Variability in case fatality rate risk due to Covid-19 according to health services provider in Mexico City hospitals

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Abstract

Objective. To describe differences in Case Fatality Rate (CFR) for Covid-19 among healthcare subsystems in Mexico City between March and December 2020. **Materials and methods.** This is a retrospective secondary data analysis from the National Epidemiological Surveillance System data of Covid-19 cases. Information about health provider institutions was retrieved from the Catalogue of Health Establishments (CLUES). Logistic regressions were fitted to determine the association between health subsystems and mortality associated to Covid-19. The analyses were divided between hospitalized and ambulatory patients. **Results.** The probability of dying from Covid-19 was higher among those treated at *Instituto Mexicano del Seguro Social* (IMSS) (Hospitalized:OR=5.11, Ambulatory:OR=36.57), *Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado* (ISSSTE) (Hospitalized:OR=2.10, Ambulatory:OR=9.19), *Secretaría de Salud* (SS) (Hospitalized:OR=1.94, Ambulatory:OR=5.29) or other public institutions (Hospitalized: OR=1.70, Ambulatory:OR=9.56) than in those treated in private institutions. **Conclusions.** Differences in healthcare quality and access between health subsystems are profound. It is imperative to increase the capacity and quality of the different health subsystems to improve health outcomes.

Keywords: Mexico; health systems; inequality; Covid-19; mortality

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Resumen

Objetivo. Describir diferencias en letalidad por Covid-19 entre subsistemas de salud en la Ciudad de México entre marzo y diciembre de 2020. **Material y métodos.** Análisis secundario retrospectivo del Sistema Nacional de Vigilancia Epidemiológica sobre casos Covid-19. La información sobre instituciones proveedoras de salud fue obtenida del Catálogo de Establecimientos de Salud. Se ajustaron regresiones logísticas para determinar la asociación entre los subsistemas de salud y la mortalidad atribuida a Covid-19. Los análisis se dividieron entre pacientes hospitalizados y ambulatorios. **Resultados.** La probabilidad de morir fue mayor entre aquéllos atendidos en el Instituto Mexicano del Seguro Social (IMSS) (Hospitalizados:OR=5.11, Ambulatorios: OR=36.57), Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado (ISSSTE) (Hospitalizados: OR=2.10, Ambulatorios: OR=9.19), Secretaría de Salud (SS) (Hospitalizados: OR=1.94, Ambulatorio: OR=5.29) u otras instituciones públicas (Hospitalizados: OR=1.70, Ambulatorio: OR=9.56) que en los atendidos en instituciones privadas. **Conclusiones.** Las diferencias en calidad y acceso a la atención médica entre subsistemas de salud son profundas. Urge aumentar la capacidad y la calidad de los subsistemas de salud para mejorar los resultados en salud.

Palabras clave: México; sistemas de salud; desigualdad; Covid-19; mortalidad

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Covid-19 is testing health systems all over the globe.[1] Since February 2020,[2] Mexico has faced the Covid-19 pandemic with a fragmented health system, with a low level of trust in its institutions and physicians, marked by deep inequalities in the access and quality of health care services.[3-6] This has resulted in a scenario where inequalities have had a marked influence over the course of the Covid-19 pandemic and has exposed stark sociodemographic and healthcare access inequities.[7]

The healthcare system in Mexico is divided in three main subsystems: employment based social insurances (*Instituto Mexicano del Seguro Social* [IMSS]; *Instituto de Seguridad y Servicios Sociales para Trabajadores del Estado*, [ISSSTE]), public assistance services for uninsured population (*Secretaría de Salud*, [SS]), and a private sector with service providers and insurers.[8] The IMSS is the oldest and largest institution in the country, insuring 68 158 455 beneficiaries in 2018.[9] The ISSSTE provides insurance to workers of the executive, legislative and judicial power branches of the federal government and workers of the federal autonomous dependencies.[10] The SS offers health protection for the non-insured population[11] since 1983 through an evolving[5] set of programs with an intended increasing coverage,[12] the most recent proposed in November of 2019, and approved until November 2020[13-16] (more details in supplementary material). Each of them has a different form of financing, resulting in a different budget per capita assigned to beneficiaries. These facts have a variety of implications resulting in a heterogeneity of quality among subsystems and within each subsystem,[17-19] such as the organizational culture, the insufficient coordination between institutions and among the whole sector, unstandardized processes and protocols, difference of supplies and technology, inadequate infrastructure, and deficient competencies among healthcare workers.[20]

Such differences may be related with health outcomes, which is aggravated by the evidence that the most vulnerable population are the most affected, especially for access to health services.[3] Despite such differences, Mexico has faced the Covid-19 pandemic with the available resources in infrastructure, organizational, personnel, and supplies. However, it is relevant to characterize differences within healthcare subsystems in Mexico and evaluate the results of this experience by estimating gaps in mortality associated with Covid-19 to identify and improve areas of opportunity to achieve better health outcomes. Therefore, this study aims to describe the differences in case fatality rate (CFR) for Covid-19 among healthcare subsystems, the level of care and the type of patient in Mexico City between March and December of 2020.

Materials and methods

Design and sample

The present study is a retrospective secondary data analysis or a city-wide Covid-19 registry within Mexico City. Data was gathered from the *Sistema Nacional de Vigilancia Epidemiológica* (Sinave) of Mexico, designed to track Covid-19 possible cases in the city and made available by the Health Ministry of Mexico City on its open data portal. This database includes characteristics of patients attended for the possible presence of Covid-19 and the institution that provided medical care and was last consulted on January 22, 2021. At the moment of enquiry, the database had the information of 1 491 245 suspected cases for Covid-19 defined by the presence of clinical symptoms described elsewhere.[21]

We included those individuals with a positive RT-PCR or rapid antigen test for SARS-CoV-2 between the months of March and December 2020. Those individuals with missing data on the result of RT-PCR o rapid antigen test for SARS-CoV-2 were excluded. The Unique Key of Health Establishments (CLUES) catalogue was used to obtain the level of care (first, second or third) of health institutions in Mexico City. This catalogue is made available to the public by the *Dirección General de Información en Salud* (DGIS) Information of the national ministry of health, and its purpose is to identify all health establishments in the country and their main characteristics.[22]

Dependent variable: Case Fatality Rate

The study's dependent variable was defined as the death or survival status among patients with a positive Covid-19 test. In order to construct it, a dichotomous variable was generated based on the case evolution indicated in the Sinave database. A value of "1" was assigned when the case evolution result was death and "0" for any other result.

Institutional variables

The institutional variable of interest for this study corresponds to the institution where patients were treated; generating a categorical variable considering five options: private sector, IMSS, ISSSTE, SS, and other health institutions (Red Cross, IMSS -*Oportunidades*, *Petróleos Mexicanos* [Pemex], *Secretaría de la Defensa Nacional* [Sedena], *Secretaría de Marina* [Semar] and university hospitals). This variable and the municipality where the establishment is located were obtained from the Sinave

database. The level of care of the establishment (primary, secondary or tertiary), and the number of clinics and beds, were obtained from the CLUES catalogue; these variables were matched with the Sinave database using the name of the establishment present in both datasets. Finally, two variables regarding the number of patients per medical office and the number of patients per bed were created by dividing the number of SARS-CoV-2 positive patients by the number of medical offices and beds. This was done in order to have variables considering the patient saturation of medical establishments.

Cofounding variables

Sociodemographic variables

The sociodemographic variables included sex, age and occupation of patients, all of them obtained from the Sinave database. The gender variable was kept as a binary variable categorized into men and women, while the age variable was divided into quartiles in such way that it ended distributed in the following groups: under 30 years old, 30 to 41, 42 to 53, and over 53 years old. Meanwhile, the occupation variable reported by patients was divided into four groups: students, workers, health workers and, finally, the segment of patients dedicated to the household, unemployed or retired.

Health variables

Health variables included in the study correspond to pre-existing conditions among patients and symptoms associated with the presence of the SARS-CoV-2 virus and its evolution. Pre-existing conditions variables include diabetes, obesity, hypertension and asthma; all of them were coded as dichotomous (no/yes) variables that show the absence or presence of these conditions. On the other hand, health variables associated with the virus included the presence of pneumonia, the number of respiratory symptoms (dyspnea, polypnea, cyanosis, fever and cough), the number of non-respiratory symptoms (headache, myalgia, arthralgia, attack of the general condition, abdominal pain, chest pain, conjunctivitis, irritability and vomiting) as previously described,[23] the number of days with symptoms at the time of admission to the health facility and, in the case of hospitalized patients, intubation. Finally, a variable was included to show the month of diagnosis of the patient, between March and December 2020. All health variables were obtained from the Sinave database.

Analysis

The descriptive analysis was performed by dividing hospitalized and ambulatory patients and, in each of these groups, making a subdivision between deceased and surviving patients. The significance of the differences between surviving and deceased patients was evaluated by t-tests for continuous variables and by Chi-square tests for categorical variables. Afterwards, we fitted two logistic regressions considering CFR associated with SARS-CoV-2 as the dependent variable. In one of the regressions, only the hospitalized patients were considered, while in the other included only the ambulatory population. The independent variable of interest was the institution to which the health establishment where the patients were treated belongs. Also, the sociodemographic, health and institutional variables previously listed were included. To consider heterogeneity between institutions, we fitted the model with a random intercept within a mixed-effects framework to account for heterogeneity in care amongst different hospitals within different healthcare subsystems.

As other retrospective studies regarding the ongoing Covid-19 pandemic, the sampling used by the Sinave might be prone to some biases.[24] Therefore, some limitations should be considered: first, early in the pandemic, testing was reserved for higher risk cases, which likely skewed risk assessment towards higher risk cases and may have improved later in the pandemic with the implementation of rapid antigen testing.[25] Second, attainment of the differences in CFR risk within healthcare subsystems is complex and cannot be uniquely assigned to differences in access or quality of care but also to admission criteria, severity spectrum of admitted cases and local influence of pandemic dynamics. Third, although cases with ambulatory care often indicate cases with milder presentations of Covid-19, initially asymptomatic or milder cases may not be fully accounted for in second and third level care clinics, which may explain the increased risk in those institutions. Finally, disaggregated denominators for the volume of patients treated at each healthcare subsystem is not available and analyses of adjusted rates by number of patients treated at each subsystem could not be performed within a Poisson regression framework.

Results

Study population

Our analysis included 349 890 persons with a positive Covid-19 lab test during the period March-December 2020. From this total, 43 974 were hospitalized, and 305 916 were ambulatory patients. The mean age of patients attended for the possible presence of Covid-19 during March-December 2020 was 42.5 (±16.9) years old. Those who died were older than those who survive either among the hospitalized (63.2 ± 13.9 vs. 61.3 ± 14.5 years old) or ambulatory (53.3 ± 16.4 vs. 40.3 ± 15.8). Among all, 50.9% were female, and 59.7% were non-health-related workers (table I).

The attention of Covid-19 within healthcare facilities in Mexico City

Concerning the place of attention, 75.5% of the cases were attended on first-level clinics, 13.3% in second-level hospitals and 11.3% on third-level hospitals, with significant differences between healthcare subsystems (p<0.001) going from 6.7% of ministry of health patients attended on third-level hospitals to 15.7% of patients from IMSS, 16.2% of private institutions patients, 65.1% of patients from ISSSTE and 82.5% of patients of other institutions attended at this level. There is a significant difference in the level of attention between hospitalized and ambulatory patients (p<0.001). Considering hospitalized patients, 4.7% were attended in first-level clinics,

Table I
Description of Covid-19 positives in Mexico City, January 2020

Variables	*Hospitalized N=43 974*			*Ambulatory N=305 916*			*Total*
	Survivors	*Defunctions*	*p-value*	*Survivors*	*Defunctions*	*p-value*	
Sociodemographic							
Age, mean (SD)	53.3 (16.4)	63.2 (13.9)	0.0000	40.3 (15.8)	61.3 (14.5)	0.0000	42.5 (16.9)
Sex, n (%)							
Man	15 716 (59.0)	11 385 (65.7)	0.0000	143 407 (47.2)	1 171 (66.3)	0.0000	171 679 (49.1)
Woman	10 915 (41.0)	5 958 (34.3)		160 742 (52.8)	596 (33.7)		178 211 (50.9)
Occupation, n (%)							
Home, unemployed or retired	9 835 (36.9)	8 848 (51.0)	0.0000	61 191 (20.1)	796 (45.0)	0.0000	80 670 (23.1)
Student	452 (1.7)	52 (0.3)		30 545 (10.0)	3 (0.2)		31 052 (8.9)
Worker	14.753 (55.4)	8 075 (46.6)		185 102 (60.9)	875 (49.5)		208 805 (59.7)
Health worker	1 591 (6.0)	368 (2.1)		27 311 (9.0)	93 (5.3)		29 363 (8.4)
Health conditions							
Days with symptoms at admission, mean (SD)	5.4 (4.1)	5.2 (3.4)	0.0000	3.7 (3.4)	5.2 (3.5)	0.0000	3.9 (3.5)
Number of respiratory symptoms, mean (SD)	2.6 (1.1)	2.8 (1.0)	0.0000	1.3 (1.0)	2.4 (1.1)	0.0000	1.5 (1.1)
Number of non-respiratory symptoms, mean (SD)	3.4 (1.9)	3.4 (1.9)	0.0000	2.3 (2.0)	3.3 (1.9)	0.0000	2.4 (2.0)
Intubated, n (%)	1 966 (7.4)	7 139 (41.2)	0.0000	0 (0.0)	0.(0.0)	0.0000	9 105 (2.6)
Pneumonia, n (%)	17 258 (64.8)	13 218 (76.2)	0.0000	5 897 (1.9)	934 (52.9)	0.0000	37.307 (10.7)
Diabetes, n (%)	6 714 (25.2)	6 184 (35.7)	0.0000	25 963 (8.5)	583 (33.0)	0.0000	39 444 (11.3)
Obesity, n (%)	5 837 (21.9)	3 863 (22.3)	0.1470	37 943 (12.5)	446 (25.2)	0.0000	48 089 (13.7)
Hypertension, n (%)	7 655 (28.7)	7 140 (41.2)	0.0000	34 464 (11.3)	714 (40.4)	0.0000	49 973 (14.3)
Asthma, n (%)	532 (2.0)	251 (1.5)	0.0000	6 570 (2.2)	25 (1.4)	0.0000	7 378 (2.1)
Institutional characteristics							
Health attention level							
First, n (%)	1 285 (4.8)	783 (4.5)	0.0000	261 262 (85.9)	561 (31.8)	0.0000	263 992 (75.5)
Second, n (%)	14 049 (52.8)	10 172 (58.7)		21 447 (7.1)	678 (38.4)		46 346 (13.3)
Third, n (%)	11 297 (42.42)	6 388 (36.8)		21 339 (7.0)	528 (29.9)		39 552 (11.3)

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Institution							
Private, n (%)	1 767 (6.6)	254 (1.5)		3 814 (1.3)	16 (0.9)		5 851 (1.7)
IMSS, n (%)	10 997 (41.3)	10 251 (59.1)		39 433 (13.0)	1 157 (65.5)		61 838 (17.7)
ISSSTE, n (%)	2 931 (11.0)	1 728 (10.0)	0.0000	1 443 (0.5)	69 (3.9)	0.0000	6 171 (1.8)
SS, n (%)	8 113 (30.5)	4 094 (23.6)		255 096 (83.9)	426 (24.1)		267 729 (76.5)
Other, n (%)	2 823 (10.6)	1 016 (5.8)		4 363 (1.4)	99 (5.6)		8 301 (2.4)
Municipality							
Azcapotzalco, n (%)	3 861 (14.5)	2 986 (17.2)		21 795 (7.2)	239 (13.5)		28 881 (8.3)
Benito Juárez, n (%)	2 655 (10.0)	1 459 (8.4)		16 693 (5.5)	120 (6.8)		20 927 (6.0)
Coyoacán, n (%)	1 460 (5.5)	1 278 (7.4)		16 199 (5.3)	95 (5.4)		19 032 (5.4)
Cuajimalpa, n (%)	48 (0.2)	22 (0.1)		8 109 (2.7)	10 (0.6)		8 189 (2.3)
Cuauhtémoc, n (%)	3 063 (11.5)	2 181 (12.6)		33 774 (11.1)	259 (14.7)		39 277 (11.2)
Gustavo A. Madero, n (%)	3 297 (12.4)	2 918 (16.9)		30 271 (10.0)	110 (6.2)		36 596 (10.5)
Iztacalco, n (%)	1 093 (4.1)	1 050 (6.1)		11 558 (3.8)	108 (6.1)		13 809 (4.0)
Iztapalapa, n (%)	1 933 (7.3)	1 367 (7.9)	0.0000	29 288 (9.6)	189 (10.7)	0.0000	32 777 (9.4)
Magdalena Contreras, n (%)	145 (0.5)	29 (0.2)		12 429 (4.1)	28 (1.6)		12 631 (3.6)
Miguel Hidalgo, n (%)	1 867 (7.0)	624 (3.6)		15 676 (5.2)	106 (6.0)		18 273 (5.2)
Milpa Alta, n (%)	134 (0.5)	43 (0.3)		7 787 (2.6)	23 (1.3)		7 987 (2.3)
Tlalpan, n (%)	3 695 (13.9)	1 738 (10.0)		30 470 (10.0)	200 (11.3)		36 103 (10.3)
Tláhuac, n (%)	315 (1.2)	248 (1.4)		14 743 (4.9)	38 (2.2)		15 344 (4.4)
Venustiano Carranza, n (%)	248 (0.9)	17 (0.1)		17 703 (5.8)	26 (1.5)		17 994 (5.1)
Xochimilco, n (%)	4 (0.1)	0 (0.0)		12 521 (4.1)	7 (0.4)		12 532 (3.6)
Álvaro Obregón, n (%)	2 813 (10.6)	1 383 (8.0)		25 133 (8.3)	209 (11.8)		29 538 (8.4)

Source: Own elaboration with data from the National Epidemiological Surveillance System and the Catalogue of Health Establishments (CLUES).

55.1% in second-level hospitals and 40.2% in third-level hospitals. Meanwhile, 85.6% of ambulatory patients were attended in first-level clinics, 7.2% in second-level hospitals and 7.2% in third-level hospitals. Most cases (76.5%) were attended in facilities of the ministry of health, followed by IMSS (17.7%), ISSSTE (1.8%) and private facilities (1.7%). In contrast, higher proportion of the deaths occurred when the attention was given in the IMSS (59.1% and 65.5% for the hospitalized and the ambulatory, respectively), followed by the ministry of health (23.6 and 24.1% for the hospitalized and the ambulatory, repectively), the ISSTE (10 and 3.9% for the hospitalized and the ambulatory, respectively), and the private sector (1.5 and 0.9% for the hospitalized and the ambulatory, respectively). The municipality in Mexico City presenting the higher proportion of cases (11.2%) was Cuauhtémoc, and the one who presented the least (2.3%) was Milpa Alta. The municipality with higher proportion of deaths was Azcapotzalco (16.9%; 2 986 hospitalized and 239 ambulatories), and the one with the least was Xochimilco (0.04%; 0 of the hospitalized and 7 in the ambulatory) (table I and table II). For all the variables, we observed significant differences in the distribution of variables under study for those who died for Covid-19 and those who survived the disease, with the exception of obesity for hospitalized cases.

Influence of healthcare subsystem on Covid-19 CFR

The multivariable logistic regression model for CFR in hospitalized patients showed that the probability of dying from Covid-19 for a patient treated at a facility within the IMSS (OR 5.11, 95%CI 4.16,6.27), ISSSTE (OR 2.10, 95%CI 1.69,2.62), SS (OR 1.94, 95%CI 1.57,2.40) or other institutions (OR 1.7, 95%CI 1.33,2.18, table III) is higher than those in private institutions, even after adjustment for age, sex, comorbidities and symptom severity. As for ambulatory patients, the probability of dying was higher for patients treated within IMSS

facilities (OR 36.57, 95%CI 16.62,80.46), ISSSTE (OR 9.19, 95%CI 3.92,21.55), SS (OR 5.29, 95%CI 2.37,11.81), and other institutions (OR 9.56, 95%CI 4.11,22.23) than for those attending in private institutions (table IV). The probability was higher for men; for those dedicated to the household, unemployed or retired subjects; for those requiring intubation; those with diagnosis of clinical pneumonia or a higher number of respiratory symptoms; those with diabetes or hypertension as preexisting conditions, and were attended in facilities with a higher number of patients per bed. As expected, the probability of dying increased with age. The pre-existence of obesity or asthma, being attended in a third-level care centre, and the number of patients per medical office were not statistically significant.

Changes across time and level of care in Covid-19 CFR

CFR associated with Covid-19 within hospitalized patients decreased after the initial peak in March-April, when it was higher than any of the months from May to October; however, increased CFR was observed in November compared to March and April after adjusting for relevant covariates. Treatment within a third-level healthcare hospital was associated with an increased risk for CFR associated with Covid-19 compared to second-level care (OR 1.11, 95%CI 1.03,1.19, table III). In contrast, for ambulatory patients, CFR was consistently lower in subsequent months. Finally, when considering the level of care within the model

Table II
Description of Covid-19 positives in Mexico City by health institution, January 2021

Variables	*Institution*					*p-value*	*Total*
	Private	*IMSS*	*ISSSTE*	*SS*	*Other*		
Sociodemographic							
Age, mean (SD)	47.1 (18.1)	47.2 (16.7)	55.4 (16.7)	40.8 (16.5)	49.3 (17.5)	0.0000	42.5 (16.9)
Sex, n (%)							
Man	3 352 (57.3)	31 754 (51.4)	3 555 (57.6)	128 332 (47.9)	4 686 (56.5)	0.0000	171 679 (49.1)
Woman	2 499 (42.7)	30 084 (48.7)	2 616 (42.4)	139 397 (52.1)	3 615 (43.6)		178 211 (50.9)
Ocupation, n (%)							
Home, unemployed or retired	1 113 (19.0)	15 657 (25.3)	1 842 (29.9)	59 822 (22.2)	2 236 (26.9)	0.0000	80 670 (23.1)
Student	318 (5.4)	1 155 (1.9)	95 (1.5)	29 246 (10.9)	238 (2.9)		31 052 (8.9)
Worker	3 943 (67.4)	32 427 (52.4)	2 967 (48.1)	164 571 (61.5)	4 897 (59.0)		208 805 (59.7)
Health worker	477 (8.2)	12 599 (20.4)	1 267 (20.5)	14 090 (5.7)	930 (11.2)		29 363 (8.4)
Health conditions							
Days with symptoms at admission, mean (SD)	3.4 (3.7)	4.7 (4.1)	4.9 (3.5)	3.7 (3.3)	3.9 (3.5)	0.0000	3.9 (3.5)
Number of respiratory symptoms, mean (SD)	1.3 (1.1)	2.1 (1.1)	2.4 (1.1)	1.3 (1.1)	1.9 (1.1)	0.0000	1.5 (1.1)
Number of non-respiratory symptoms, mean (SD)	1.8 (1.7)	3.4 (1.8)	3.4 (1.9)	2.2 (2.0)	2.7 (1.7)	0.0000	2.4 (2.0)
Intubated, n (%)	384 (19.0)	3 724 (17.5)	941 (20.2)	3 573 (29.3)	483 (12.7)	0.0000	9 105 (2.6)
Pneumonia, n (%)	1 890 (32.3)	14 871 (24.1)	4 151 (67.3)	13 593 (5.1)	2 802 (33.8)	0.0000	37.307 (10.7)
Diabetes, n (%)	638 (10.9)	10 094 (16.3)	1 784 (28.9)	25 577 (9.6)	1 351 (16.3)	0.0000	39 444 (11.3)
Obesity, n (%)	575 (9.8)	11 334 (18.3)	1 378 (22.3)	33 430 (12.5)	1 372 (16.5)	0.0000	48 089 (13.7)
Hypertension, n (%)	962 (16.4)	12 859 (20.8)	2 057 (33.3)	32 529 (12.2)	1 566 (18.9)	0.0000	49 973 (14.3)
Asthma, n (%)	108 (1.9)	1 480 (2.4)	152 (2.5)	5 475 (2.0)	163 (2.0)	0.0000	7 378 (2.1)
Institutional characteristics							
Health attention level							
First, n (%)	320 (5.5)	25 202 (40.8)	86 (1.4)	238 384 (89.0)	0 (0.0)	0.0000	263 992 (75.5)
Second, n (%)	4 581 (78.3)	26 918 (43.5)	2 070 (33.5)	11 326 (4.2)	1 451 (17.5)		46 346 (13.3)
Third, n (%)	950 (16.2)	9 718 (15.7)	4 015 (65.1)	18 019 (6.7)	6 850 (82.5)		39 552 (11.3)

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Municipality							
Azcapotzalco, n (%)	0 (0.0)	12 534 (20.3)	0 (0.0)	13 992 (5.2)	2 355 (28.4)		28 881 (8.3)
Benito Juárez, n (%)	1 135 (19.4)	6 074 (9.8)	1 411 (22.9)	12 307 (4.6)	0 (0.0)		20 927 (6.0)
Coyoacán, n (%)	45 (0.8)	6 311 (10.2)	0 (0.0)	12 676 (4.7)	0 (0.0)		19 032 (5.4)
Cuajimalpa, n (%)	122 (2.1)	524 (0.9)	0 (0.0)	7 543 (2.8)	0 (0.0)		8 189 (2.3)
Cuauhtémoc, n (%)	1 162 (19.9)	8 074 (13.1)	27 (0.4)	30 014 (11.2)	0 (0.0)		39 277 (11.2)
Gustavo A. Madero, n (%)	239 (4.1)	7 804 (12.6)	1 478 (24.0)	27 075 (10.1)	0 (0.0)		36 596 (10.5)
Iztacalco, n (%)	2 (0.0)	5 156 (8.3)	0 (0.0)	8 651 (3.2)	0 (0.0)		13 809 (4.0)
Iztapalapa, n (%)	0 (0.0)	6 266 (10.1)	744 (12.1)	25 767 (9.6)	0 (0.0)		32 777 (9.4)
Magdalena Contreras, n (%)	1 297 (22.2)	1 537 (2.5)	0 (0.0)	9 797 (3.7)	0 (0.0)	0.0000	12 631 (3.6)
Miguel Hidalgo, n (%)	399 (6.8)	820 (1.3)	536 (8.7)	14 416 (5.4)	2 102 (25.3)		18 273 (5.2)
Milpa Alta, n (%)	0 (0.0)	0 (0.0)	3 (0.1)	7 984 (3.0)	0 (0.0)		7 987 (2.3)
Tlalpan, n (%)	501 (8.6)	1 772 (2.9)	1 (0.0)	32 356 (12.1)	1 473 (17.7)		36 103 (10.3)
Tláhuac, n (%)	0 (0.0)	0 (0.0)	0 (0.0)	15 344 (5.7)	0 (0.0)		15 344 (4.4)
Venustiano Carranza, n (%)	0 (0.0)	1 089 (1.8)	0 (0.0)	16 905 (6.3)	0 (0.0)		17 994 (5.1)
Xochimilco, n (%)	0 (0.0)	0 (0.0)	0 (0.0)	12 532 (4.7)	0 (0.0)		12 532 (3.6)
Álvaro Obregón, n (%)	949 (16.2)	3 877 (6.3)	1 971 (31.9)	20 370 (7.6)	2 371 (28.6)		29 538 (8.4)

Source: Own elaboration with data from the National Epidemiological Surveillance System and the Catalogue of Health Establishments (CLUES).
IMSS: *Instituto Mexicano del Seguro Social*; ISSSTE: *Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado*; SS: *Secretaría de Salud.*

Table III
LOGISTIC REGRESSION ON DEATHS BY COVID-19 AMONG HOSPITALIZED PATIENTS IN MEXICO CITY, DECEMBER 2020

Deaths	*Odds Ratio*	*Std. Err.*	z	*P>z*	*[95%CI]*
Month of hospital admission: March and April (reference)					
May	0.88	0.04	-2.60	0.0090	0.80,0.97
June	0.76	0.04	-5.61	0.0000	0.69,0.83
July	0.61	0.03	-9.10	0.0000	0.55.0.68
August	0.64	0.04	-7.76	0.0000	0.57,0.72
September	0.58	0.03	-9.36	0.0000	0.52,0.65
October	0.60	0.03	-9.01	0.0000	0.54,0.67
November	0.66	0.03	-7.96	0.0000	0.60,0.73
December	0.82	0.04	-4.10	0.0000	0.75,0.90
Female	0.63	0.02	-18.61	0.0000	0.60,0.66
Age: Cuartil 1: <30 (reference)					
Cuartil 2: 30-41	1.57	0.14	5.05	0.0000	1.32,1.87
Cuartil 3: 42-53	2.72	0.23	11.97	0.0000	2.31,3.21
Cuartil 4: 54+	5.55	0.45	20.94	0.0000	4.73,6.51
Occupation: household, unemployed and retired (reference)					
Students	0.72	0.12	-1.91	0.0560	0.52,1.01
Workers	0.77	0.02	-10.07	0.0000	0.73,0.81
Health workers	0.40	0.03	-13.44	0.0000	0.35,0.46
Days with symptoms before admission	0.98	0.00	-6.74	0.0000	0.97,0.99
Number of respiratory symptoms	1.16	0.01	12.74	0.0000	1.14,1.19
Number of non-respiratory symptoms	0.96	0.01	-6.90	0.0000	0.94,0.97

(continues…)

Pneumonia	2.23	0.06	27.96	0.0000	2.11,2.36
Diabetes	1.19	0.03	6.96	0.0000	1.14,1.26
Obesity	1.05	0.03	1.82	0.0690	1.00,1.11
Hypertension	1.20	0.03	7.34	0.0000	1.15,1.26
Asthma	0.85	0.08	-1.84	0.0660	0.71,1.01
Tertiary care center	1.11	0.04	2.83	0.0050	1.03,1.19
Number of patients per medical office	1.00	0.00	2.05	0.0400	1.00,1.00
Number of patients per bed	0.99	0.00	-4.85	0.0000	0.99,0.99
Institution: private (reference)					
IMSS	5.11	0.54	15.54	0.0000	4.16,6.27
ISSSTE	2.10	0.24	6.63	0.0000	1.69,2.62
SS	1.94	0.21	6.15	0.0000	1.57,2.40
Other	1.70	0.22	4.23	0.0000	1.33,2.18
Constant	0.04	0.01	-12.15	0.0000	0.02,0.06
Municipality					
Constant	0.68	0.32			0.27,1.69

N=38 995 P=0.0000
Source: Own elaboration with data from the National Epidemiological Surveillance System and the Catalogue of Health Establishments (CLUES).
IMSS: *Instituto Mexicano del Seguro Social*; ISSSTE: *Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado*; SS: *Secretaría de Salud.*

Table IV
Logistic regression on deaths by Covid-19 among ambulatory patients in Mexico City, December 2020

Deaths	*Odds Ratio*	*Std. Err.*	*z*	*P>z*	*[95%CI]*
Month of hospital admission: March and April (reference)					
May	0.70	0.08	-3.29	0.0010	0.56,0.86
June	0.36	0.04	-8.84	0.0000	0.28,0.45
July	0.28	0.04	-9.83	0.0000	0.22,0.36
August	0.22	0.03	-10.73	0.0000	0.17,0.29
September	0.21	0.03	-10.84	0.0000	0.16,0.28
October	0.17	0.02	-12.26	0.0000	0.13,0.23
November	0.16	0.02	-13.48	0.0000	0.13,0.21
December	0.13	0.02	-16.51	0.0000	0.10,0.17
Female	0.43	0.03	-13.28	0.0000	0.38,0.49
Age: Cuartil 1: <30 (reference)					
Cuartil 2: 30-41	2.23	0.48	3.74	0.0000	1.46,3.40
Cuartil 3: 42-53	5.25	1.07	8.11	0.0000	3.52,7.84
Cuartil 4: 54+	16.24	3.26	13.86	0.0000	10.95,24.08
Occupation: homemakers, unemployed and retired (reference)					
Students	0.22	0.13	-2.49	0.0130	0.07,0.73
Workers	0.56	0.04	-8.69	0.0000	0.49,0.64
Health workers	0.15	0.02	-15.40	0.0000	0.11,0.19
Days with symptoms before admission	1.00	0.01	-0.50	0.6170	0.98,1.01
Number of respiratory symptoms	1.64	0.05	16.77	0.0000	1.55,1.73
Number of non-respiratory symptoms	0.92	0.02	-5.12	0.0000	0.89,0.95
Pneumonia	9.80	0.61	36.72	0.0000	8.68,11.07

(continues…)

(continuation)

Diabetes	1.55	0.10	6.47	0.0000	1.36,1.77
Obesity	1.32	0.09	4.10	0.0000	1.16,1.51
Hypertension	1.49	0.10	6.06	0.0000	1.31,1.69
Asthma	0.68	0.15	-1.74	0.0820	0.44,1.05
Attention level: First care center (reference)					
Secondary care center	3.36	0.27	15.26	0.0000	2.87,3.92
Tertiary care center	4.60	0.45	15.69	0.0000	3.80,5.56
Number of patients per medical office	1.00	0.00	-7.40	0.0000	1.00,1.00
Institution: private (reference)					
IMSS	36.57	14.71	8.95	0.0000	16.62,80.46
ISSSTE	9.19	4.00	5.10	0.0000	3.92,21.55
SS	5.29	2.17	4.07	0.0000	2.37,11.81
Other	9.56	4.11	5.25	0.0000	4.11,22.23
Constant	0.00	0.00	-18.35	0.0000	0.00,0.00
Municipality					
Constant	0.11	0.05			0.05,0.27

N=301 143 P=0.0000
Source: Own elaboration with data from the National Epidemiological Surveillance System and the Catalogue of Health Establishments (CLUES).
IMSS: *Instituto Mexicano del Seguro Social*; ISSSTE: *Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado*; SS: *Secretaría de Salud.*

for ambulatory patients, odds for CFR associated with Covid-19 was higher for the third and second levels of care (OR 4.60, 95%CI 3.80,5.56; and OR 3.36, 95%CI 2.87,3.92, respectively) compared to ambulatory cases attending first-level clinics, and after controlling by relevant covariates (table IV).

Discussion

Our study aimed to describe the differences in CFR for Covid-19 among healthcare subsystems and level of care in Mexico between March and December of 2020. We observed higher CFR for the hospitalized patients at the IMSS, ISSSTE, other health services, and SS than at a private health service; while observing higher CFR among the ambulatory patients attending at the IMSS, other health services, ISSSTE and SS than among patients attending to a private health service. Our study does not claim a direct causal effect of healthcare subsystem utilization with the Covid-19 CFR, it only points out there are statistically significant differences in Covid-19 CFR across susbsystems, which may be attributable to additional structural factors or unmeasured confounders, particularly regarding underlying Covid-19 severity. Further research is needed to determine whether this differences are a direct effect of the studied variables or not.

Similarly, we observed higher CFR among those hospitalized at the third-level of care and those ambulatory patients attending institutions within the third and second levels of care than those attending to institutions within the first-level of care. Clinical algorithms state that patients with more risk factors and more severe disease must be referred to second and third level facilities, which might explain the differences in CFR.[26] It should not be ruled out that, besides the severity of the disease, these differences might be associated with improved ambulatory care in primary care facilities or a more stringent selection criteria under peak periods of the pandemic in second and third-level care facilities, which likely led cases with more severe profiles to be treated in an ambulatory setting. Also, analyzed data shows significant differences in the proportion of hospitalized cases by municipality; this could be influenced by health access barriers originated by location factors or hospital saturation.

Our results are similar to those previously reported by Carrillo-Vega and colleagues,[27] who reported an 8.25 risk of dying in Mexico's public health services. However, while Carrillo-Vega ando colleagues included available national data, our analysis was restricted to Mexico's City residents; similarly, the mean age of patients attended for the possible presence of Covid-19 during March may have been different and was accounted for in our model by controlling by the month of diagnosis or hospitalization, and the municipality where the health institution was located among additional covariates. Finally, our analysis included 349 890 persons with a positive Covid-19 test during the period

March-December 2020, which contrasts with the early estimations made in the previous study which focused on early Covid-19 CFR.

Despite having a fragmented health system, Mexico is facing the Covid-19 pandemic with all available resources. However, our results suggest that differences in healthcare quality provision and access within the Mexican Health System are profound and reveal a necessity to standardize procedures and protocols within health subsystems to improve Covid-19 care as vaccine rollouts proceed with limited resources.[28] Despite observing a step decline in the CFR associated with Covid-19 from May to December, probably resulting from an increase in testing, and an improved criteria for identifying patients for ambulatory care, our results' only potential explanation is highlighting that public health services attended 96.0% of the positive Covid-19 cases between March and December in Mexico City, suggesting an overload for health personnel, who have also accumulated time and tiredness while facing the pandemic.[29] This has been shown at individual-level institutions, where increased demand for healthcare services led to unequal resource allocation and subsequently increased CFR due to limited resources attributable to hospital saturation during pandemic peaks.[30] Private healthcare services in Mexico are very expensive and often unaffordable for a large fraction of the Mexican population therefore, when facing a possible infection from SARS-CoV-2, people might have prefered to receive care on public services,[8] which might explain the increased demand in public hospitals and their saturation.

The Covid-19 pandemic brought several challenges for every health system since it has demonstrated that the Mexican healthcare system was mostly unprepared for this task.[31] It has been recognized that besides physical and financial barriers, the organizational schemes and bureaucratic procedures,[3] the differences between staffing and resources among hospitals of the same and different subsystems harm health outcomes.[3,17] Therefore, the experiences of the Covid-19 pandemic urge to update the fragmented Mexican Health System by tackling the known and still unknown sources of inequalities in the access and quality of health services,[3-6] by designing, implementing and promoting the use of telehealth services,[32,33] the infrastructure, the organizational culture, coordination, processes and protocols, and improving competences among healthcare workers,[34] enrichening their decision-making an approach from an individual focus to a public health focus.

Supplementary material

Health system in Mexico is divided in three subsystems: employment based social insurances (IMSS, ISSSTE), public assistance services for uninsured (SS), and a private sector with service providers and insurers.[8]

Among the employment-based social insurances, IMSS is the oldest and largest institution in the country, insuring 68 158 455 beneficiaries in 2018.[9] It was created in 1943, providing insurance to formal workers of private companies, retired formal workers, students at public universities, domestic workers, and the families of those affiliated, as well as some families that voluntarily pay for the insurance.[35] Therefore, nearly 50% of Mexicans are affiliated with it. IMSS financing comes from a tripartite scheme with the workers, their bosses, and the federal government contribute.

ISSSTE was created in 1959 and provides insurance to workers of the executive, legislative and judicial power branches of the federal government and the workers of the federal autonomous dependencies such as the office of the Attorney General, the Constitutional Autonomous Organizations, and the Jurisdictional Autonomous Organs.[10] However, it does not provide insurance to the military forces (Sedena and Semar) and the national oil company Pemex; each has its insurance institutions. The institutions that ensure State workers are financed through a double scheme, with contributions from the worker and the State.[36]

It was until 1983 when the government declared the right of health protection for all in the Federal Constitution.[11] Since then, there have been several efforts to achieve universal health access coverage for all Mexicans. In response to these needs, in 2004, the *Seguro Popular* (Popular Insurance) was created. Any Mexican could affiliate to this institution that was financed by public taxes and by client fees that were calculated according to the insured's socioeconomic status. This insurance would only cover some of the most common and severe health ailments; if the health service needed was not in CAUSES, the patient had to pay out-of-pocket. By 2019, 89% of the population had health coverage.[12] The *Seguro Popular* Services were provided in health facilities run by the Federal Ministry of Health or by local government's ministries or institutions.[37]

November 29 of 2019, the Federal Government reformed the National Health Act to substitute the *Seguro Popular* for the *Instituto Nacional de Salud para el Bienestar* (Insabi).[13] Insabi aims to achieve universal health coverage, universal coverage of services, significant reductions in out-of-pocket spending, eradicating

corruption from health services, and improving people's well-being.[15] In March 2020, a reengineering plan for the Health Ministry and health services was proposed son the Insabi could be implemented effectively to achieve its goals. This plan centres the health services on critical and integrated care in primary health care.[14] Along with these changes, the Federal Government announced the centralization of purchases of medicine and health care supplies and the regularization of health workers as federal employees (in contrast to local government employees in *Seguro Popular*).[15] The Organization's Governing Statutes for the Insabi were not approved until November 2020.[16] Therefore, the SARS-CoV-2 pandemic arrived during one of the most ambitious and essential health transitions in recent Mexican history.

Declaration of conflict of interests. The authors declare that they have no conflict of interests.

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