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ORIGINAL ARTICLE

Criticism of the sentinel model of epidemiological surveillance in COVID-19

Crítica al modelo centinela de vigilancia epidemiológica en la COVID-19

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Abstract

Objective: *The objective of the study was to analyze the increase in sentinel cases of COVID-19 in Mexico calculated from the effective number of reproductions of the infection (R_t) and compare its evolution with that reported by Italy, Spain and the United States of America during the first 20 weeks of evolution of the epidemic.* **Methods:** *In an analytical cross-sectional design, the total number of cases of COVID-19 in Mexico from February 29 to July 24, 2020 was studied, and compared with sentinel cases calculated from the R_t. A descriptive and comparative analysis of prevalence, cumulative incidence and case fatality was performed to summarize the epidemiological data for Mexico and in relation to information for Italy, Spain, and the United States of North America.* **Results:** *In Mexico, until July 24, 2020, there are a total of 390,516 cases of COVID-19 and 43,680 deaths from this disease; with the use of R_t to calculate the correction of cases and unidentified deaths, the figure increases to 3,780,195 cases (p = 0.0002) and 211,469 deaths (p = 0.001). This suggests underreporting in the identification of cases and deaths and is associated with one of the highest case fatality rates in the world for SARS-CoV-2 infection.* **Conclusions:** *In Mexico, the sentinel model presents a significant loss of unquantified information. It is necessary to reinforce epidemiological surveillance through a better case detection strategy in our country and continue to apply measures that allow the containment and mitigation of the COVID-19 pandemic.*

Keywords: *Human coronavirus. SARS-CoV-2. Diagnosis. Sentinel model.*

Resumen

Objetivo: *Analizar el incremento de los casos centinela de COVID-19 en México calculados a partir del número efectivo de reproducción de la infección (R_t) y comparar su evolución con lo reportado por Italia, España y los Estados Unidos de Norteamérica durante las primeras 20 semanas de evolución de la pandemia.* **Métodos:** *En un diseño transversal analítico se estudió el total de casos de COVID-19 en México del 29 de febrero al 24 de julio de 2020, y se comparó con los casos centinela calculados a partir del R_t. Se realizó un análisis descriptivo y comparativo de la prevalencia, la incidencia acumulada y la letalidad para resumir los datos epidemiológicos para México y en relación con la información de Italia, España y los Estados Unidos de Norteamérica.* **Resultados:** *En México, hasta el 24 de julio de 2020 se habían producido 390,516 casos de COVID-19 y 43,680 defunciones por esta enfermedad; con el uso del R_t para el cálculo de la corrección de casos y defunciones no identificadas, la cifra aumenta a 3,780,195 casos (p = 0.0002) y 211,469 defunciones (p = 0.001). Lo anterior*

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sugiere un subregistro en la identificación de casos y defunciones, y se asocia con una de las tasas de letalidad más altas del mundo para la infección por SARS-CoV-2. **Conclusiones:** *El modelo centinela presenta una pérdida importante de información no cuantificada. Es necesario reforzar la vigilancia epidemiológica mediante una mejor estrategia de detección de casos en nuestro país y seguir aplicando medidas que permitan la contención y la mitigación de la pandemia de COVID-19.*

Palabras clave: *Coronavirus humano. SARS-CoV-2. Diagnóstico. Modelo centinela.*

Introduction

At present, the world has been paralyzed by the spread of the new SARS-CoV-2 coronavirus discovered in December 2019, an agent that causes the disease known as COVID-19[1]. It is a contagious disease in humans for which there is no specific treatment or vaccine for preventing it, and that generates a severe acute respiratory syndrome in susceptible people[2]. Two plausible scenarios have been suggested for the origin of SARS-CoV-2: a process of natural selection in an animal host before zoonotic transfer or natural selection in humans following zoonotic transfer[3]. The virus spread rapidly around the world, and it reached Europe in less than 2 months and then America. Due to its high contagiousness and morbidity, this infection is considered by the World Health Organization (WHO) to be a global emergency[4]. Initial mortality rate was 2.9% in Hubei province, China[5], and rapidly increased to 5.5% globally. Some countries have had mortality figures higher than 10%, such as Italy, Spain and Mexico[1], which suggests that they are doing something wrong to control the occurrence of new cases[6].

In Mexico, the first case was detected in an individual who traveled to Italy in late February 2020[7], and cases from Spain, France and the United States of America, among others, quickly added[8]. The Mexican strategy to respond to COVID-19 has been controversial because massive testing is not carried out on the general population. The sentinel surveillance that was implemented only investigates those individuals who meet the definition of suspected case and his/her contacts (when this is possible), who should undergo a diagnostic test for SARS-CoV-2[9].

In any infectious disease, new secondary cases are expected for each case reported in the susceptible population, and this knowledge is used to analyze the transmission potential of the disease[10]. The WHO initially estimated that COVID-19 produced between 1.4 and 2.5 secondary infections for each initial case that was identified[11,12].There is no doubt that there is a large unquantified proportion of cases that will never be investigated because they have mild symptoms or are asymptomatic, while others will rapidly worsen and die before receiving hospital medical care for COVID-19. Twenty weeks have elapsed since the appearance of the first case in Mexico and a total of 349,396 confirmed cases and 39,485 deaths from COVID-19 have already been reported, with a case fatality rate higher than 11%. The figure reported everyday by the health authority in Mexico is an incomplete value that does not include all "sentinel cases" that might exist, which modifies the epidemiological scenario and complicates any prediction that can be made about this disease. Due to SARS-CoV-2 high infectiousness among susceptible population, the goal of epidemiological interventions (social distancing, use of face masks, immunology testing, isolation of contacts, closure of borders, etc.)[13] is to reduce the reproduction number of new cases. Infection effective reproductive number (R_t) is an epidemiological parameter that can be used to assess the transmission of infectious agents and represents the average number of infections in time "*t*" per infected case in the course of his/her infection[14,15]. If R_t remains below 1.0, the incidence of new infections decreases, which ultimately results in control of the epidemic. Conversely, if R_t is > 1, then infections will increase (depending on how much higher the reproduction number is above 1.0) until reaching the peak of the epidemic curve and eventually will decline due to the acquisition of herd immunity[14].

The purpose of this study was to analyze the increase in COVID-19 sentinel cases in Mexico calculated based on the effective reproductive number (R_t) of infection, and to compare its evolution with those reported by Italy, Spain, and the United States of America during the first 20 weeks of epidemic evolution.

Methods

With information available at the WHO (www.who.int), at the Center for Systems Science and Engineering of Johns Hopkins University at Maryland, in the

United States of America (coronavirus.jhu.edu), and at the Epidemiological and Sanitary Intelligence Unit of Mexico's Ministry of Health (www.coronavirus.gob.mx), an analytical cross-sectional study was carried out based on the cases reported as positive for COVID-19 (SARS-CoV-2) in Mexico[16]. To find out the "sentinel cases" that were occult within the population, a stochastic model was constructed by calculating the effective reproductive number (R_t) of infection according to the methodology proposed by Wallinga and Lipsitch[17] and based on a model in susceptible, infected and recovered population derived from the Lotkae-Euler equation[18], which is a linear equation that is expressed as [$R_t = 1 + r * T$] and that is different from the exponential equation [$R_{exp} = \exp(r*T)$], which takes into account the variability in new cases generation time as an approximation to the exponential factor. For this, we carried out the following procedure: first, the cumulative incidence (CI) of COVID-19 cases per week in Mexico from February 29 to July 24, 2020, was calculated, weekly increase of cases in CI was analyzed, which was called "r" (exponential growth rate or increase in the number of new cases per day), because CI in outbreaks of an infectious disease is known to initially increase approximately exponentially over time (therefore, incidence has an exponential growth). The "T" value was defined as the time in days between the infection of an index case and a secondary case generated from the index case, which according to the previous studies, in COVID-19, it is known to be 5.8 ± 2.6 days on average[12,19-21]; for this study, we defined it as 4.0 days according to the figure published by Guan et al.[22]. The purpose of this procedure was to obtain a better approximation to total cases occult in the population that have not been quantified for the reasons already explained. Table 1 shows R_t calculation based on COVID-19 cases daily increase during the first 20 weeks of the epidemic in Mexico. To know the total number of severe acute respiratory infections that occurred during the first semester of 2019 and 2020, the Epidemiological Bulletin of the National Epidemiological Surveillance System (single information system) of the Ministry of Health was consulted (https://www.gob.mx/salud).

With the obtained data, a database was constructed with the help of the Excel statistical package for Windows®, version 2007, and a descriptive analysis was carried out to summarize the data that were found about the behavior of cases for Mexico and in comparison with data reported by Italy, Spain, and the United States of America. Prevalence, cumulative incidence, and case fatality rates were calculated for the epidemiological information that was obtained, which were summarized in frequency tables and dispersion figures. For inferential analysis of the presented curves, Student's t-test was used for numerical variables and ratio variables for intragroup analysis; for the comparison of disease evolution between Mexico, Italy, Spain, and the United States of America during the first 20 weeks of evolution of the epidemic, a one-factor analysis of variance test was used; a *post hoc* analysis with Tukey's test was carried out to know those data that produced a difference in disease evolution. A p-value ≤ 0.05 was regarded as statistically significant.

Results

Since the beginning of the COVID-19 pandemic in Mexico, efforts have been made to flatten the epidemic curve by implementing some mitigation and containment strategies. In addition to the above, a sentinel surveillance system that applies only a sampling of cases that arrive at a hospital unit with a serious disease presentation has been maintained. According to the data obtained in this study, considering the count of cases by the Mexican health authority until the 3rd week of July 2020, there is a total of 390,516 COVID-19 cases, but if we add the calculated sentinel cases, there are approximately 3,780,195 cases ($p = 0.0002$). Table 2 and figure 1 summarize the new cases reported each week by the Ministry of Health of Mexico since the beginning of the pandemic.

In the case of deaths, there would also be underreporting: while the official figure reports 43,680 deaths in Mexico, calculation by this methodology shows approximately 211,469 deaths ($p = 0.001$). Figure 2 summarizes the information on deaths reported each week and the calculation of sentinel deaths from COVID-19 in Mexico from February 29 to July 24, 2020.

A more accurate method for projecting the evolution of cases is through CI in the population susceptible to fall ill. Thus, unlike Italy and Spain, which managed to control the increase of cases during the first 10 weeks, in Mexico, CI for COVID-19 cases is constantly increasing. While Italy has a CI of 2.7 cases per 100,000 population at week 20, in Spain it is 26.0 per 100,000 population and in the United States of America (the country with most cases occurred in the

Table 1. Calculation of the effective reproductive number of infection (R_t) based on COVID-19 cases daily increase during the first 20 weeks of the epidemic in Mexico

Week	Positive cases	Negative cases	Suspected cases	Cumulative incidence*	r†	R_t‡
1	53	653	706	0.04	--	--
2	314	3747	4061	0.2	0.2	1.83
3	727	14718	15445	0.5	0.3	2.31
4	1345	33375	34720	1.0	0.4	2.96
5	2575	62565	65140	2.0	0.9	4.90
6	3758	97683	101441	2.9	0.9	4.75
7	6757	48849	55606	5.3	2.3	10.51
8	9376	84206	93582	7.4	2.0	9.30
9	11422	123470	134892	9.0	1.6	7.49
10	15306	172153	187459	12.1	3.0	13.31
11	19472	199039	218511	15.4	3.3	14.21
12	22330	232385	254715	17.7	2.2	10.06
13	22776	299713	322489	18.0	0.3	2.41
14	30162	349530	379692	23.9	5.8	24.41
15	34858	377576	412434	27.6	3.7	15.89
16	35535	414221	449756	28.1	0.5	3.15
17	41093	482041	523134	32.5	4.4	18.62
18	42685	499491	542176	33.8	1.2	6.05
19	44961	535462	580423	35.6	1.8	8.21
20	46093	574011	620104	36.5	0.9	4.59
Average	391,598	4,604,887	4,996,485		+ 1.9	8.6

*Cases per 100,000 population (considering a population for Mexico of 126,190,788 inhabitants).
†r=new cases – cases from previous week.
‡Rt=1 + r * T, where T is the time between infection of an index case and appearance of a secondary case (4 days).
Weekly increase = (positive cases×100)/suspected cases.
Source: statistical information from February 29 to July 24, 2020, available at www.coronavirus.gob.mx.

world) it is 140.6 per 100,000 population, in Mexico, if we add the sentinel cases, CI is 341.1 per 100,000 population. This is associated with cumulative cases: Italy, 244,976 cases; Spain, 272,389; the United States of America, 4,009,746 cases; and Mexico, 3,780,195 sentinel cases ($F = 20.18$; $p = 0.000000001$). It is evident that both Mexico and the United States of America show a significant difference in the evolution of cases of the pandemic in comparison with what occurred in Spain and Italy. Table 3 and figure 3 show the CI comparison between weekly COVID-19 cases and deaths during the first 20 weeks of the epidemic in Mexico, Italy, Spain, and the United States of America.

Tables 2 and 3, and figure 4, summarize the deaths that occurred for the countries compared to Mexico. As it can be observed, Mexico has an incidence of deaths of 19.3 per 100,000 population, while in Italy it is 0.1 per 100,000 population, in Spain, 1.7 per 100,000 population, and in the United States of America, 1.8 per 100,000 population. This originates in total number of observed deaths, which for Italy is 35,090, for Spain 29,858, for the United States of America 143,663, and for Mexico 211,469 (with sentinel deaths added) ($F = 12.69$; $p = 0.000001$).

Figure 5 shows that Italy has the highest COVID-19 case fatality rate in the world (14.3), followed by Spain and Mexico with 11.3 and 11.2, respectively.

Table 2. Comparison between weekly cases and deaths from COVID-19 during the first 20 weeks of the epidemic in Mexico

Week	Cases			Deaths		
	New	Sentinel*	Sum	New	Sentinel†	Sum
1	53	451	504	0	22	22
2	198	1727	1925	2	86	88
3	597	5182	5779	26	257	283
4	1295	11241	12536	97	556	653
5	2518	21856	24374	171	1082	1253
6	3600	31248	34848	390	1547	1937
7	6416	55691	62107	665	2757	3422
8	8794	76332	85126	803	3778	4581
9	11551	100263	111814	1311	4963	6274
10	14197	123230	137427	1712	6100	7812
11	19401	168401	187802	2217	8336	10553
12	22044	191342	213386	2536	9471	12007
13	26439	229491	255930	3769	11360	15129
14	29734	258091	287825	3442	12776	16218
15	33708	292585	326293	4684	14483	19167
16	36307	315145	351452	4823	15600	20423
17	39996	347165	387161	3991	17185	21176
18	42902	372389	415291	4367	18433	22800
19	44474	386034	430508	4178	19109	23287
20	46292	401815	448107	4496	19890	24386
Sum	390,516	3,389,679	3,780,195	43,680	167,789	211,469

* Sentinel cases: adjustment of cases obtained by multiplying daily reported cases by the calculated R_t value (8.6).
†Sentinel deaths: adjustment of occurred deaths by multiplying daily reported deaths by known global case fatality rate (4.95%).
Source: statistical information from February 29 to July 24, 2020, available at https://covid19.who.int/.

The United States of America have a case fatality rate of 3.6 and have managed to remain within a value similar to the global figure of 4.1 ($F = 20.43$; $p = 0.00001$). The case fatality rate is strongly influenced by the number of cases detected by screening tests, and this fact produces a bias in this data. For this reason, both Mexico and Spain, as well as Italy, show a high case fatality rate that is not real and that would undoubtedly decrease if more COVID-19 diagnostic tests were carried out. A more real value results from calculating the CI for occurred deaths; table 3 summarizes this information, and a steady and gradual decrease can be observed for Italy, Spain, and the United States of America, but not for Mexico, where it continues to increase.

There is no doubt that the sentinel surveillance, which is applied every year in Mexico, allows an accurate monitoring of severe acute respiratory infections to be carried out. During the month of January, both in 2019 and in 2020, there were more than two million severe acute respiratory infections, which gradually and synchronously decreased in both cases until the beginning of March, but in 2020, at that time, an increase is observed that lasted until the 1st days of April, when there was an accelerated decrease, which can be explained by the mitigation measures applied to limit the spread of SARS-CoV-2 in the population (social distancing, closure of the economy, and Healthy Distance National Campaign), which were maintained until mid-May, when the population

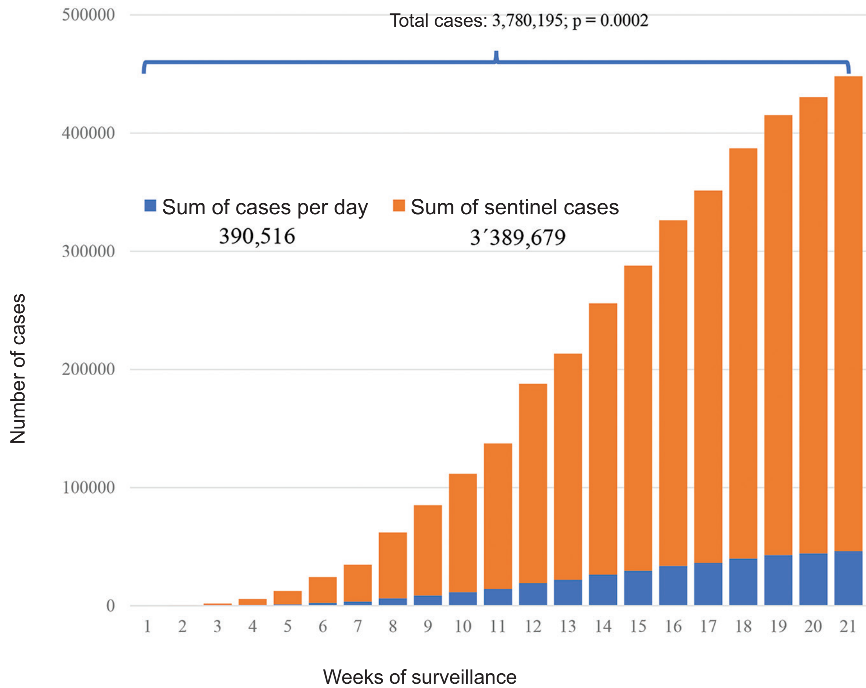

Figure 1. *Comparison of COVID-19 new and sentinel cases in Mexico from February 29 to July 24, 2020. Sentinel cases: adjustment of cases obtained by multiplying daily reported cases by the calculated R_t value (8.6). Adapted from the World Health Organization.*[15]

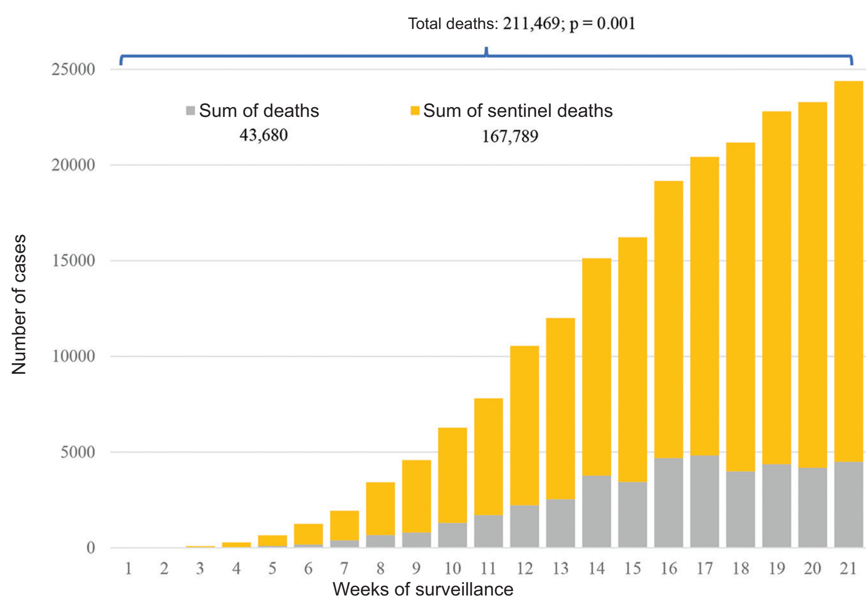

Figure 2. *Comparison of COVID-19 new and sentinel deaths in Mexico from February 29 to July 24, 2020. Sentinel death: Occurred deaths adjustment by multiplying daily reported deaths by the known case fatality rate (4.95%). Adapted from the World Health Organization.*[15]

confined to their homes got tired and the impact on their economy drove to a gradual return to activities and, consequently, to an increase in cases that lasted until June, when the population was again invited to stay home by establishing a color-based national traffic light signaling system (red, orange, yellow, and green) at each state of the country. With the red traffic light, only essential economic activities are allowed, with orange, companies with non-essential economic activities are allowed to work with 30% of

Table 3. Comparison of cumulative incidence between COVID-19 weekly cases and deaths during the first 20 weeks of the epidemic in Mexico, Italy, Spain and the United States of America

Week	Cases				Deaths			
	Italy	Spain	USA	Mexico*	Italy	Spain	USA	Mexico*
1	33.5	12.23	0.4	0.04	1.4	0.1	0.01	0.02
2	53.6	41.01	4.0	0.3	3.6	1.2	0.02	0.1
3	64.3	101.21	26.6	1.5	7.5	6.1	0.2	0.2
4	53.2	112.26	51.4	4.5	9.3	12.0	0.9	0.5
5	45.7	79.38	66.1	9.9	8.5	13.2	3.3	1.0
6	39.1	63.8	61.1	19.3	8.2	10.3	5.4	1.5
7	32.1	40.7	61.5	27.6	5.2	5.3	4.2	2.7
8	23.1	15.4	58.7	49.2	3.8	5.5	4.9	3.6
9	14.7	11.9	45.8	67.4	2.8	2.9	3.9	5.0
10	10.7	15.2	49.4	88.6	2.3	1.4	3.2	6.2
11	7.5	9.8	48.0	108.9	1.6	1.1	2.5	8.4
12	5.5	9.2	44.5	148.8	1.0	1.1	2.3	9.5
13	3.5	3.6	51.5	169.1	0.8	2.2	2.3	12.0
14	3.0	4.9	44.0	202.8	0.8	0.8	1.6	12.9
15	2.6	4.9	53.2	228.0	0.5	1.7	1.3	15.2
16	3.0	5.4	73.4	258.5	0.2	0.0	1.8	16.2
17	2.1	4.4	97.9	278.5	0.2	0.0	1.3	16.8
18	2.3	7.1	116.9	306.8	0.2	0.0	1.3	18.1
19	2.3	13.5	114.9	329.1	0.2	0.0	1.3	18.5
20	2.7	26.0	140.6	341.1	0.1	0.0	1.8	19.3

*Calculated based on sentinel cases obtained considering the R_t value (8.6).
Adapted from World Health Organization.[15]

personnel for their operation, with yellow, all working activities are allowed, and with green, all activities, including school activities, are allowed. It should be noted that that most part of the country has remained on red since then. Figure 6 shows the incidence of severe acute respiratory infections during the first semesters of 2019 and 2020 in Mexico.

Discussion

SARS-CoV-2 infection has a higher transmission rate than that observed for other similar viral diseases. SARS-CoV-2 rapid spread requires the generation of evidence to help mitigate global harm. Data reported by China during its epidemic outbreak indicated 80% of mild cases, only 15-20% required hospital admission and 3-5% required intensive care unit admission[22]. Perhaps we are only seeing the tip of the iceberg, because most countries in the world cannot carry out a sufficient number of tests on their population, and the cases they report are only those that are within that 15-20% that had access to receive medical attention, with a large number of cases being left unidentified. Accurate measurement with appropriate clinical and epidemiological indicators is a necessary step for reducing the individual and population burden of ongoing pandemic. Mathematical models of transmission have become invaluable management tools in the planning for emerging infectious diseases control[17]. A key variable in such models is the R reproductive number on its different calculation forms. One of these forms is infection effective reproductive

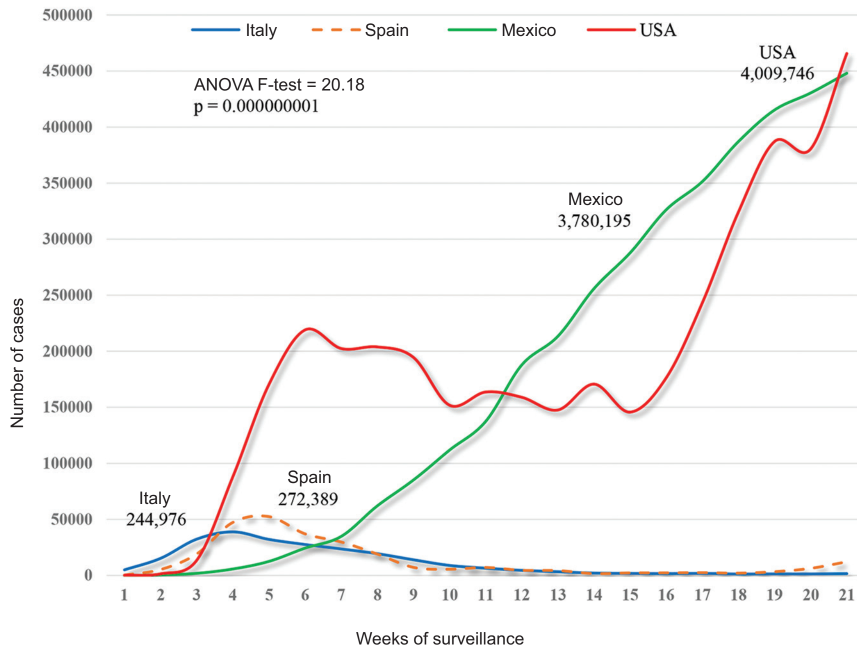

Figure 3. *Comparison of COVID-19 cases in Italy, Spain, the United States of America (USA) and Mexico (sentinel cases) from February 29 to July 24, 2020. Sentinel cases: adjustment of obtained cases by multiplying daily reported cases by calculated R_t value (8.6). Adapted from the World Health Organization.*[15]

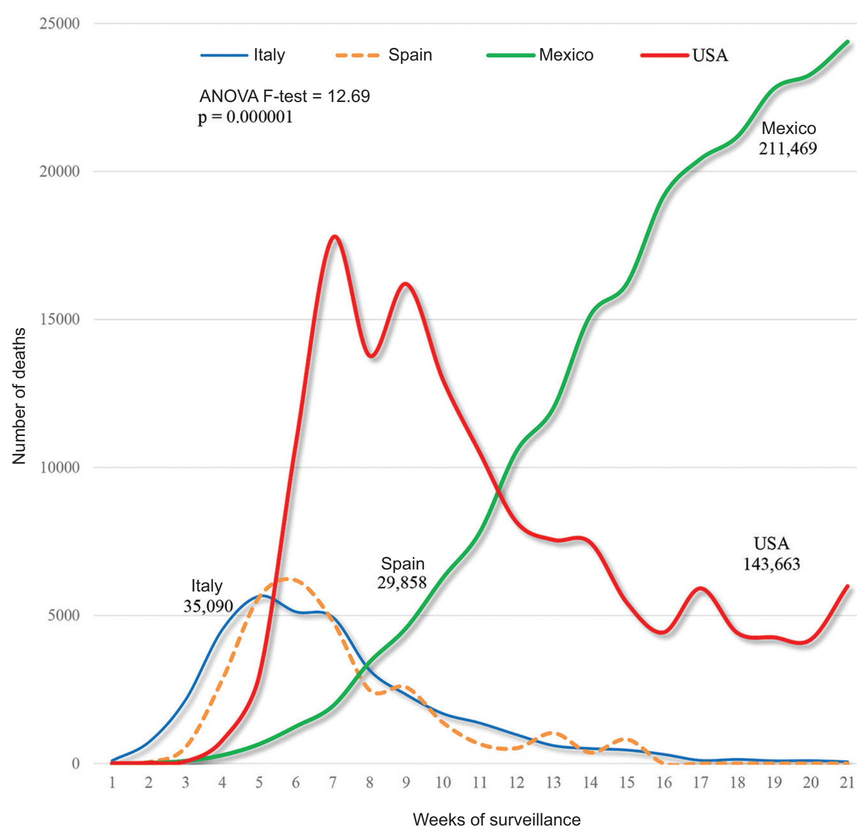

Figure 4. *Comparison of COVID-19 deaths in Italy, Spain, the United States of America (USA) and Mexico (sentinel deaths) from February 29 to June 24, 2020. Sentinel death: adjustment of occurred deaths by multiplying daily reported deaths by known global case fatality rate (4.95%). Adapted from the World Health Organization.*[15]

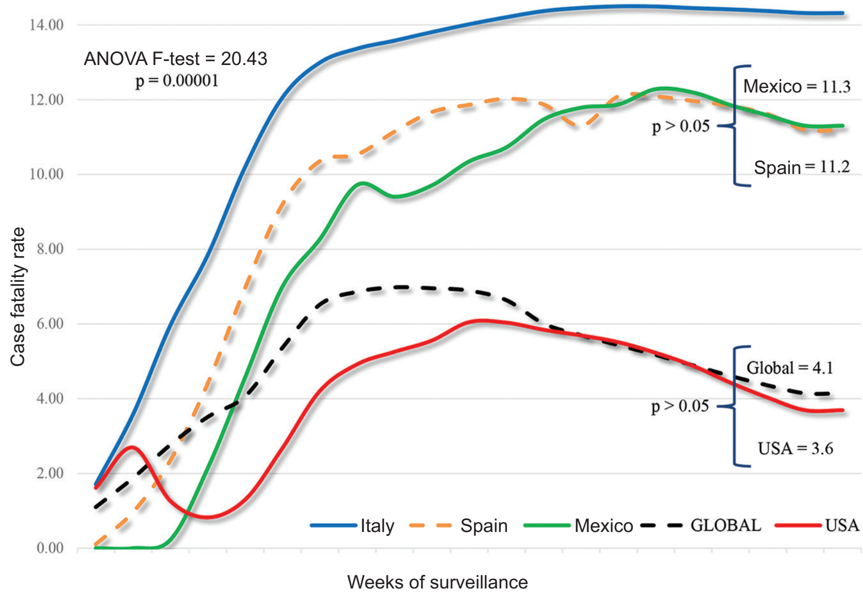

Figure 5. *Comparison of COVID-19 global case fatality rate in Italy, Spain, the United States of America (USA), and Mexico.*

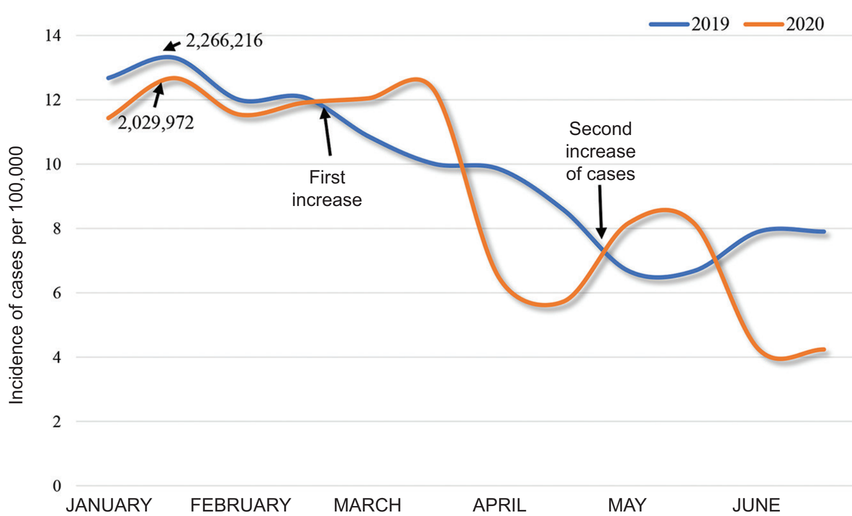

Figure 6. *Comparison of the incidence of acute respiratory infections during 2019 and 2020 first semesters in Mexico (cases per 100,000). Source: Epidemiological Bulletin of the National Epidemiological Surveillance System (Single information system) of the Ministry of Health, available at https://www.gob.mx.*

number (R_t)[18], which if < 1, indicates a low capacity for expansion of an infectious disease, while R_t values > 1 indicate the need for using control measures to limit its spread. It is concerning that for Mexico such a high value (8.6) is recorded, since the country would be going through a pandemic without control and navigating blindly by not knowing where the cases are in order to be able to contain and mitigate the disease. Yuan et al.[23] calculated the R_t value in some European countries and found that, for Italy, it was 3.2; for the Lombardy region (Italy), 6.3; for France, 6.3; for Germany, 6.0; and for Spain, 5.0; the authors concluded that, in those countries, R_t value was > 2 and, consequently, the COVID-19 outbreak would continue as long as stricter prevention and control measures were not implemented in order to curb the spread of the disease. It should not be forgotten that the strict quarantine applied in the city of Wuhan, Hubei province, in China, was able to quickly restrain COVID-19 cases[24]. In addition to the above, it is necessary to carry out enough tests for detection of the virus to more accurately estimate the rates of transmission in the population at risk, isolating suspected cases, and thus cutting the transmission chain[25].

The 1st weeks of an outbreak are critical for developing a deep understanding of the dynamics of transmission and disease severity[26]. In Mexico, COVID-19 containment measures were initially not efficiently applied, which caused a rapid arrival of cases from Italy, Spain and the United States of America[7].

Sentinel surveillance is useful for emerging diseases and in places where socioeconomic conditions do not allow having a better surveillance system[27]. Since the influenza pandemic in 2006, the "National Influenza Pandemic Preparedness and Response Plan" was established[28,29], which laid the groundwork for yearly monitoring of acute respiratory infections with an emphasis on seasonal influenza[30]. However, influenza is a disease we already know. In contrast, COVID-19, which started in Mexico in March 2020, is a new disease, unknown to us, with no treatment yet available and with a higher contagiousness rate than SARS-CoV-1[12,31]; for that reason, perhaps the sentinel model was not the best surveillance option for identification of new cases.

In COVID-19, asymptomatic individual's identification is a challenge that had not been seen with other respiratory viruses. These subjects can be contagious for several days[32,33], thus turning into highly efficient SARS-CoV-2 spreaders. In Wuhan, China, up to 79% of undiagnosed asymptomatic subjects were observed to be responsible for infections in the susceptible population[34]. In Mexico, excessive mobility of the population and a false perception of low risk for COVID-19 have originated a failure in the strategies for containing the disease. Now we know that social distancing measures[35] can have a "rebound" effect, mainly when the susceptible population belongs to a weak socioeconomic stratum and that in order to survive they have to go out to work every day[36], a situation in which a high percentage of the population is found.

According to the comparison made with the countries included in this study, the number of cases reported by the Mexican health authority is not consistent with the expected growth pattern for a country with more than 126 million inhabitants and that is attacked by an infectious, lethal, and rapidly transmissible disease without a specific treatment.

Airborne transmission could partially explain the high rates of secondary transmission that have been observed in many countries, including Mexico; however, the health authority has not had a clear policy in this regard and there has been much hesitation about mandatory implementation of the use of face masks in the population, even when it is already known that it is an epidemic control measure that demonstrated its efficacy for reducing SARS-CoV-2 transmission in places such as Taiwan, Hong Kong, Singapore, and South Korea[37].

Finally, it is important to remember that the case fatality rate is a mortality indicator that depends on the ability to identify cases and deaths during the epidemiological surveillance process and allows both the magnitude and impact of the epidemic process to be summarized. The differences observed in the case fatality rate between Italy, Spain, Mexico, and the United States of America can be explained by population differences, socioeconomic, and environmental factors, and access to medical care. In the case of Mexico, the results of this study indicate that the most likely hypothesis is a lack of undetected cases identification for not performing SARS-CoV-2 diagnostic tests in the susceptible population and, as a consequence, a false increase in the case fatality rate magnitude. We should not forget that Mexico is ranked within the first places in the world in the rates of obesity, diabetes mellitus, high blood pressure, and other chronic degenerative diseases, and that all these conditions are recognized risk factors for mortality from COVID-19 that have an influence for causing a mortality excess that has already been observed in some studies in Mexico[38] and the world[39-41].

As weaknesses of our study, we can mention the type of study and the absence of follow-up of COVID-19 infection cases due to lack of access to this information.

We can conclude that flattening of the epidemic curve in Mexico has not been achieved, and it is urgent to continue applying the COVID-19 pandemic mitigation and containment strategies in the population. The sentinel model, as it has been applied for epidemiological surveillance in Mexico, shows a significant loss of unquantified information. It is necessary for epidemiological surveillance to be reinforced by a better case detection strategy in our country. SARS-CoV-2 arrival has represented an unprecedented challenge for public health in Mexico.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Ethical disclosures

Protection of human and animal subjects. The authors declare that the procedures that were followed adhered to the ethical standards of the responsible committee for experimentation on human subjects and were in agreement with the World Medical Association and the Declaration of Helsinki.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

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