	n	%	%
Mexican Institute of Social Security	1,457	48.68	7,862	20.29	15.63
Ministry of Health Guanajuato State	1,260	42.10	29,159	75.26	4.14
Mexican Oil	44	1.47	324	0.84	11.96
Institute of Social Security and Services for State Workers	36	4.90	1,017	1.76	3.42
Ministry of Marine	13	0.43	107	0.28	10.83
Ministry of National Defense	1	0.03	2	0.01	33.33
Private	73	2.44	621	1.60	10.52

Source: NSES/GED [11]

Table 3. Distribution of confirmed COVID-19 cases by admission to the Intensive Care Unit

Was in ICU?	Deaths		No deaths		X^2(df) *P*-Value	OR (95%CI)
	n	%	n	%		
Yes	303	12.90	208	5.08	125.28 (1) .0001	2.77
No	2,045	87.10	3,889	94.92		(2.30 – 3.33)

ICU Intensive Care Unit df Degree of freedom OR Odds Ratio CI95% Confidence intervals 95%
Source: NSES/GDE [11]

Among the confirmed COVID-19 cases, it was found that the greatest effects are obtained by chronic kidney disease, COPD, diabetes, hypertension, and cardiovascular disease with OR higher than 5. For immunosuppression conditions, the OR was 3.91. In all the models that included these comorbidities, age group and sex acted as confounders. Considering obesity and smoking as risk factors for death caused by COVID-19, the OR were 2.20 and 1.71, respectively. Asthma showed a protective effect to death due to COVID-19 (Table 4).

Table 4. Distribution of comorbidities and deaths among confirmed cases of COVID-19, OR and adjusted by age and sex

Comorbidity	Deaths		Non-deaths		X^2 (df) P-value	OR (95%CI)	OR (95%CI) adjusted by age group	OR (95%CI) adjusted by sex	OR (95%CI) adjusted by age and sex
	n	%	n	%					
Diabetes					2000	5.16	2.35	5.23	2.44
Yes	1,250	41.82	4,733	12.22	(1)	(4.77 – 5.59)	(2.16 - 2.57)	(4.84 – 5.67)	(2.23 – 2.66)
No	1,739	58.18	33,997	87.78	.0001				
COPD					615.21	6.34	1.57	6.64	1.67
Yes	214	7.16	465	1.20	(1)	(5.37 – 7.49)	(1.31 - 1.88)	(5.61 – 7.86)	(1.38 – 2.01)
No	2,776	92.84	38,272	98.80	.0001				
Asthma					4.72	0.72	0.64	0.78	0.70
Yes	47	1.57	839	2.17	(1)	(0.54 - 0.97)	(0.47 - 0.88)	(0.58 -1.05)	(0.51 – 0.96)
No	2,944	98.43	37,900	97.83	.03				
Immunosuppression					61.06	2.85	1.94	2.92	2.01
					(1)	(2.17 – 3.76)	(1.42 – 2.63)	(2.21 – 3.85)	(1.47 – 2.75)
Yes	63	2.11	290	0.75	.0001				
No	2,927	97.89	38,447	99.25					
Hypertension					1.800	4.74	1.90	4.80	2.00
Yes	1,406	47.01	6,110	15.77	(1)	(4.39 – 5.11)	(1.74 – 2.07)	(4.44 – 5.19)	(1.83 – 2.18)
No	1,585	52.99	32,626	84.23	.0001				
HIV/AIDS					1.24	0.60	0.49	0.54	0.44
Yes	5	0.17	107	0.28	(1)	(0.25 – 1.48)	(0.19 – 1.26)	(0.22 – 1.32)	(0.17 – 1.14)
No	2,987	99.83	38,626	99.72	.3				
CVD					294.12 (1)	4.20	1.61	4.13	1.61
Yes	167	5.58	538	1.39	.0001	(3.51 - 5.02)	(1.32 – 1.96)	(3.45 – 4.94)	(1.32 – 1.96)
No	2,824	94.42	38,199	98.61					
Obesity					219.59 (1)	1.87	1.84	1.92	1.97
Yes	844	28.21	6,729	17.37	.0001	(1.72 - 2.03)	(1.68 – 2.02)	(1.77 – 2.09)	(1.80 – 2.16)
No	2,148	71.79	32,007	82.63					

Comorbidity	Deaths		Non-deaths		X^2	OR	OR	OR	OR (95%CI)
Chronic kidney disease					594.13 (1) .0001	6.27 (5.30 – 7.42)	4.19 (3.46 - 5.09)	6.02 (5.08 – 7.14)	4.32 (3.57 – 5.23)
Yes	209	6.99	459	1.18					
No	2,780	93.01	38,280	98.82					
Smoking					56.15 (1) .0001	1.60 (1.41 - 1.81)	1.50 (1.31 - 1.72)	1.39 (1.23 -1.58)	1.27 (1.10 – 1.46)
Yes	312	10.44	2,632	6.80					
No	2,677	89.56	36,100	93.20					

COPD Chronic Obstructive Pulmonary Disease CVD Cardiovascular Disease df Degree of freedom
Source: NSES/DGE [10]

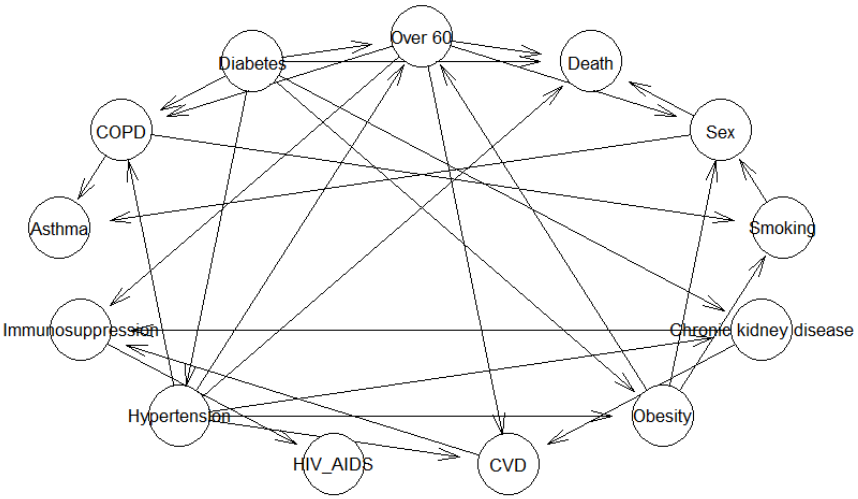

Fig. 2. Inferred Bayesian Network of comorbidities, risk factors, and death by COVID-19

Fig. 2 shows the resulting network using the package bnlearn [13]. According to the algorithm, Hypertension, Diabetes, being over 60 years old, and Sex have a major impact on death. Also, the relation between comorbidities and risk factors can be observed.

Once the model is fitted, the probability of death given that a subject with COVID-19 is male, is over 60 years, has Diabetes and Hypertension, is nearly 0.37. From the diagram, it can be concluded that according to the data, Death and Asthma are statistically independent given the sex.

Worldwide, at the time of this study, confirmed cases have been reported in 215 countries with 34,161,721 cases, of which there have been 1,016,986 deaths, with a case fatality ratio of 2.98%. In Mexico, there have been 753,090 confirmed cases with 78,492 deaths reported, with a case fatality ratio of 10.42% [14].

In the Guanajuato population, as of October 2, 2020, 41,734 confirmed cases had been detected, of which 2,993 died, having a case fatality ratio of 7.17%.

Advanced age is a risk factor for dying due to COVID-19 [15,16]. In the Guanajuato population, 40.93% of the deaths were in persons aged 60 to 69 years and 20.82% in persons aged 70 or over (Table 1), confirming that the highest fatality is in ages over 60 years.

Male has also been considered as a risk factor for severity of COVID-19 or fatality from the same disease; 67.4% of the deceased were men according to Bienvenu et al. report [17] and in the Guanajuato population, 64.62% of the deceased were men (Table 2). Male patients with COVID-19 presented more symptomatic and with a more severe disease, with higher mortality rates [17].

On June 1, 2020 throughout Mexico the social distancing campaign was concluded, and this led to an increase in confirmed cases and deaths due to COVID-19 as shown in Fig. 1, starting in June, deaths increased, with the month of July showing the highest daily numbers of deaths.

In the state of Guanajuato, confirmed cases were treated more frequently in MHGS, MISS, ISSSSW [11] and the CFR were quite different between institutions; MHSG despite attending to most of the confirmed cases (72.89%) in the state, the CFR was much lower than in the MISS (4.1 and 15.63%, respectively) (Table 2).

Smoking showed a significant relationship on fatality due to COVID-19 and the effect on fatality was that those who died were almost twice as likely to have been smokers (Table 4). Despite reports of absence of association between smoking and severity of COVID-19 by Liuppi and Henry [18], in further analysis of that data, by Guo [19], a significant association between smoking and COVID-19 severity was shown and is considered the most important risk factor [20].

Some risk factors for dying from COVID 19 have been identified as obesity, diabetes, and cardiovascular disease [21-22]. SARS-CoV-2 enters the cell by binding to the angiotensin converting enzyme 2 (ACE2). ACE2 dysregulation in diabetes can predispose one to

severe lung damage [23] and this protein has a protective role in diabetes and cardiovascular disease [24], losing this effect in the presence of SARS-CoV-2 helps explain why people with diabetes and vascular disease have worse clinical outcomes [25].

It is reported that during the COVID-19 pandemic, there has been an increment in the number of deaths from cardiovascular disease, mainly acute myocardial infarctions [26]. In Fardman et al. [27] it is also shown that there is an increase of acute myocardial infarctions post-COVID-19.

Among the confirmed death cases, 47.1% had hypertension, 41.82% diabetes, and 28.21% obesity (Table 4), confirming that people with these pathologies develop more severe consequences by COVID-19 [26].

The effect of comorbidities in relation to death from COVID-19 showed a significant effect for all, except asthma and HIV / AIDS, with ORs greater than 1 (Table 4). HIV / AIDS did not show any effect on fatality of cases and asthma showed a protective effect for dying from COVID, which has been consistent in the Mexican population [5,26].

Asthma is a protective factor against death in the Mexican population. But this effect disappears after adjusting the model by sex and age. Nevertheless, in the database analyzed there are no distinctions among slight, moderate, or severe asthma, which could be a bias in the analysis. Also, another possible bias is that the prevalence of asthma is higher among women than in men [28].

When analyzing age and sex as potential confounders of the different pathologies, both showed that they have a confounding effect on the effect of comorbidities on fatalities from COVID-19 (Table 4). And this is explained by the fact that age and sex are known to be risk factors for dying from SARS-CoV-2 disease [15,16].

Given the high correlations among comorbidities and risk factors, it is advisable to consider these characteristics when analyzing deaths due to COVID-19. Fig. 2 gives a more detailed landscape on these relations.

3.1 Strengths

Some cases were eliminated from the analysis because they did not have the rRT-PCR result (0.8%), and some others did not have data about comorbidities. However, they were low percentages, none reached 0.5%, so they did not affect the result.

The number of records is large, which gives greater strength to the statistical analysis of the data, which is reflected in the narrow 95% confidence intervals.

The analysis of comorbidities and risk factors using Bayesian networks provides a wider picture on the phenomenon of death due to COVID-19 by showing the statistical relations among them.

3.2 Weaknesses

When using a Mexican government database, the quality of the data depends on who collected the information, considering that they are official data for the state of Guanajuato and that they may be subject to bias. In the database the severity of asthma is not registered and the protective effect on death could be a bias.

4. CONCLUSION

Among the Guanajuato population with COVID-19, it is confirmed that being older than 60 and male are risk factors for dying.

Diabetes, COPD, immunosuppression, cardiovascular disease, chronic kidney disease, obesity, and smoking are risk factors for dying from COVID-19 in the Guanajuato population.

HIV / AIDS has no effect on fatality from SARS-CoV-2 disease. From the mentioned risk factors and comorbidities, most of theirs effects may be due to the relation among them.

Asthma is shown as a protective factor for dying from COVID-19 in the Guanajuato population, which had already been reported in the Mexican population. Nevertheless, most of this protective effect may be due to the relation among asthma and sex.

Studies and monitoring on comorbidities and risk factors are crucial actions to mitigate the current COVID-19 pandemic. Most of them are noncommunicable diseases that must be addressed not only to avoid deaths due to COVID-19 but to provide a better quality of life.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

Informed consent was waived by Ethics committee. Informed consent was not used because only work with database from Secretary of Health. Personnel identifiers were not obtained.

ETHICAL APPROVAL

The protocol was approved by Bioethics Committee of Campus Celaya-Salvatierra of the University of Guanajuato with registry CBCCS-05230042020.

DATA AVAILABILITY

The dataset supporting the conclusions of this article is available in the Open Science Framework repository [29], Padilla-Raygoza N. Analysis of mortality in Guanajuato population until October 2, 2020. OSF. 2020. Doi: http://doi.org/10.17605/OSF.IO/RU2ZF].

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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