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Risk of hospitalization and mortality due to COVID-19 in people with obesity: An analysis of data from a Brazilian state

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Abstract

The aim of this article is to assess the odds ratio of hospitalization and mortality due to COVID-19 in people with obesity using data from residents of Espírito Santo, Brazil. An observational, quantitative, cross-sectional study was carried out from the database available on the official channel of the State Health Secretariat of Espírito Santo. Crude odds ratio estimates (ORs) referring to the association between variables were calculated, as well as adjusted odds ratios (adjusted odds ratios—OR adj.) and their respective 95% confidence intervals (CI 95%). The results indicate that men, non-white, no education or with lower education level and age over 40 years old were more likely to be hospitalized and died of COVID-19. People with obesity are at risk of hospitalization and death due to COVID-19 54% and 113% higher than people who do not have obesity. People with obesity had a higher chance of hospitalization when they were over 40 years old, had breathing difficulty, and the comorbidities diabetes (2.18 higher) and kidney disease (4.10 higher). The odds ratio of death for people with obesity over 60 years old was 12.51 higher, and those who were hospitalized was 17.9 higher compared to those who were not hospitalized.

Introduction

The hospitalization and mortality rates due to COVID-19 have varied considerably due to several aspects, such as age group, current comorbidities, socioeconomic conditions, among other characteristics [1–6]. Regarding comorbidities, chronic diseases such as diabetes, coronary heart -disease and obesity have been associated with the worst prognosis for the disease [7–11].

When the first studies on risk factors for the severity of the disease began to be published, obesity was identified as one of those in which the risk of hospitalization and death increased,

painel-covid-19-es. The authors confirm that they did not have any special access privileges.

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which throughout the pandemic period was confirmed by different systematic reviews [12–14]. However, few published studies that investigate the role of obesity as a risk factor for the severity of COVID-19 were carried out in Brazil. Carneiro et al (2021) investigated the relationship between overweight and obesity with the COVID-19 mortality rate in Brazilian states [15]. The authors found a positive and significant correlation between the variables. Souza et al (2021) in a study carried out with information on notified cases of the disease, noticed that individuals with heart disease, diabetes and declining age present a worse health outcome; in addition, they identified that socioeconomic conditions would also be associated with a worse outcome. Thus, they conclude that COVID-19 affects different population groups differently and unequally [16].

Thus, considering the high prevalence of people with overweight and obesity in Brazil, added to the still out-of-control pandemic context, it is important to know the factors related to hospitalization and death in people with obesity, to establish protection mechanisms for this population.

In this context, this cross-sectional study aims to assess associated odds ratio of hospitalization and mortality due to COVID-19 in people with obesity based on data from Espírito Santo residents, Brazil.

Method

This is an observational, quantitative, cross-sectional study, conducted from the database available on the official channel of the Health Department of Espírito Santo Government, "COVID-19 Panel", for the dissemination of coronavirus cases in state level (https://coronavirus.es.gov.br/painel-COVID-19-es). The COVID-19 Panel is a system developed by government and powered by the eSUS/Health Surveillance System (eSUS/VS), which records all suspected and/or confirmed cases of COVID-19 in the state of Espírito Santo (ESPÍRITO SANTO, 2020) from notification forms filled out by health professionals from health units throughout the state.

This study included all patients confirmed by COVID-19 in Espírito Santo, until September 10th, 2020, which corresponded to 118,138 cases, according to Fig 1. The confirmation and notification of cases followed the criteria of Technical Note COVID-19 No. 29/2020 –GEVS/SESA/ES, elaborated by Health Department of Espírito Santo: 1. Case confirmed by laboratory diagnosis: the positive result Reverse Transcription—Polymerase Chain Reaction (RT-PCR) in real time per validated protocol; or the positive validated serological test (rapid test). 2. Case confirmed by clinical-epidemiological diagnosis: suspected case with a history of close or home contact with a laboratory confirmed case for COVID-19 [17]. Individuals with a confirmed diagnosis for COVID-19 and who had the evolution of the case closed (cure or death by COVID-19) were selected for this study. Therefore, all those who were still undergoing treatment for the disease, without information or who died of other causes, were excluded.

The study variables were derived from the eSUS/VS System notification forms, considering the following patient data: age group, gender, race/color, education level, signs and symptoms (defined by the database the options: fever, breathing difficulty, cough, running nose, sore throat, diarrhea and headache), comorbidities (defined by the database the options: lung disease, cardiovascular disease, kidney disease, diabetes, smoking, obesity), hospitalization (yes / no) and evolution (cure / death by COVID-19). This study was based on the STROBE guidelines for reporting observational studies [18].

Considering the study design, cross-sectional, the study population was observed only once and information regarding the outcome and exposure was collected at the same time. Thus, this study is a Fig 1 of the population and the associations which were noticed here do not

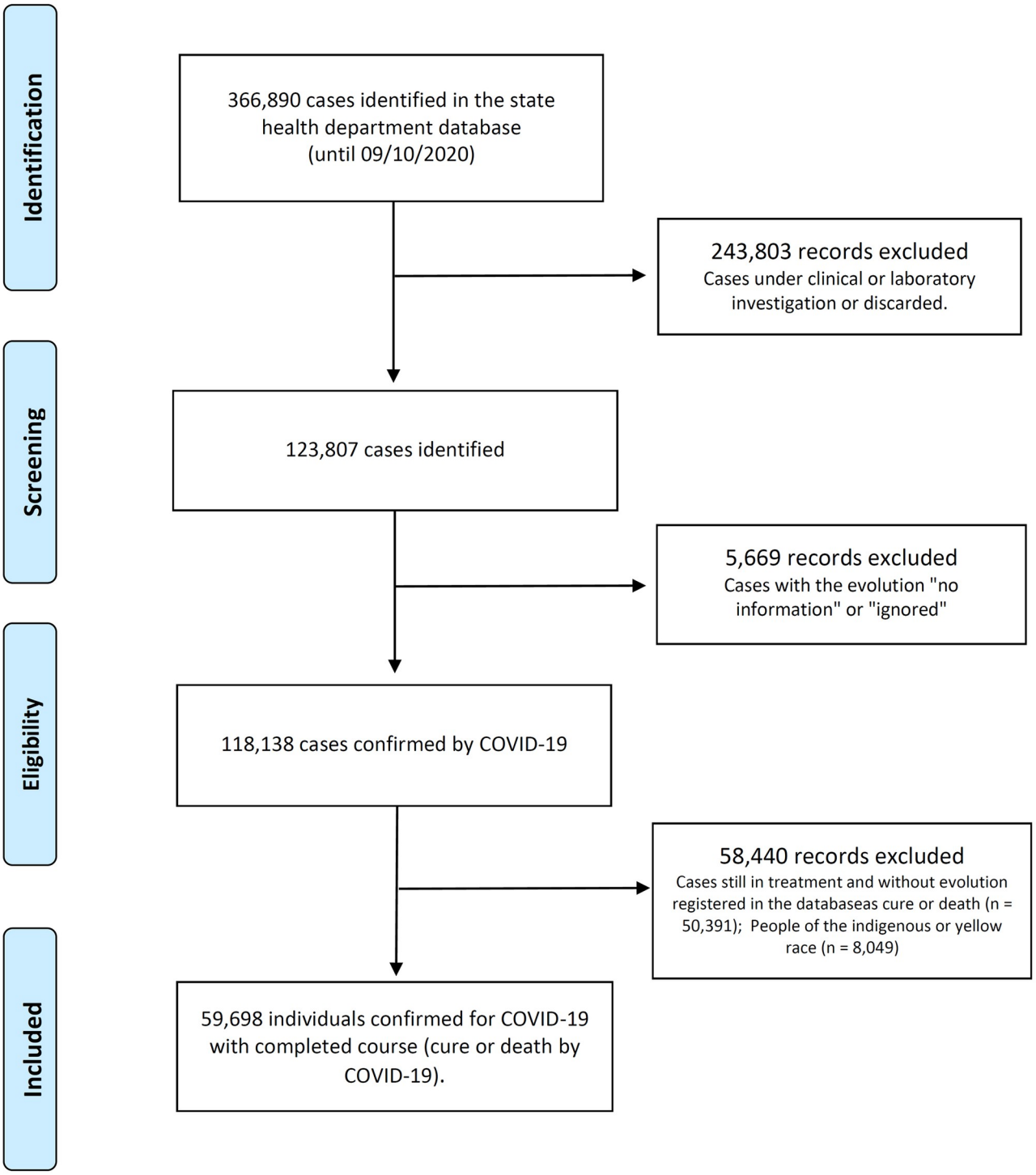

Fig 1. Flow diagram of the selection of individuals participating in the study.

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have a cause-effect relationship. To quantify the noticed associations, crude odds ratio estimates (*odds ratio*—OR) were presented for the association among exposure variables and the outcome, as well as adjusted odds ratios (adjusted *odds ratio*—OR adj.) and their respective 95% confidence intervals (95%CI).

All analyzes were performed using R.4.0.3 software.

The study was carried out in accordance with the ethical principles of Resolution 466/2012 of the National Health Council; the approval of the work required by the Research Ethics Committee was not necessary, due to the use of secondary data, with free access and without identification of the subjects.

Results

Since the beginning of the pandemic until September 10th, 2020, 118,138 cases were confirmed by COVID-19 in the state of Espírito Santo. People who had not yet evolved (cure or death by COVID-19) described in the database were excluded, and data from 59.698 people were analyzed, and of these, 3025 were people with obesity (Fig 1).

Tables 1 and 2 show the characteristics of people with COVID-19 considered in this study by hospitalized group and mortality.

Most people who were hospitalized because of COVID-19 were over 60 years old (59.8%), male (41.8%), black or brown (58.0%) and had full high school (23.6%).

Regarding signs and symptoms, 68.5% had cough, 68.5% fever and 29.5% headache. The most frequent comorbidities among hospitalized patients were cardiovascular disease (55.6%), diabetes (30.9%) and obesity (10.3%).

Among people who died of COVID-19, most people were male (57.8%), were black or brown (54.3%), over 60 years old (76.7%), and had incomplete elementary school (4 to 8 years of schooling) (17.8%). Regarding signs and symptoms, cough and fever were the most frequent symptoms, 65.7% and 62.2% respectively. The most common registered comorbidities were cardiovascular disease (60.0%) and diabetes (34.1%), followed by obesity (10.9%).

According to the results presented in Table 3, fixing the other variables, it was identified that women are 37% less likely to be hospitalized by COVID-19 when compared to men. Black individuals are 21% more likely to be hospitalized by COVID-19 than white individuals.

Individuals from 40 to 59 years old and 60 years old or more had a chance of hospitalization by COVID-19 2.05 and 6.11 times, respectively, the chance of people from 18 to 39 years old.

Regarding education level, no education people and those with incomplete elementary school have a chance of hospitalization by COVID-19 respectively, 1.85 and 1.90 times the chance of people with a university diploma to be hospitalized.

Obesity, fever and breathing difficulty are characteristics associated with the chance of hospitalization by COVID-19. When compared to people who do not have these characteristics, the chance of hospitalization is, respectively, 1.62, 1.46 and 5.80 times in symptomatic cases. Running nose, sore throat, diarrhea and headache presented values indicating a "protective effect" for hospitalization by COVID-19, that is, in cases which individuals had these symptoms, there was a reduction in the chance of hospitalization by 45%, 48%, 32% and 60% compared to individuals who did not have these symptoms.

Individuals who have heart and kidney diseases, diabetes and smoke have increased chances of hospitalization by COVID-19, respectively, 1.38, 2.56, 1.71 and 1.97 times the chance of those who do not have these conditions of health.

The data in Table 4 only consider people with obesity, fixing the other variables, and indicate that women have 40% less chance of being hospitalized by COVID-19 when compared to men; black individuals are 61% more likely to be hospitalized by COVID-19 than white individuals to be hospitalized; people from 40 to 59 years old and 60 years old or more reflect a chance of hospitalization by COVID-19 1,98 and 4,23 times, respectively, the chance of people from 18 to 39 years old to be hospitalized. Education level does not impact the chance of hospitalization by COVID-19 in this scenario.

Table 1. Sociodemographic characteristics, comorbidities and signs and symptoms of confirmed and hospitalized cases with COVID-19, Espírito Santo, Brazil, 2020.

Variables	Hospitalized					
	Yes		No		Not informed	
	n = 1110	% (CI 95%)	n = 34586	% (CI 95%)	n = 24002	% (CI 95%)
Gender						
Male	646	58.2% (55.3–61.1)	14575	42.1% (41.6–42.7)	10744	44.8% (44.1–45.4)
Female	464	41.8% (38.9–44.7)	20011	57.9% (57.3–58.4)	13258	55.2% (54.6–55.9)
Race/Color:						
White	466	42.0% (39.1–44.9)	16069	46.5% (45.9–47.0)	11418	47.6% (46.9–48.2)
Black/Brown	644	58.0% (55.1–60.9)	18517	53.5% (53.0–54.1)	12584	52.4% (51.8–53.1)
Age Group						
18 to 39 years old	125	11.3% (9.5–13.3)	16172	46.8% (46.2–47.3)	11720	48.8% (48.2–49.5)
40 to 59 years old	321	28.9% (26.3–31.7)	13264	38.4% (37.8–38.9)	8892	37.0% (36.4–37.7)
60 years old or more	664	59.8% (56.9–62.7)	5150	14.9% (14.5–15.3)	3390	14.1% (13.7–14.6)
Education level						
No education	103	9.3% (7.7–11.1)	565	1.6% (1.5–1.8)	350	1.5% (1.3–1.6)
Incomplete elementary school	232	20.9% (18.6–23.4)	2866	8.3% (8.0–8.6)	2923	12.2% (11.8–12.6)
Full elementary school	192	17.3% (15.2–19.6)	4657	13.5% (13.1–13.8)	3169	13.2% (12.8–13.6)
Incomplete primary school	140	12.6% (10.8–14.7)	1876	5.4% (5.2–5.7)	1142	4.8% (4.5–5.0)
Full primary school	67	6.0% (4.8–7.6)	1431	4.1% (3.9–4.4)	1035	4.3% (4.1–4.6)
Full high school	262	23.6% (21.2–26.2)	15341	44.4% (43.8–44.9)	10027	41.8% (41.2–42.4)
University diploma	114	10.3% (8.6–12.2)	7850	22.7% (22.3–23.1)	5356	22.3% (21.8–22.8)
Fever						
No	392	35.3% (32.7–38.3)	15686	45.4% (44.8–45.9)	12592	52.5% (51.9–53.2)
Yes	714	64.3% (61.7–67.3)	18893	54.6% (54.1–55.2)	11384	47.4% (46.8–48.1)
Missing	4 (0.4%)		7 (0.0%)		26 (0.1%)	
Breathing Difficulty						
No	386	34.8% (32.1–37.7)	26775	77.4% (77.0–77.9)	19511	81.3% (80.9–81.9)
Yes	722	65.0% (62.3–67.9)	7805	22.6% (22.1–23.0)	4466	18.6% (18.1–19.1)
Missing	2 (0.2%)		6 (0.0%)		25 (0.1%)	
Cough						
No	345	31.1% (28.6–34.0)	13107	37.9% (37.4–38.4)	11083	46.2% (45.6–46.9)
Yes	760	68.5% (66.0–71.4)	21473	62.1% (61.6–62.6)	12893	53.7% (53.1–54.4)
Missing	5 (0.5%)		6 (0.0%)		26 (0.1%)	
Running nose						
No	873	78.6% (76.4–81.2)	20148	58.3% (57.7–58.8)	15455	64.4% (63.8–65.1)
Yes	233	21.0% (18.8–23.6)	14431	41.7% (41.2–42.3)	8522	35.5% (34.9–36.2)
Missing	4 (0.4%)		7 (0.0%)		25 (0.1%)	
Sore throat						
No	955	86.0% (84.1–88.2)	22972	66.4% (65.9–66.9)	16620	69.2% (68.7–69.9)
Yes	152	13.7% (11.8–15.9)	11606	33.6% (33.1–34.1)	7357	30.7% (30.1–31.3)
Missing	3 (0.3%)		8 (0.0%)		25 (0.1%)	
Diarrhea						
No	960	86.5% (84.7–88.7)	27893	80.6% (80.2–81.1)	19793	82.5% (82.1–83.0)
Yes	146	13.2% (11.3–15.3)	6686	19.3% (18.9–19.8)	4184	17.4% (17.0–17.9)
Missing	4 (0.4%)		7 (0.0%)		25 (0.1%)	
Headache						
No	778	70.1% (67.6–73.0)	13603	39.3% (38.8–39.9)	11476	47.8% (47.2–48.5)

(*Continued*)

Table 1. (Continued)

Variables	Hospitalized					
	Yes		No		Not informed	
	n = 1110	% (CI 95%)	n = 34586	% (CI 95%)	n = 24002	% (CI 95%)
Yes	328	29.5% (27.0–32.4)	20976	60.6% (60.1–61.2)	12501	52.1% (51.5–52.8)
Missing	4 (0.4%)		7 (0.0%)		25 (0.1%)	
Obesity						
No	992	89.4% (87.8–91.3)	32814	94.9% (94.8–95.3)	23037	96.0% (95.9–96.3)
Yes	114	10.3% (8.7–12.2)	1714	5.0% (4.7–5.2)	934	3.9% (3.7–4.1)
Missing	4 (0.4%)		58 (0.2%)		31 (0.1%)	
Lung Disease						
No	1014	91.4% (90.0–93.2)	33308	96.3% (96.2–96.6)	23280	97.0% (96.9–97.3)
Yes	91	8.2% (6.8–10.0)	1259	3.6% (3.4–3.8)	696	2.9% (2.7–3.1)
Missing	5 (0.5%)		19 (0.1%)		26 (0.1%)	
Cardiovascular Disease						
No	489	44.1% (41.3–47.2)	26918	77.8% (77.4–78.3)	20007	83.4% (83.0–83.9)
Yes	617	55.6% (52.8–58.7)	7652	22.1% (21.7–22.6)	3970	16.5% (16.1–17.0)
Missing	4 (0.4%)		16 (0.0%)		25 (0.1%)	
Kidney Disease						
No	1055	95.0% (94.0–96.5)	34368	99.4% (99.3–99.5)	23840	99.3% (99.3–99.5)
Yes	51	4.6% (3.5–6.0)	201	0.6% (0.5–0.7)	137	0.6% (0.5–0.7)
Missing	4 (0.4%)		17 (0.0%)		25 (0.1%)	
Diabetes						
No	763	68.7% (66.2–71.6)	31782	91.9% (91.6–92.2)	22576	94.1% (93.9–94.5)
Yes	343	30.9% (28.4–33.8)	2788	8.1% (7.8–8.4)	1399	5.8% (5.5–6.1)
Missing	4 (0.4%)		16 (0.0%)		27 (0.1%)	
Smoking						
No	1027	92.5% (91.3–94.3)	33778	97.7% (97.5–97.9)	23558	98.2% (98.1–98.4)
Yes	78	7.0% (5.7–8.7)	791	2.3% (2.1–2.5)	417	1.7% (1.6–1.9)
Missing	5 (0.5%)		17 (0.0%)		27 (0.1%)	

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Regarding the symptoms, breathing difficulty was a symptom associated with the chance of hospitalization due to COVID-19. When compared to people who do not have this symptom, the chance of hospitalization is, respectively, 3.20 times in symptomatic cases. Symptoms such as sore throat, diarrhea and headache presented values indicating a "protective effect" for hospitalization by COVID-19, that is, in cases which individuals had these symptoms, there was a reduction in the chance of hospitalization of 48%, 57% and 52% compared to individuals who did not have these symptoms.

Individuals who had kidney disease and diabetes have a chance of hospitalization by COVID-19, respectively, 5.32 and 2.04 times the chance of those who do not have these health problems.

Table 5 presents the logistic regression model for the association of sociodemographic factors and symptoms with death by COVID-19, and the data show that women are 34% less likely to evolve to death by COVID-19 when compared to men.

People from 40 to 59 years old or 60 years old or more have a chance of death by COVID-19 3.85 and 21.01 times, respectively, the chance of people from 18 to 39 years old of dying. Missing a university diploma is a risk factor for death by COVID-19, and the chance of death

Table 2. Sociodemographic characteristics, comorbidities, and signs and symptoms of confirmed cases that died of COVID-19, Espírito Santo, Brazil, 2020.

Variables	Death by covid-19			
	Yes		No	
	N = 1406	% (CI 95%)	N = 58292	% (CI 95%)
Gender				
Male	813	57.8% (55.2–60.4)	25152	43.1% (42.7–43.6)
Female	593	42.2% (39.6–44.8)	33140	56.9% (56.4–57.3)
Race/Color:				
White	643	45.7% (43.1–48.3)	27310	46.9% (46.4–47.3)
Black	763	54.3% (51.7–56.9)	30982	53.1% (52.7–53.6)
Age Group				
18 to 39 years old	52	3.7% (2.8–4.8)	27965	48.0% (47.6–48.4)
40 to 59 years old	276	19.6% (17.6–21.8)	22201	38.1% (37.7–38.5)
60 years old or more	1078	76.7% (74.4–78.8)	8126	13.9% (13.7–14.2)
Education level				
University diploma	74	5.3% (4.2–6.6)	13246	22.7% (22.4–23.1)
No education	167	11.9% (10.3–13.7)	851	1.5% (1.4–1.6)
Incomplete elementary school	250	17.8% (15.9–19.9)	5771	9.9% (9.7–10.1)
Full elementary school	277	19.7% (17.7–21.9)	7741	13.3% (13.0–13.6)
Incomplete primary school	264	18.8% (16.8–20.9)	2894	5.0% (4.8–5.1)
Full primary school	117	8.3% (7.0–9.9)	2416	4.1% (4.0–4.3)
Full high school	257	18.3% (16.3–20.4)	25373	43.5% (43.1–43.9)
Fever				
No	526	37.4% (35.0–40.1)	28144	48.3% (47.9–48.7)
Yes	875	62.2% (59.9–65.0)	30116	51.7% (51.3–52.1)
Missing	5 (0.4%)		32 (0.1%)	
Breathing Difficulty				
No	582	41.4% (38.9–44.0)	46090	79.1% (78.8–79.4)
Yes	822	58.5% (56.0–61.1)	12171	20.9% (20.6–21.2)
Missing	2 (0.1%)		31 (0.1%)	
Cough				
No	477	33.9% (31.6–36.6)	24058	41.3% (40.9–41.7)
Yes	924	65.7% (63.4–68.4)	34202	58.7% (58.3–59.1)
Missing	5 (0.4%)		32 (0.1%)	
Running Nose				
No	1112	79.1% (77.1–81.4)	35364	60.7% (60.3–61.1)
Yes	290	20.6% (18.6–22.9)	22896	39.3% (38.9–39.7)
Missing	4 (0.3%)		32 (0.1%)	
Sore throat				
No	1214	86.3% (84.8–88.3)	39333	67.5% (67.1–67.9)
Yes	187	13.3% (11.7–15.2)	18928	32.5% (32.1–32.9)
Missing	5 (0.4%)		31 (0.1%)	
Diarrhea				
No	1212	86.2% (84.7–88.3)	47434	81.4% (81.1–81.7)
Yes	188	13.4% (11.7–15.3)	10828	18.6% (18.3–18.9)
Missing	6 (0.4%)		30 (0.1%)	
Headache				
No	998	71.0% (68.9–73.6)	24859	42.6% (42.3–43.1)
Yes	401	28.5% (26.4–31.1)	33404	57.3% (56.9–57.7)

(*Continued*)

Table 2. (Continued)

Variables	Death by covid-19			
	Yes		No	
	N = 1406	% (CI 95%)	N = 58292	% (CI 95%)
Missing	7 (0.5%)		29 (0.0%)	
Obesity				
No	1246	88.6% (87.3–90.6)	55597	95.4% (95.3–95.7)
Yes	153	10.9% (9.4–12.7)	2609	4.5% (4.3–4.7)
Missing	7 (0.5%)		86 (0.1%)	
Lung Disease				
No	1280	91.0% (89.7–92.7)	56322	96.6% (96.5–96.8)
Yes	122	8.7% (7.3–10.3)	1924	3.3% (3.2–3.5)
Missing	4 (0.3%)		46 (0.1%)	
Cardiovascular Disease				
No	557	39.6% (37.2–42.3)	46857	80.4% (80.1–80.8)
Yes	844	60.0% (57.7–62.8)	11395	19.5% (19.2–19.9)
Missing	5 (0.4%)		40 (0.1%)	
Kidney Disease				
No	1325	94.2% (93.2–95.6)	57938	99.4% (99.4–99.5)
Yes	77	5.5% (4.4–6.8)	312	0.5% (0.5–0.6)
Missing	4 (0.3%)		42 (0.1%)	
Diabetes				
No	921	65.5% (63.2–68.2)	54200	93.0% (92.8–93.3)
Yes	480	34.1% (31.8–36.8)	4050	6.9% (6.7–7.2)
Missing	5 (0.4%)		42 (0.1%)	
Smoking				
No	1314	93.5% (92.5–95.0)	57049	97.9% (97.8–98.1)
Yes	86	6.1% (5.0–7.5)	1200	2.1% (1.9–2.2)
Missing	6 (0.4%)		43 (0.1%)	
Hospitalized				
No	514	36.6% (34.1–39.1)	34072	58.5% (58.0–58.9)
Not informed	305	21.7% (19.6–23.9)	23697	40.7% (40.3–41.1)
Yes	587	41.7% (39.2–44.3)	523	0.9% (0.8–1.0)

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may range from 1.61 to 4.08 times, and the behavior of decreasing OR is almost linear as education level increases.

Obesity increased the chance of death by 2.08 times when compared to people who did not have this condition. Symptoms such as fever and breathing difficulty were associated with the chance of death by COVID-19. When compared to people who do not have these symptoms, the chance of dying is, respectively, 1.43 and 3.15 times in symptomatic cases. Running nose, sore throat, diarrhea and headache presented values that indicate a "protective effect" for death by COVID-19, that is, in cases which individuals had these symptoms, there was a reduction in the chance of death of 32%, 37%, 21% and 48% compared to individuals who did not have these symptoms.

Individuals who had lung, heart, kidney diseases and diabetes have a chance of dying by COVID-19, respectively, 1.34, 1.24, 2.90 and 1.70 times the chance of those who do not have these health problems.

Table 3. Logistic regression model for the association of sociodemographic factors and symptoms with hospitalization for COVID-19, Espírito Santo, Brazil, 2020.

Variables	n	OR	CI 95%	Logistic Model	
				OR adj.	CI 95%
Gender					
Male	25905	1,00	Ref.	1,00	Ref.
Female	33670	0,53	0,47; 0,60***	0,63	0,55; 0,73***
Race/Color					
White	27899	1,00	Ref.	1,00	Ref.
Black	31676	1,21	1,07; 1,36**	1,21	1,05; 1,38**
Age (Notification date)					
18 to 39 years old	27958	1,00	Ref.	1,00	Ref.
40 to 59 years old	22434	3,08	2,51; 3,81***	2,05	1,65; 2,56***
60 years old or more	9183	16,52	13,66; 20,14***	6,11	4,86; 7,73***
Education level					
University diploma	13293	1,00	Ref.	1,00	Ref.
No education	1015	12,68	9,57; 16,78***	1,85	1,34; 2,55***
Incomplete elementary school	6015	5,54	4,42; 6,99***	1,90	1,48; 2,46***
Full elementary school	8007	2,82	2,23; 3,58***	1,27	0,99; 1,65
Incomplete primary school	3151	5,10	3,96; 6,59***	1,08	0,81; 1,43
Full primary school	2531	3,25	2,38; 4,41***	0,95	0,67; 1,33
Full high school	25563	1,18	0,95; 1,48	0,95	0,75; 1,20
Obesity					
No	56814	1,00	Ref.	1,00	Ref.
Yes	2761	2,21	1,80; 2,69***	1,62	1,28; 2,04***
Fever					
No	28634	1,00	Ref.	1,00	Ref.
Yes	30941	1,52	1,34; 1,72***	1,46	1,27; 1,68***
Breathing difficulty					
No	46613	1,00	Ref.	1,00	Ref.
Yes	12962	6,37	5,61; 7,23***	5,80	5,06; 6,66***
Cough					
No	24505	1,00	Ref.	1,00	Ref.
Yes	35070	1,35	1,18; 1,53**	1,06	0,92; 1,23
Running nose					
No	36425	1,00	Ref.	1,00	Ref.
Yes	23150	0,37	0,32; 0,43***	0,55	0,47; 0,65***
Sore throat					
No	40475	1,00	Ref.	1,00	Ref.
Yes	19100	0,31	0,26; 0,37***	0,52	0,43; 0,62***
Diarrhea					
No	48569	1,00	Ref.	1,00	Ref.
Yes	11006	0,63	0,53; 0,75***	0,68	0,56; 0,82***
Headache					
No	25809	1,00	Ref.	1,00	Ref.
Yes	33766	0,28	0,24; 0,31***	0,40	0,34; 0,46***
Lung Disease					
No	57531	1,00	Ref.	1,00	Ref.
Yes	2044	2,39	1,90; 2,96***	1,25	0,96; 1,62
Heart Disease					

(*Continued*)

Table 3. (Continued)

Variables	n	OR	CI 95%	Logistic Model	
				OR adj.	CI 95%
No	47353	1,00	Ref.	1,00	Ref.
Yes	12222	4,43	3,93; 5,01***	1,38	1,19; 1,61***
Kidney Disease					
No	59189	1,00	Ref.	1,00	Ref.
Yes	386	8,39	6,07; 11,39***	2,56	1,75; 3,71***
Diabetes					
No	55054	1,00	Ref.	1,00	Ref.
Yes	4521	5,15	4,51; 5,89***	1,71	1,45; 2,00***
Smoking					
No	58291	1,00	Ref.	1,00	Ref.
Yes	1284	3,27	2,55; 4,13***	1,97	1,47; 2,60***

Abbreviations: OR—*odds ratio*; 95% CI; 95% confidence interval.

*** p-value <0.001;

** 0.001 ≤ p-value <0.01;

* 0.01 ≤-p-value <0.05.

n: Number of individuals with the exposure who presented the outcome.

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The results presented in Table 6 only consider people with obesity and show that women are 32% less likely to evolve to death by COVID-19 when compared to men. People from 40 to 59 years old or 60 years old or more increase the chance of death by COVID-19 in 3.86 and 20.28 times, respectively, when compared to the chance of people from 18 to 39 years old to die. Missing a university diploma is a risk factor for death by COVID-19, the chance of death may range from 1.60 to 3.99 times.

Fever and breathing difficulty are symptoms associated with the chance of death by COVID-19. When compared to people who do not have these symptoms, the chance of dying is, respectively, 1.43 and 3.22 times in symptomatic cases. Running nose, sore throat, diarrhea and headache showed estimates that indicate a "protective effect" for death by COVID-19, that is, in cases which individuals had this symptom, there was a reduction in the chance of death in 33%, 37%, 21% and 47% compared to individuals who did not present these symptoms.

Individuals with kidney disease and diabetes have a chance of dying by COVID-19 of 5.32 and 2.04 times, respectively, the chance of individuals who do not have these comorbidities of dying. It is important to emphasize that the low prevalence of death in patients with kidney disease, may have resulted in its statistical significance.

Discussion

Data showed that men, non-white, no education or with low education level and declining age were more likely to be hospitalized and die of COVID-19 in the state of Espírito Santo.

The severity of the disease according to gender has also been assessed in other studies [19,20]. Previous research has shown that the X chromosome is known to keep the largest number of genes related to the immune system in the entire genome. Women, for presenting chromosome XX, are generally more responsive to infections [19]. In addition, studies show that in males there is a greater presence of receptors for SARS-CoV-2, the Angiotensin-Converting Enzyme 2 (ECA2), in their alveolar cells if compared to women [21].

Table 4. Logistic regression model for the association of sociodemographic factors and symptoms with hospitalization by COVID-19 in patients with obesity, Espírito Santo, Brazil, 2020.

Variables	n	OR	CI 95%	Logistic Model	
				OR adj.	CI 95%
Gender					
Male	25921	1,00	Ref.	1,00	Ref.
Female	33701	0,59	0,40; 0,87***	0,60	0,39; 0,93**
Race/Color					
White	27914	1,00	Ref.	1,00	Ref.
Black	31708	1,24	0,84; 1,83	1,61	1,04; 2,50***
Age (notification date)					
18 to 39 years old	27980	1,00	Ref.	1,00	Ref.
40 to 59 years old	22454	2,66	1,54; 4,80***	1,98	1,09; 3,75***
60 years old or more	9188	7,41	4,29; 13,43***	4,23	2,15; 8,59***
Education level					
University diploma	13300	1,00	Ref.	1,00	Ref.
No education	1015	3,17	1,09; 8,13***	0,96	0,29; 2,83
Incomplete elementary school	6018	1,59	0,77; 3,22	0,72	0,32; 1,62
Full elementary school	8011	1,38	0,71; 2,71	0,87	0,41; 1,83
Incomplete primary school	3151	2,21	0,97; 4,62	0,79	0,33; 1,87
Full primary school	2531	2,34	0,98; 5,18	1,29	0,50; 3,16
Full high school	25596	0,84	0,47; 1,54	0,87	0,47; 1,68
Fever					
No	28655	1,00	Ref.	1,00	Ref.
Yes	30967	1,15	0,78; 1,74	1,26	0,80; 2,02
Breathing difficulty					
No	46648	1,00	Ref.	1,00	Ref.
Yes	12974	3,56	2,40; 5,36***	3,20	2,09; 4,97***
Cough					
No	24520	1,00	Ref.	1,00	Ref.
Yes	35102	1,22	0,79; 1,95	1,45	0,88; 2,47
Running nose					
No	36450	1,00	Ref.	1,00	Ref.
Yes	23172	0,46	0,30; 0,70***	0,74	0,45; 1,19
Sore throat					
No	40519	1,00	Ref.	1,00	Ref.
Yes	19103	0,34	0,20; 0,55***	0,52	0,30; 0,88***
Diarrhea					
No	48612	1,00	Ref.	1,00	Ref.
Yes	11010	0,36	0,19; 0,63***	0,43	0,22; 0,77***
Headache					
No	25837	1,00	Ref.	1,00	Ref.
Yes	33785	0,34	0,23; 0,51***	0,48	0,31; 0,74***
Lung Disease					
No	57578	1,00	Ref.	1,00	Ref.
Yes	2044	1,59	0,78; 2,92	1,00	0,43; 2,10
Heart Disease					
No	47391	1,00	Ref.	1,00	Ref.
Yes	12231	2,16	1,46; 3,25***	1,02	0,64; 1,65

(*Continued*)

Table 4. (Continued)

Variables	n	OR	CI 95%	Logistic Model	
				OR adj.	CI 95%
Kidney Disease					
No	59235	1,00	Ref.	1,00	Ref.
Yes	387	7,94	2,96; 19,52***	5,32	1,63; 16,23***
Diabetes					
No	55096	1,00	Ref.	1,00	Ref.
Yes	4526	3,34	2,25; 4,92***	2,04	1,29; 3,21***
Smoking					
No	58338	1,00	Ref.	1,00	Ref.
Yes	1284	3,07	1,58; 5,56***	2,16	0,98; 4,46

Abbreviations: OR—*odds ratio*; 95% CI; 95% confidence interval.

*** p-value <0.001;

** 0.001 ≤ p-value <0.01;

* 0.01 ≤-p-value <0.05.

n: Number of individuals with the exposure who presented the outcome.

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Takahashi et al. (2020) while monitoring 98 patients with COVID-19 admitted to Yale Hospital from March 18th to May 9th, 2020, noticed significantly higher levels of pro-inflammatory chemokines and cytokines in male participants, such as IL-8, IL-18 and CCL5, and a significantly lower number of T cells, both in the total count and in the proportion of live cells, over the course of the disease, which contributed to the worsening of their clinical condition [22].

Other authors also evaluated the frequency of race/color in people with COVID-19 and identified differences. An analysis carried out in the United Kingdom noticed that hospitalization by COVID-19 was found in 32 out of 7714 (0.4%) black participants, 28 out of 10.614 (0.2%) Asian participants and 489 out of 400,438 (0.1%) white participants [23]. A similar result was noticed in a study conducted in Detroit, United States, in which 2.316 (63.7%) people diagnosed with COVID-19 and who were hospitalized, 55.7% were black/brown [24].

Analyzes by Baqui et al (2020) with 11.321 Brazilian patients diagnosed with COVID-19 showed that, after age, the most important factor for hospital mortality was being brown or, to a lesser extent, black compared to white race [25].

Racial differences in the frequency of aggravation of COVID-19 can be multifactorial and are still unclear. These data may reflect differences in working conditions and health determinants they are submitted to, as well as being related to potential biological factors [23,26,27]. However, black/brown Brazilians have, on average, less economic security, live in favorable conditions to contagion, are less likely to be able to work remotely and constitute a substantial proportion of health workers, making them the most vulnerable to COVID– 19 [28].

In our study, no education people or those with lower education level had a higher chance of hospitalization and death, which can be explained by less access to information and health services, possibly having the incomes affected during the pandemic and living in inadequate hygienic and sanitary conditions [29].

In the investigation of 45,161 questionnaires carried out nationwide, by Oswaldo Cruz Foundation (Fiocruz), it was highlighted that the groups that least adhered to the social distance initiatives to control COVID-19 were composed by men (31.7%), from 30 to 49 years old (36.4%), with low education level (33.0%) and who kept working during the pandemic (81.3%) [30].

Table 5. Logistic regression model for the association of sociodemographic factors and symptoms with death by COVID-19, Espírito Santo, Brazil, 2020.

Variables	n	OR	CI 95%	Logistic Model	
				OR adj.	CI 95%
Gender					
Male	25905	1,00	Ref.	1,00	Ref.
Female	33670	0,55	0,50; 0,62***	0,66	0,58; 0,76***
Race/Color					
White	27899	1,00	Ref.	1,00	Ref.
Black	31676	1,05	0,94; 1,16	1,00	0,87; 1,14
Age (Notification date)					
18 to 39 years old	27958	1,00	Ref.	1,00	Ref.
40 to 59 years old	22434	6,66	5,00; 9,06***	3,85	2,85; 5,31***
60 years old or more	9183	70,33	53,77; 94,15***	21,01	15,61; 28,84***
Education level					
University diploma	13293	1,00	Ref.	1,00	Ref.
No education	1015	34,68	26,24; 46,24***	4,08	2,90; 5,77***
Incomplete elementary school	6015	7,62	5,90; 9,96***	2,23	1,64; 3,06***
Full elementary school	8007	6,33	4,92; 8,25***	2,88	2,15; 3,91***
Incomplete primary school	3151	16,07	12,44; 21,00***	2,94	2,17; 4,03***
Full primary school	2531	8,66	6,47; 11,66***	2,29	1,63; 3,25***
Full high school	25563	1,80	1,40; 2,35***	1,61	1,21; 2,18***
Obesity					
No	56814	1,00	Ref.	1,00	Ref.
Yes	2761	2,63	2,21; 3,12***	2,08	1,66; 2,59***
Fever					
No	28634	1,00	Ref.	1,00	Ref.
Yes	30941	1,55	1,39; 1,73***	1,43	1,24; 1,64***
Breathing difficulty					
No	46613	1,00	Ref.	1,00	Ref.
Yes	12962	5,35	4,80; 5,96***	3,15	2,75; 3,61***
Cough					
No	24505	1,00	Ref.	1,00	Ref.
Yes	35070	1,35	1,21; 1,51***	0,96	0,83; 1,11
Running nose					
No	36425	1,00	Ref.	1,00	Ref.
Yes	23150	0,40	0,35; 0,46***	0,68	0,58; 0,79***
Sore throat					
No	40475	1,00	Ref.	1,00	Ref.
Yes	19100	0,32	0,27; 0,37***	0,63	0,52; 0,75***
Diarrhea					
No	48569	1,00	Ref.	1,00	Ref.
Yes	11006	0,67	0,57; 0,78***	0,79	0,66; 0,96**
Headache					
No	25809	1,00	Ref.	1,00	Ref.
Yes	33766	0,30	0,26; 0,33***	0,52	0,45; 0,60***
Lung Disease					
No	57531	1,00	Ref.	1,00	Ref.
Yes	2044	2,76	2,27; 3,33***	1,34	1,02; 1,73**
Heart Disease					

(*Continued*)

Table 5. (Continued)

Variables	n	OR	CI 95%	Logistic Model	
				OR adj.	CI 95%
No	47353	1,00	Ref.	1,00	Ref.
Yes	12222	6,25	5,60; 6,97***	1,24	1,07; 1,43***
Kidney Disease					
No	59189	1,00	Ref.	1,00	Ref.
Yes	386	10,42	7,99; 13,43***	2,90	2,00; 4,13***
Diabetes					
No	55054	1,00	Ref.	1,00	Ref.
Yes	4521	6,99	6,22; 7,84***	1,70	1,46; 1,98***
Smoking					
No	58291	1,00	Ref.	1,00	Ref.
Yes	1284	3,09	2,45; 3,86***	1,21	0,88; 1,65
Hospitalized					
No	34511	1,00	Ref.	1,00	Ref.
Not informed	23965	0,86	0,74; 1,02	0,96	0,82; 1,12
Yes	1099	75,23	64,95; 87,22***	19,59	16,41; 23,42***

Abbreviations: OR—*odds ratio*; 95% CI; 95% confidence interval.

*** p-value <0.001;

** 0.001 ≤ p-value <0.01;

* 0.01 ≤-p-value <0.05.

n: Number of individuals with the exposure who presented the outcome.

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Regarding signs and symptoms, cough, headache and fever were the most ordinary identified ones in our study. Fever and breathing difficulty increased the chances of hospitalization and death, while running nose, sore throat, diarrhea and headache were shown to be protective effects. In addition, the fact of being hospitalized increased the chances of death in almost 20 times. In Wuhan, China, the most ordinary symptoms at the beginning of the disease in 138 hospitalized people were fever (136 [98.6%]), fatigue (96 [69.6%]), dry cough (82 [59.4%]), myalgia (48 [34.8%]) and dyspnea (43 [31.2%]). The less ordinary symptoms were headache, dizziness, abdominal pain, diarrhea, nausea and vomiting [31].

For 278 positive patients for COVID-19 in New York, the presence of gastrointestinal symptoms was associated with a longer duration of the disease, however, with a tendency for a lower rate of admission to the Intensive Care Unit and lower mortality [32].

In our analyses have also shown that obesity, heart, kidney and lung diseases, diabetes and smoking increased the chances of hospitalization. Obesity represented 4.5% of the total diagnoses of COVID-19, among comorbidities, it was the third risk factor that most increased the chances of hospitalization and the second related to the increase of the chances of death.

Vardavas and Nikitara (2020) evidenced in their systematic review that smoking patients were more likely to worsen COVID-19 than non-smokers [33]. Smoking is related to a higher expression of SARS-CoV-2 receptors, which can be the reason for the highest prevalence of more severe symptoms in this subgroup of patients [34]. In the study by Azar et al [35], comorbidities such as congestive heart failure or type 2 diabetes were associated with a greater chance of hospitalization compared to those who did not have these conditions.

Bello-Chavolla et al. [36] when evaluating the confirmed and negative cases of COVID-19 and their demographic and health characteristics in the General Directorate of Epidemiology

Table 6. Logistic regression model for the association of sociodemographic factors and symptoms with death by COVID-19 in patients with obesity, Espírito Santo, Brazil, 2020.

Variables	n	OR	CI 95%	Logistic Model	
				OR adj.	CI 95%
Gender					
Male	25921	1,00	Ref.	1,00	Ref.
Female	33701	0,55	0,50; 0,62***	0,68	0,59; 0,78***
Race/Color					
White	27914	1,00	Ref.	1,00	Ref.
Black	31708	1,05	0,94; 1,16	0,99	0,86; 1,13
Age (Notification date)					
18 to 39 years old	27980	1,00	Ref.	1,00	Ref.
40 to 59 years old	22454	6,66	5,00; 9,06***	3,86	2,86; 5,31***
60 years old or more	9188	70,33	53,77; 94,15***	20,28	15,07; 27,84***
Education level					
University diploma	13300	1,00	Ref.	1,00	Ref.
No education	1015	34,68	26,24; 46,24***	3,99	2,84; 5,64***
Incomplete elementary school	6018	7,62	5,90; 9,96***	2,19	1,61; 3,01***
Full elementary school	8011	6,33	4,92; 8,25***	2,86	2,13; 3,87***
Incomplete primary school	3151	16,07	12,44; 21,00***	2,91	2,15; 3,99***
Full primary school	2531	8,66	6,47; 11,66***	2,27	1,61; 3,21***
Full high school	25596	1,80	1,40; 2,35***	1,60	1,20; 2,16***
Fever					
No	28655	1,00	Ref.	1,00	Ref.
Yes	30967	1,55	1,39; 1,73***	1,43	1,24; 1,64***
Breathing difficulty					
No	46648	1,00	Ref.	1,00	Ref.
Yes	12974	5,35	4,80; 5,96***	3,22	2,81; 3,68***
Cough					
No	24520	1,00	Ref.	1,00	Ref.
Yes	35102	1,35	1,21; 1,51***	0,96	0,83; 1,11
Running nose					
No	36450	1,00	Ref.	1,00	Ref.
Yes	23172	0,40	0,35; 0,46***	0,67	0,57; 0,79***
Sore throat					
No	40519	1,00	Ref.	1,00	Ref.
Yes	19103	0,32	0,27; 0,37***	0,63	0,52; 0,75***
Diarrhea					
No	48612	1,00	Ref.	1,00	Ref.
Yes	11010	0,67	0,57; 0,78***	0,79	0,66; 0,95***
Headache					
No	25837	1,00	Ref.	1,00	Ref.
Yes	33785	0,30	0,26; 0,33***	0,53	0,46; 0,61***
Lung Disease					
No	57578	1,00	Ref.	1,00	Ref.
Yes	2044	2,76	2,27; 3,33***	1,35	1,04; 1,75**
Heart Disease					
No	47391	1,00	Ref.	1,00	Ref.
Yes	12231	6,25	5,60; 6,97***	1,29	1,12; 1,50***

(*Continued*)

Table 6. (Continued)

Variables	n	OR	CI 95%	Logistic Model	
				OR adj.	CI 95%
Kidney Disease					
No	59235	1,00	Ref.	1,00	Ref.
Yes	387	10,42	7,99; 13,43***	2,87	1,98; 4,09***
Diabetes					
No	55096	1,00	Ref.	1,00	Ref.
Yes	4526	6,99	6,22; 7,84***	1,76	1,51; 2,05***
Smoking					
No	58338	1,00	Ref.	1,00	Ref.
Yes	1284	3,09	2,45; 3,86***	1,27	0,92; 1,72
Hospitalized					
No	34552	1,00	Ref.	1,00	Ref.
Yes	1100	75,23	64,95; 87,22***	19,70	16,50; 23,55***
Not informed	23970	0,86	0,74; 0,99	0,96	0,83; 1,12

Abbreviations: OR—*odds ratio*; 95% CI; 95% confidence interval.

*** p-value <0.001;

** 0.001 ≤ p-value <0.01;

* 0.01 ≤-p-value <0.05.

n: Number of individuals with the exposure who presented the outcome.

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of the Ministry of Health of Mexico found that 51,633 individuals tested positive for SARS-CoV-2. When assessing age, there was a reduced chance of positivity for SARS-CoV-2 in patients <40 years old. However, in stratified models, it was found that for patients with diabetes, positivity for SARS-CoV-2 was associated with obesity, male gender and age <40 years old. Patients with obesity who had COVID-19 confirmed had an almost five-time increase in the risk of mortality (OR = 4.989; 95% CI = 4.444–5.600). In addition, they also had higher rates of Intensive Care Unit admission (5.0% vs. 3.3%) and were more likely to be intubated (5.2% vs. 3.3%) [36].

In our study, the highest chances of hospitalization and death for people with obesity were related to age over 60 years old, followed by the age group from 40 to 59 years old, who had breathing difficulties, diabetes and who had been hospitalized. The analysis by Klang et al. (2020), in New York City, with data from 3,406 patients, 572 patients under 50 years old and 2.834 over 50 years old have shown that in the youngest age group, 60 (10.5%) patients died, and the analysis univariate demonstrated that, for the youngest group, BMI ≥ 40 kg / m^2 was significantly associated with death (p <0.001) [37].

In the research by Ong et al. (2020), in Singapore, in patients under 60 years old it was verified that BMI ≥25kg / m^2 was significantly associated with pneumonia on chest X-ray at admission (p = 0.017), requiring low oxygen supplementation flow (OR = 6.32; 95% CI = 1.23–32.34) and mechanical ventilation (OR = 1.16; 95% CI = 1.00–1.34). BMI ≥25kg / m^2 was also associated with significantly higher serum levels of lactate dehydrogenase (p = 0.011), which were associated with the severity of the disease [38].

The mechanisms involving the role of obesity in the pathogenesis of COVID-19 are not yet well defined, but individuals with obesity generally have a decreased immune response to infectious pathogens, which can also affect the lung parenchyma, increasing the risk of inflammatory lung diseases [39]. In addition, as it is characterized as a low-grade inflammation, in

obesity mononuclear cells increase the transcription of pro-inflammatory cytokines, which increases the secretion of these cytokines [40].

Evidence suggests that adipose tissue is a pro-immunogenic and richly vascularized organ, with the ability to increase the pro-inflammatory response to viral infection. Thus, it can potentiate and prolong viral shedding in an environment that is already inflamed with the local amplification of cytokines, which can hinder the patient's recovery [41].

Zhang and colleagues in a logistic regression model also identified the factors that address the mechanisms underlying obesity predisposing COVID-19 patients to death. Through which the index related to inflammation, PCR, heart damage (hs-cTnI and *NT-proBNP*) and increased clotting activity (D-dimer) are characterized as significantly associated with adverse clinical outcomes in patients with high BMI. In addition, the decrease in lymphocytes and eosinophils or in total globulin levels was also correlated with the poor prognosis in these patients [42].

Abdominal obesity can restrict ventilation, preventing diaphragm excursion, as it reduces the compliance of the lung, chest wall and the entire respiratory system, resulting in decreased blood oxygen saturation and breathing functional capability [41,43].

Therefore, the data analyzed here confirm those found by other authors and show that obesity can be considered a risk factor for hospitalization and death by COVID-19, especially when in addition to obesity, other conditions such as age over 40 years old are present (more severe for those over 60 years old), the presence of comorbidities such as diabetes and kidney disease.

Study limitations

This study has some limitations that deserve to be highlighted. Among them are the limitations of a cross-sectional study that analyzed data from a specific time and did not assess other aspects related to the illness of these individuals over time. Another important limitation is that this study is based on data from the state health department, which are obtained through the records in the Health Units, and although the notification forms have a lot of mandatory registration information, one cannot be sure about the recording quality of these data.

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