International Research Journal of Medicine and Biomedical Sciences Vol.5 (4),pp. 29-35, September 2020
Available online at http://www.journalissues.org/IRJMBS/
https://doi.org/10.15739/irjmbs.20.007

ISSN 2488-9032

Original Research Article

Estimating the risk of death from COVID-19 in Saudi Arabia

Received 5 June, 2020 Revised 23 July, 2020 Accepted 4 August, 2020 Published 22 September, 2020

Hamid H. Hussien

Department of Mathematics, College of Science and Arts, King Abdulaziz University, P.O. Box 344, Rabigh 21911,Saudi Arabia.

Author's Email: hamid128@yahoo.com

This study aims to estimate the risk of death in terms of case fatality ratio (CFR) and point prevalence using a dataset of COVID-19 infections from Saudi Arabia. Another method for estimating CFR by regression modeling was employed, in which the linear functional relationship between the cumulative number of deaths and the cumulative number of confirmed cases was evaluated. The main findings are: The point prevalence of COVID-19 ranged from 0.06% to 4.27%, suggesting that approximately 0.427% of the population of Saudi Arabia has been infected by COVID-19 as of June 18, 2020. The CFR exhibited changes overtime as follows: it was 1.3 on March 24, reached its peak (14.69) on April 7, and gradually declined and stabilized at 5.36. Again, it is gradually increased and reached 7.8 on June 18, 2020. The average CFR was estimated as 7.77± 0.65. The linear trend of the COVID-19 Pandemic in terms of best fit for the data was found to be statistically significant with an R^2 value of 0.97. The future of the COVID-19 Pandemic remains unclear, suggesting an extreme and massive action to slow down the global spread of the virus.

Keywords: Case fatality ratio, prevalence, COVID-19, Saudi Arabia

INTRODUCTION

In the past 20 years, various virus outbreaks, including SARS-COV, H1N1, and Middle East respiratory coronavirus (MERS-CoV) syndrome, have caused a huge burden on several Asian countries (Cascella et al., 2020). In December 2019, several cases of acute respiratory syndrome were identified in Wuhan City, Hubei Province, China. The virus was described as an extreme acute respiratory syndrome of coronavirus 2 (SARS-CoV-2) in the Betacoronavirus family. SARS-CoV-2 is highly communicable and pathogenic (Mandal, 2020). The mode of this virus is human-to-human transmission. Studies have estimated that, on average, one infected individual would infect between two and three other people. The virus can survive on different surfaces for up to a few days, depending on the type of the material of the surface. The incubation period has been estimated to bebetween1and 14days (Lauer et al., 2020). Elderly people aged>70 years and individuals with underlying health conditions are at considerably higher risk of developing severe disease from this virus (Nikpouraghdam et al., 2019).

Due to the high connectivity of China to international airports, the early outbreak in China spread rapidly to cities and countries with high air passenger volumes from China (Bogoch et al., 2020), leading to substantial outbreaks and eventually prompting the WHO to declare it as a "global health emergency" by the end of January 2020 (Wilder-Smith et al., 2020). On March 11, 2020, the WHO finally made the assessment that COVID-19 can be characterized as a pandemic (Liu et al., 2020), as the disease infected more than three million people and led to 916 deaths globally (Rodríguez-Morales et al., 2020). The majority of cases and deaths occur in the Americas and Europe. However, the WHO regions of the Eastern Mediterranean, Southeast Asia, and Africa are also at risk. In neighboring countries, Iran was reported the first case of corona-virus on February 19, 2020. The disease has expanded significantly in the following months and travelling is one of the most effective factors causing spread of COVID-19 outbreak in Iran (Azarafza et al., 2020). Therefore, experiences from different countries have suggested that management of intercity travel will help to minimize corona emissions. According to the WHO, the disease has currently affected more than 5 million people and has caused more than 300,000 deaths as of May 20, 2020(WHO, 2020).

The first case of coronavirus disease 2019 (COVID-19) in Saudi Arabia were reported on March 2, 2020 (WHO, 2020). Early precautionary measures had been implemented by the government before the declaration of COVID-19 as a pandemic by the WHO. Some of these actions were, for example, suspending entry for Umrah and visiting the holy mosques in Makkah and Al-Madinah, discontinuing issuing visas to people coming from countries affected by COVID-19, and depriving citizens of Arab countries from entering the two holy cities Makkah and Al-Madinah for Hajj and Umrah. Furthermore, the export of all medical devices and products was banned to ensure that they would be available in the event of COVID-19 infections (Alshammari et al., 2020). Moreover, all educational institutions were closed, and home schooling and online teaching were promoted. On March 20, 2020, due to the increasing number of COVID-19 cases in the Kingdom, the authorities suspended all domestic public transport, flights, trains, buses, and taxis (Yezlia e al., 2020). However, despite all these measures, the epidemic curve in the Kingdom was still observed. Consequently, the authorities declared a partial curfew in the Kingdom on March 23, 2020, which is still ongoing at the time of writing this article.

According to the report of the Saudi Ministry of Health, during the last 2 weeks of May 2020, Saudi Arabia witnessed a significant increase in the number of confirmed cases and deaths due to COVID-19, with the number of infections reaching145,911, including 1139 deaths,93,915 recovered cases, 4757active cases, and 1910 cases in critical condition.The critical cases of coronavirus in Saudi Arabia have reached a number that became a matter of concern to the authorities, because they were recorded after the decline in the number of cases in April 2020. The proportion of COVID-19-related deaths accompanied by chronic diseases represented 50% of the recorded deaths. Moreover, the rate of confirmed cases was found in different groups and ages (ARAB NEWS, 2020). However, elderly people and those with chronic diseases constituted a higher rate of confirmed cases. In addition to the new recorded cases, an increase in COVID-19 cases was observed more significantly in the cities of Riyadh, Makkah, and Jeddah.

The COVID-19 pandemic has significant negative effects on social, economic, political, as well as health statuses of affected countries. Scientists, together with the public health authorities, have the responsibility of containing the spread of COVID-19, which can help in reducing the peak incidence and its impact on public services, thereby flattening the epidemic curve and curbing the disease.

There is a great deal of uncertainty regarding the future of the COVID-19 epidemic in the world, and considerable efforts are warranted to evaluate the health measures taken by the authorities to help in the decision-making about the appropriate mitigation policies to be adopted. In this study, we estimated the risk of death from COVID-19 in terms of case fatality ratio (CFR) and point prevalence in Saudi Arabia. Furthermore, we used the least squares approach to fit a regression model in two different forms of functional relationship (linear and exponential) connecting the cumulative number of deaths and the cumulative number of confirmed cases.

MATERIAL AND METHODS

Data source

Country-level counts of COVID-19 dataset recorded from March 2, 2020, to June 18, 2020, were downloaded from the Centers for Disease Control and Prevention (CDC). This dataset consisted of daily confirmed cases, recovered cases, and number of deaths due to the COVID-19 pandemic in Saudi Arabia, including 145,991 confirmed cases and 1139 deaths. The epidemiological measures of disease point prevalence and CFRs were used as defined.

Prevalence

Prevalence is a measure the frequency of an existing disease. It is the proportion of persons in a population who have a disease or attribute at a specified point in time or over a specified period of time. The two types of prevalence are: Period prevalence which refers to prevalence measured over an interval of time and Point prevalence which refers to the prevalence measured at a particular point of time.

In this study, point prevalence was used to estimate the risk of death of COVID-19. It is defined as a proportion of the population that is ill at a single time point and can be assumed as a single snapshot of the population. it is useful in estimating the requirements of medical facilities and allocating the resources needed to treat people who are already infected. Mathematically, it can be represented as follows:

Point prevalence = $(X/Y) \times 1000$ ………..(1)

Where: x denotes the number of current cases (new and preexisting) at a specified point in time and y denotes the population at the same specified point in time.

Case fatality ratio

CFR measures the disease severity, at a time point, in a population. It is the proportion of people who die from a specified disease among all individuals diagnosed with the disease over a certain period of time. Mathematically, let $D(t)$, $R(t)$, and $C(t)$ denote the cumulative number of deaths, recoveries, and cases, at time t, respectively, then, the

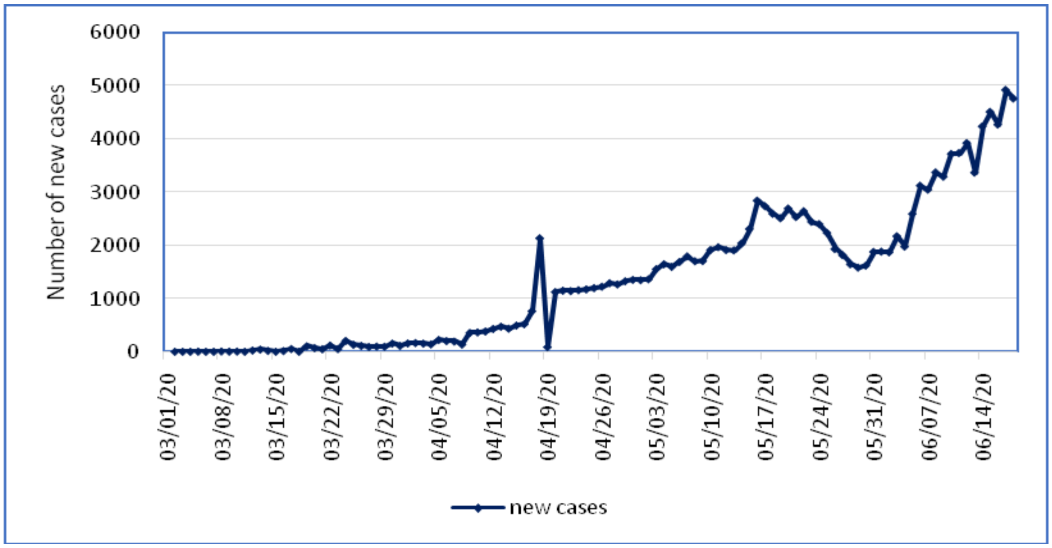


Figure1a: Trend of daily confirmed cases in Saudi Arabia as of June 18, 2020

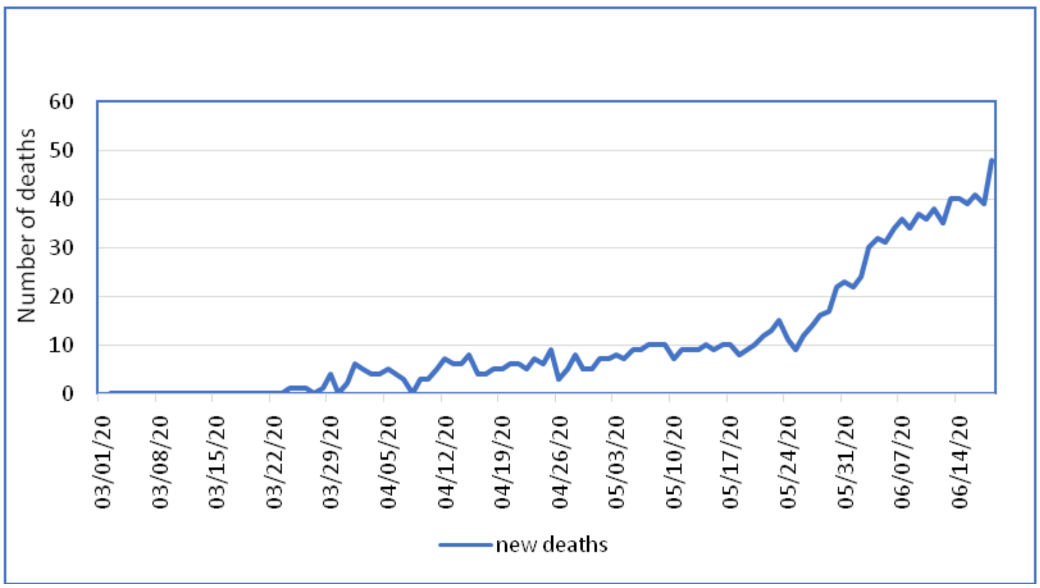


Figure 1b: Trend of daily deaths in Saudi Arabia as of June 18, 2020

estimated CFR can be computed as follows:

CFR= (D(t)/C(t))×1000 …………(2)

The limitation of this estimator is that it ignores the censoring that arises when patients remain ill in the hospital (Ghani et al., 2005).

Another method for estimating CFR by regression modeling is to regress the cumulative number of confirmed deaths on the cumulative number of confirmed cases. The slope of the simple linear regression line is termed as the CFR estimate (Öztoprak and Javed, 2020). The models are often fitted using the least squares approach. The functional linear relationship between the cumulative number of deaths (denoted by Y) and the cumulative number of confirmed cases (denoted by X) is presented as follows:

Y = α + Bx…………. (3)

where α and β denote the parameters of the models representing the intercept and the slope of the regression line, respectively. Regression analysis and further calculations, such as confidence interval (95%) and coefficient of determination, were performed using Microsoft Excel.

RESULTS

The first case of COVID-19 in Saudi Arabia was reported on March 2, 2020. By May 24, 2020, the number of confirmed cases had reached 145,991, including 1139 deaths. Figures 1a and 1b present the overall trend of new cases and deaths due to the spread of COVID-19. The highest number of cases

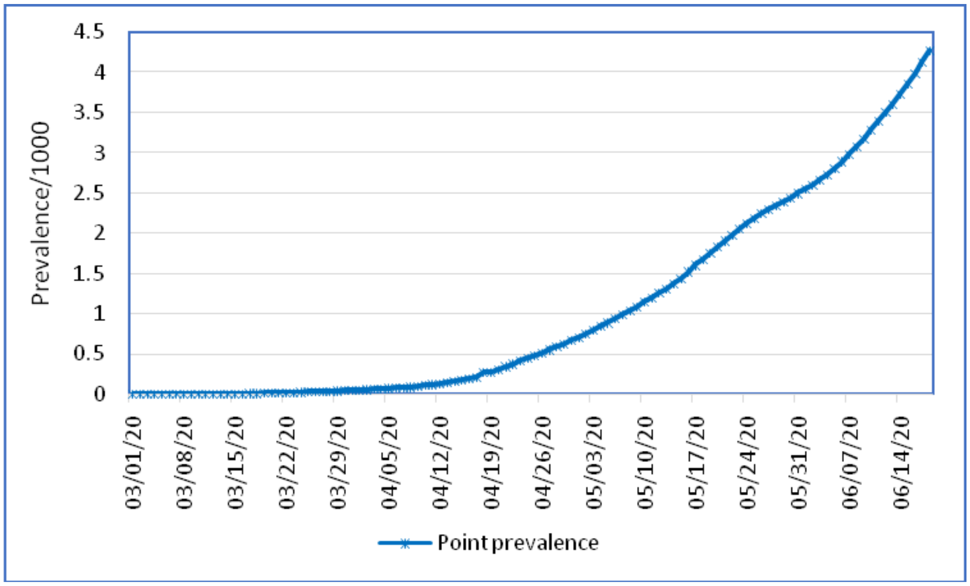


Figure 2: The prevalence of COVID-19 in Saudi Arabia from March 10 to June 18, 2020

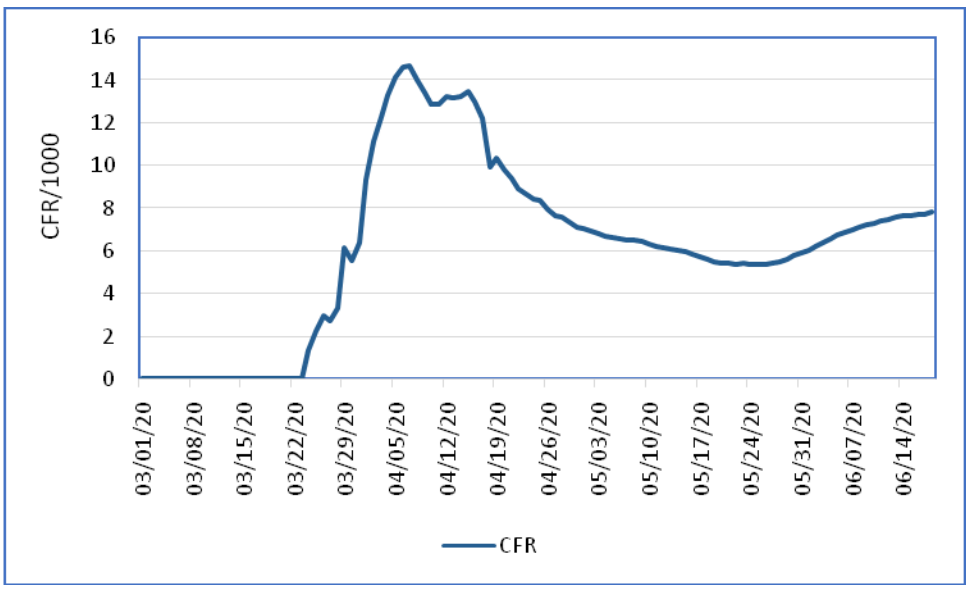


Figure 3: CFR of the COVID-19 pandemic in Saudi Arabia over time as of June 18, 2020

was reported on June 17, 2020, and the highest number of deaths was recorded on June18, 2020 (4919and 48, respectively).

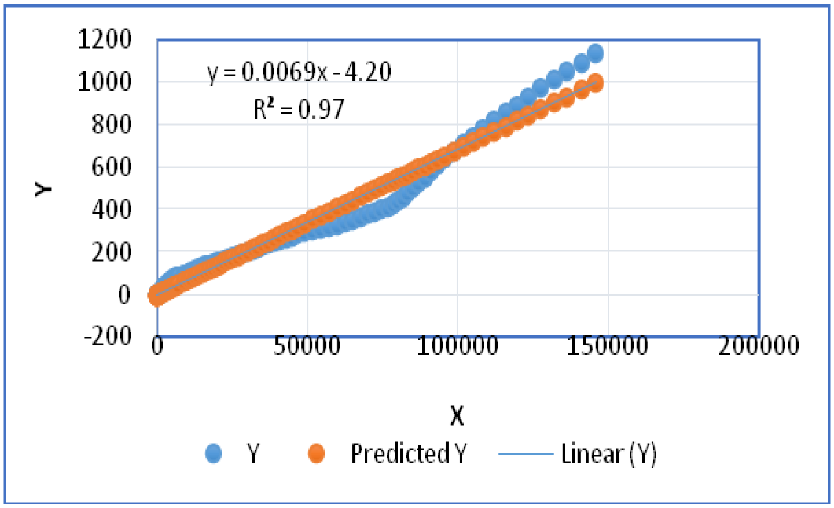
Figure 2 presents the point prevalence of COVID-19 in Saudi Arabia during the period from March 10 to June 18, 2020. This point prevalence begins at 0.0006and ends at 4.27on June 18, 2020, which indicates that 0.427% of the population had been infected with COVID-19 as of June 18, 2020, in Saudi Arabia.

The CFRs of COVID-19 calculated using the method of estimation, as suggested in Equation 2, are presented in Figure 3. The results indicate that the starting point of CFR was 1.3 on March 24; reached its peak (14.687) on April 7, during which there were thousands of confirmed cases; and then gradually declined and stabilized at 5.36. It gradually increased again and reached 7.8 on June 18, 2020.The average CFR in Saudi Arabia was calculated as 7.77±0.65.

Figure 4 presents the regression analysis equations fitting for the epidemiological dataset of COVID-19 from Saudi Arabia. The starting point for the dataset in the analysis was the date of the first reported death, i.e., March 24, 2020. Denoting the accumulative cases as x and the cumulative deaths as y, the estimated regression models yield

$y = 0.0069x + 4.2$……………(4)

This fitting revealed a p-value <0.001 for the linear model. The analysis revealed a statistically significant linear trend of the pandemic in terms of best fit for the data



Figures 4: The linear regression model fitting for COVID-19 CFR estimation

(Figure 4), with an R^2 value of 0.97. Hence, we suggest that the CFR for the period from March 15 to June 18, 2020, was 0.69% (95% CI: 0.66%–0.71%).

DISCUSSION

With more than 34 million people, Saudi Arabia is the second largest nation in the Arab world. Majority of the country's population is aged between 15 and 64 years (Algaissi et al., 2020). In this study, we estimated the risk of death from COVID-19 across this population in terms of point prevalence and CFR in order to help understand the severity of the COVID-19 pandemic. Point prevalence is useful in estimating the needs of medical facilities and allocating resources to treat people who are already infected. CFR, if we are cautious of recognizing its limitations, can help us better understand the severity of the disease.

The analysis of datain this study demonstrated that the point prevalence of COVID-19 ranged from 0.0006to 4.27, indicating that 0.427% of the population had been infected with COVID-19as of May 2020. This result indicates the ability of health authorities in the Kingdom to cope with this pandemic, despite the increase in the number of cases during the study period.

Several studies have reported that CFR varies according to location, as well as in the same location over time (Dudel et al., 2020). Precisely, Figure 2 presents the trend of CFR variations in Saudi Arabia and the typical changes over time, wherein the CFR of COVID-19 ranged from 1.3 to 14.687 during March 24 to June 18, 2020. It reached its peak (14.687) on April 7 and then gradually declined to 5.33 on May 25. However, it increased again to 7.8 on June 18, 2020. Worldwide, the CFR is stable at 3.5%, and the infection begins with a low CFR that progresses to its peak in week 13 after the first 100 cases (Assessment, 2020). The CFR for the COVID-19 outbreak in China was estimated as 9.39±0.029 in the earliest stages of the outbreak and stabilized at 0.943(Mi et al., 2020), indicating that the risk of death from COVID-19 in Saudi Arabia is lower than that in China but higher than that reported worldwide. Our analysis revealed that the linear trend of the pandemic was statistically significant (Equation 5), with a coefficient of determination (R^2) of97%. Therefore, Equation 5 can be used to determine CFR and to predict cumulative deaths. To illustrate this point, let us consider the linear regression model (Equation 4), $y = 0.0069x + 4.2$, wherein the CFR was 0.69%. Accordingly, when the number of cumulative cases reached 200,000, the number of cumulative deaths will be approximately 1384 ($y = 0.0069 \times (200{,}000) + 4.2 = 1384.2$). In comparison with the SARS outbreak in 2003, initially, during the early stages of the outbreak, the CFR was reported to be 3%–5%, but at the end, it increased to around 10% (Ghani et al., 2005). In Germany and Italy, the CFRs of COVID-19 were 0.2% and 7.7%, respectively (Lazzerini and Putoto, 2020), which confirmed that the CFR varies according to location. It should be emphasized that the changes in CFR over time do not necessarily reflect the actual differences in the risk of COVID-19. The claim that elderly people are at the maximum risk from COVID-19 may elucidate these disparities.

CONCLUSION

In this study, the functional relationship between the cumulative number of deaths and the cumulative number of confirmed cases was used as a linear model of the pandemic. The obtained model was significant and represented the best fit of data. Furthermore, the epidemiological measures of the frequency of the COVID-19 pandemic in Saudi Arabia, i.e., the point prevalence and CFR, were estimated to determine the risk of death due to this pandemic.

However, CFR has its own limitations. The risk of disease can be overestimated or underestimated .CFR can overestimate the true risk of death in cases where people have been infected with the disease but have not been diagnosed. In cases where people become currently sick and inevitably die of the disease, they are currently counted as case but will also be eventually counted as death. This implies that CFR underestimates the course of the disease. The future of the COVID-19 pandemic remains uncertain worldwide, and considerable work is required to improve epidemiological measures, so that they can be implemented effectively. Furthermore, the spread of the virus can be slowed down globally by implementing extreme and massive actions.

Declaration of interest

The author declare that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

Thanks to Abdelmgid Osman for helpful comments and for bibliographical support.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author contribution

I am the only author for the paper and I did everything by myself without any help from other.

REFERENCES

Algaissi A, Alharbi N, Hassanain M, Hashem A (2020). Preparedness and Response to COVID-19 in Saudi Arabia: Lessons Learned from MERS-CoV. Preprints; 2020040018.Crossref

Alshammari TM, Altebainawi A, Alenzi KA (2020). Importance of early precautionary actions in avoiding the spread of COVID-19: Saudi Arabia as an Example. Saudi Pharm J. Crossref

ARAB NEWS (2020). The coronavirus pandemic. Available at https://www.arabnews.com/node/1690651/saudi-arabia.

Assessment, RR 92020). Coronavirus disease 2019 (COVID-19) in the EU/EEA and the UK–tenth update. 2020. Available at: http://www.quotidianosanita.it/allegati/allegato7787850.pdf.

Azarafza M, Azarafza M, Akgun H (2020). Clustering method for spread pattern analysis of corona-virus (COVID-19) infection in Iran. medRxiv.Crossref

Bogoch II, Watts A, Thomas-Bachli A, Huber C, Kraemer MUG, Khan K (2020). Pneumonia of unknown etiology in Wuhan, China: potential for international spread via commercial air travel. J Travel Med. 2020;27(2): 1-3. Crossref

Cascella M, Rajnik M, Cuomo A, Dulebohn SC, Di Napoli R (2020). Features, Evaluation and Treatment Coronavirus (COVID-19). StatPearls [Internet]. Treasure Island (FL). Available at: https://www.ncbi.nlm.nih.gov/books/NBK554776/.

Dudel C, Riffe T, Acosta E, van Raalte AA, Myrskyla M (2020). Monitoring trends and differences in COVID-19 case fatality rates using decomposition methods: Contributions of age structure and age-specific fatality. medRxiv. 2020; published online April 8. Crossref

Ghani AC, Donnelly CA, Cox DR, Griffin JT, Fraser C, Lam TH et al. (2005). Methods for estimating the case fatality ratio for a novel, emerging infectious disease. Am J Epidemiol.162(5): 479-486.Crossref

Lauer SA, Grantz KH, Bi Q, Jones FK, Zheng Q, Meredith HR, Azman AS, Reich NG (2020). The incubation period of coronavirus disease 2019 (COVID-19). from publicly reported confirmed cases: estimation and application. Ann. Intern. Med.172(9): 577-582.Crossref

Lazzerini M, Putoto G (2020). COVID-19 in Italy: momentous decisions and many uncertainties. The Lancet Global Health; 8: e641-e642. Crossref

Liu Yen-Chin, Rei-Lin Kuo, Shin-Ru Shih (2020). COVID-19: The First Documented Coronavirus Pandemic in History. Biomed. J. 2020. Crossref

Mandal B (2020). The global emergence of severe acute respiratory syndrome coronavirus 2 in human. Virus Dis. 31(2): 67–70.Crossref

Mi YN, Huang TT, Zhang JX, Qin Q, Gong YX, Liu SY et al. (2020). Estimating instant case fatality rate of COVID-19 in China. INT J INFECT DIS. 97:1-6.Crossref

Nikpouraghdam M, Jalali Farahani A, Alishiri G, Heydari S, Ebrahimnia M, Samadinia H, Sepandi M, Jafari NJ, Izadi M, Qazvini A, Dorostkar R, Tat M, Shahriary A, Farnoosh G, Hosseini Zijoud SR, Taghdir M, Alimohamadi Y, Abbaszadeh S, Gouvarchin Ghaleh HE, Bagheri M (2020). Epidemiological characteristics of coronavirus disease 2019 (COVID-19) patients in IRAN: A single center study. J. Clin. Virol. 127:104378.Crossref

Öztoprak F, Javed A (2020). Case Fatality Rate estimation of COVID-19 for European Countries: Turkey's Current Scenario Amidst a Global Pandemic; Comparison of Outbreaks with European Countries. EJMO.4(2):149–159.

Rodríguez-Morales AJ, MacGregor K, Kanagarajah S, Patel D, Schlagenhauf P (2020). Going global - Travel and the 2019 novel coronavirus. Travel Med Infect Dis. 33(2020):101578. Crossref

Wilder-Smith A, Calvin J, Vernon JL (2020). Can we contain the COVID-19 outbreak with the same measures as for SARS? Lancet Infect Dis. 20(5):102-107.Crossref

World Health Organization (2020). WHO coronavirus disease (COVID-19) dashboard. World Health Organization, Geneva, Switzerland. https://covid19. who.

int/. Accessed MAY5, 2020.
Yezlia S, Anas K (2020). COVID-19 social distancing in the Kingdom of Saudi Arabia: Bold measures in the face of political, economic, social and religious challenges. Travel Med infect Di. Crossref