

Correlation of COVID-19 Fatality Risk with Health Care Access and Quality in 87 Countries

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Abstract

Background. The coronavirus disease 2019 (COVID-19) pandemic has been a severe threat to global health.

Method. We calculated Spearman rank correlation coefficients between a country's case fatality risk at various stages of the pandemic and the Healthcare Access and Quality (HAQ) index in 87 countries.

Results. COVID-19 case fatality risks and HAQ indexes were negatively correlated at <1000 confirmed cases. This negative correlation decreased and even turned positive (but nonsignificantly) as countries approached >5000 confirmed cases. As for per-capita cases, the aforementioned correlation was significantly negative at <100 cases per million people. This negative correlation decreased ($r = -0.0429$) and became nonsignificant as countries approached >500 cases per million people.

Conclusion. Negative correlations between COVID-19 case fatality risks and HAQ indexes weakened and then disappeared with the progressive burden of COVID-19 infection over time. In the end, even the best public health systems were overwhelmed by the COVID-19 pandemic.

Introduction

As of April 12, 2020, the coronavirus disease 2019 (COVID-19) pandemic has caused 1.7 million infections and 108,000 deaths (a case fatality risk of 6.24%) in 205 countries and territories¹. The top five countries with the highest number of cumulative confirmed cases are the United States (530 thousand cases), Spain (162 thousand cases), Italy (152 thousand cases), Germany (120 thousand cases), and France (94 thousand cases)¹. The pandemic's threat to global health is unprecedented in recent history, and an effective treatment and vaccine are still lacking.

For many infectious diseases, countries with better public health infrastructure tend to have lower case fatality risks²⁻⁵. However, many developed countries with robust public health infrastructures have reported case fatality risks of more than 10%, including France (14.8%), Italy (12.8%), the United Kingdom (12.5%), Belgium (11.9%), the Netherlands (10.8%) and Spain (10.1%)¹. By contrast, the case fatality risk in China was only 4.0%¹. The reason for such a variation in case fatality risks of COVID-19 worldwide remains unclear.

Thus, in this ecological study, we explored the association between a country's COVID-19 case fatality risk and Healthcare Access and Quality (HAQ) index; the HAQ index has been a commonly used indicator of public health capacity and quality of health care⁶.

Materials And Methods

Data on daily confirmed cases and deaths from COVID-19 (from December 31, 2019 to April 12, 2020) for all countries worldwide were extracted from the online COVID-19 Worldwide Database provided by the European Centre for Disease Prevention and Control⁷. We excluded countries with less than 500 confirmed cases of COVID-19 infection. The case fatality risk for a country at a point in time was calculated as the ratio of the cumulative number of deaths to the cumulative number of confirmed cases of COVID-19 infection. The population size of each country in 2018 was extracted from the World Bank online database⁸. HAQ index data were obtained from the Global Burden of Disease 2016 Healthcare Access and Quality Collaborators, the project that first formulated the index⁶. Each country's HAQ index (ranging from 0 to 100, where 100 indicates the highest quality) was estimated using principal component analysis, incorporating mortality-to-incidence ratios for cancers (a crude estimate of cancer survival) and risk-adjusted mortality rates for noncancer causes (a performance indicator of hospitals and medical practitioners).

We calculated Spearman rank correlation coefficients between the case fatality risks as of April 12, 2020 and HAQ indexes for all available countries ($n = 87$). To evaluate the progressive burden of COVID-19 over time, we also calculated the Spearman rank correlation coefficients for each stage of the pandemic. We demarcated these stages by cumulative and per-capita confirmed case numbers. Specifically, we calculated the coefficients for when a country first reached 500 ($n = 87$), 1000 ($n = 68$), 5000 ($n = 33$), and 10000 ($n = 20$) cases and when a country first reached 10 ($n = 85$), 50 ($n = 69$), 100 ($n = 59$), and 500 ($n = 29$) cases per million people in the population.

All statistical analyses were conducted using SAS software version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

For all 87 countries analyzed, the Spearman rank correlation coefficient between COVID-19 case fatality risk as of 12 April, 2020 and HAQ index was (r) -0.0112 ($p = 0.9183$).

Figure 1 presents the Spearman rank correlation coefficients for each stage of the pandemic, as defined by the cumulative number of cases; panels A, B, C, and D in the figure illustrate the results for 500, 1000, 5000, and 10,000 confirmed cases, respectively. Specifically, COVID-19 case fatality risk and HAQ index were negatively correlated for <1000 confirmed cases: at 500 and 1000 confirmed cases, COVID-19 case fatality risk decreased by 2.18% (95% confidence interval [CI]: 0.87% to 3.47%) and 3.22% (95% CI: 1.46% to 4.95%), respectively, for every unit increase in HAQ index. This negative correlation decreased and even turned positive (but nonsignificantly) as countries approached >5000 confirmed cases.

Figure 2 presents the Spearman rank correlation coefficients for each stage of the pandemic, as defined by per-capita number of cases; panels A, B, C, and D in the figure illustrate the results for 10, 50, 100, and 500 cases per million people in the population, respectively. Specifically, COVID-19 case fatality risk and HAQ index were negatively correlated at <100 cases per million people: at 10, 50, and 100 cases per million people, the COVID-19 case fatality risk decreased by 2.50% (95% CI: 1.19% to 3.80%), 3.63% (95%

CI: 1.46% to 5.75%), and 3.10% (95% CI: 0.51% to 5.61%), respectively, for every unit increase in HAQ index. This negative correlation decreased ($r = -0.0429$) and became nonsignificant as countries approached >500 cases per million people.

Discussion

The negative correlation between COVID-19 case fatality risk and HAQ index weakened and then disappeared with the progressive burden of COVID-19 infection over time. In the early phase of the COVID-19 outbreak, countries with better public health infrastructure tended to have a lower case fatality risk. However, at more than 5000 confirmed cases (or more than 500 confirmed cases per million people), countries had similar case fatality risks regardless of the quality of their public health infrastructure. This indicates that even the best public health systems were overwhelmed by the COVID-19 pandemic, a pandemic that has been unprecedented in the past half a century. By comparison, recent pandemics such as those of severe acute respiratory syndrome (SARS) in 2003, the H1N1 influenza virus in 2009, Middle East respiratory syndrome (MERS) in 2012, the Ebola virus in 2014, and the Zika virus in 2015⁹ had a substantially lower global burden at 8096 cumulative confirmed cases (case fatality risk: 9.56%) for SARS¹⁰, 620,000 cases (1.26%) for H1N1¹¹, 2502 cases (34.41%) for MERS¹², 15,227 cases (39.52%) for Ebola¹³, and 220,000 cases (almost 0%) for Zika¹⁴.

Case fatality risk is also correlated with the scale of COVID-19 testing. Asymptomatic people with COVID-19 (also known as silent spreaders) were estimated to comprise nearly one-third of all people with COVID-19¹⁵. Mass testing helps identify asymptomatic carriers, and they can then be isolated to mitigate disease transmission; with a greater denominator from a larger number of confirmed asymptomatic cases, the overall case fatality risk decreases¹⁶. We calculated the test-positivity rate (number of confirmed cases/total number of people tested), which allowed us to obtain data for the denominator (total number of people tested) from the Our World in Data¹⁷ database. We obtained such data only for high-HAQ countries (HAQ > 80) at >10,000 confirmed cases. As illustrated in Figure 3, larger-scale COVID-19 testing (positivity rate < 10%) resulted in a consistently low case fatality risk as the pandemic progressed; by contrast, smaller-scale testing (positivity rate > 10%) resulted in a rapid increase in case fatality risk as the pandemic progressed. The scope of testing also impacts the overall mortality rate in the population at large. Figure 4 shows that as the scope of testing becomes smaller (positivity rate becomes larger), the COVID-19 mortality rate increases. In view of these, we strongly urge all countries still in the early stage of COVID-19 outbreaks to expand the scope of COVID-19 testing to mitigate disease transmission and avoid the impending collapse of health systems.

Finally, although age and comorbidity are strong predictors of COVID-19 case fatality risk¹⁸⁻²¹, data on these two predictors were unavailable for analysis in this ecological correlation study.

Abbreviations

COVID-19: coronavirus disease 2019; HAQ: healthcare access and quality; SARS: severe acute respiratory syndrome; MERS: middle east respiratory syndrome

Declarations

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Competing interests

The authors declare that they have no competing interests.

Research Ethics Approval

Not Applicable. The aggregate-level data by country was used in this study, and no personal information was used and showed in the text and result.

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Figures

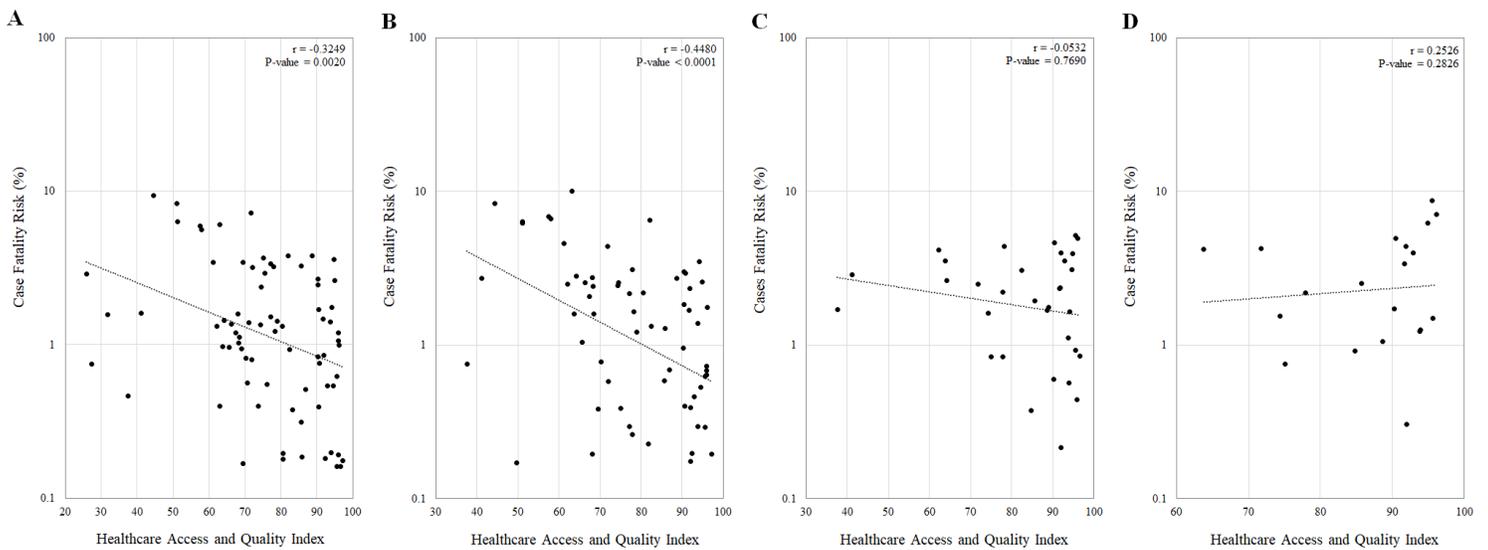


Figure 1

Countries' Spearman rank correlation coefficients between COVID-19 case fatality risk and HAQ index at 500 (A), 1000 (B), 5000 (C), and 10000 (D) cumulative confirmed cases.

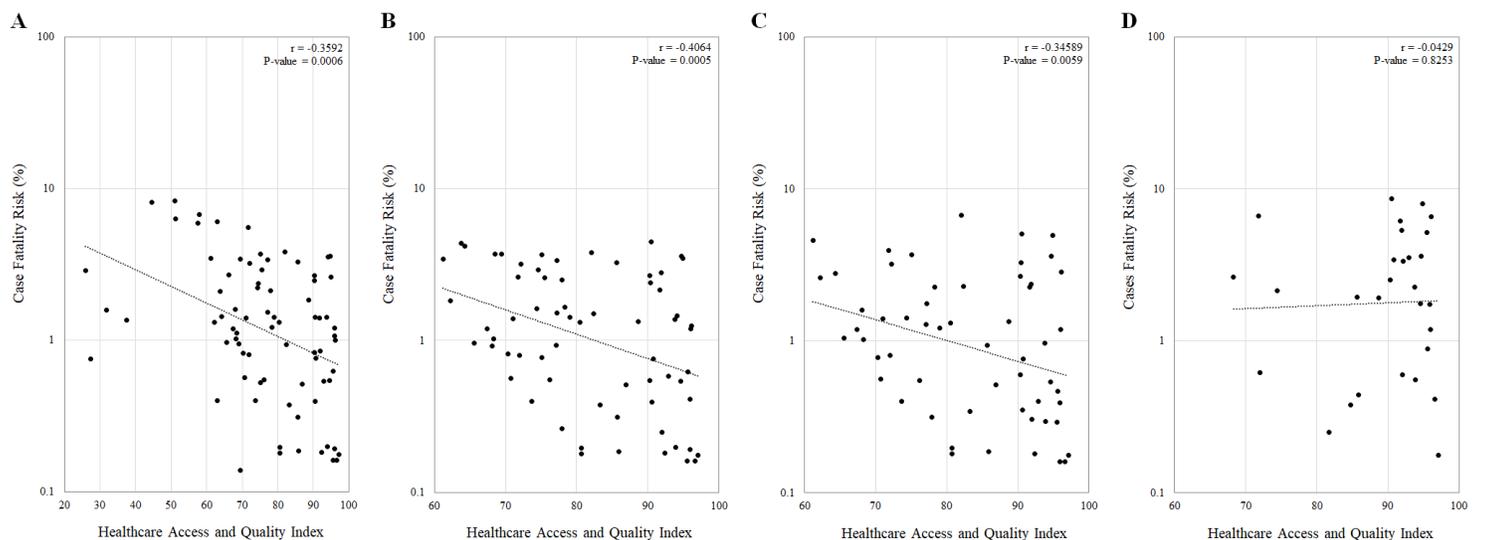


Figure 2

Countries' Spearman rank correlation coefficients between COVID-19 case fatality risk and HAQ index at 10 (A), 50 (B), 100 (C), and 500 (D) cases per million people in the population.

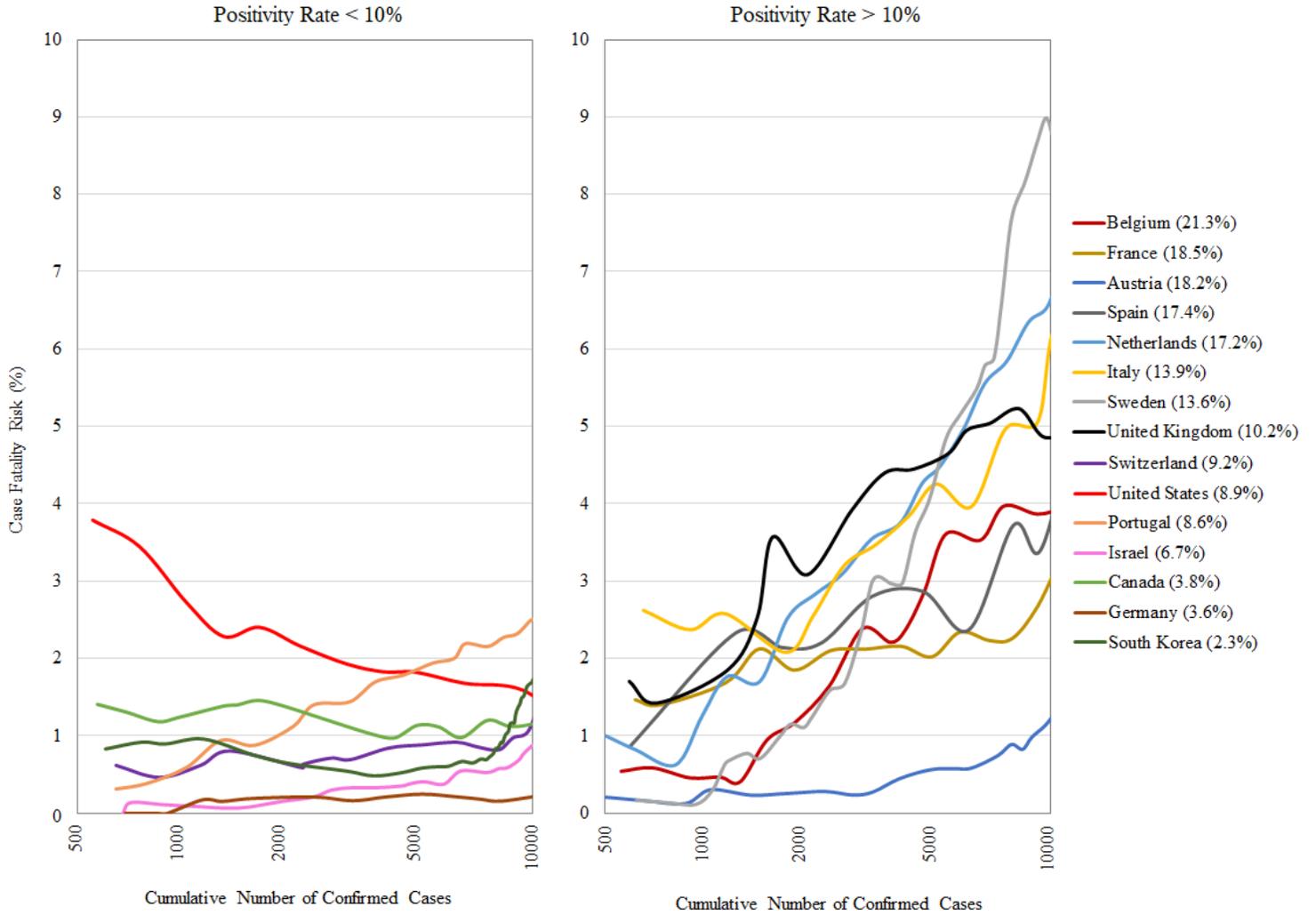


Figure 3

Evolution of case fatality risk with progressive burden of COVID-19 infection for high-HAQ countries (HAQ > 80).

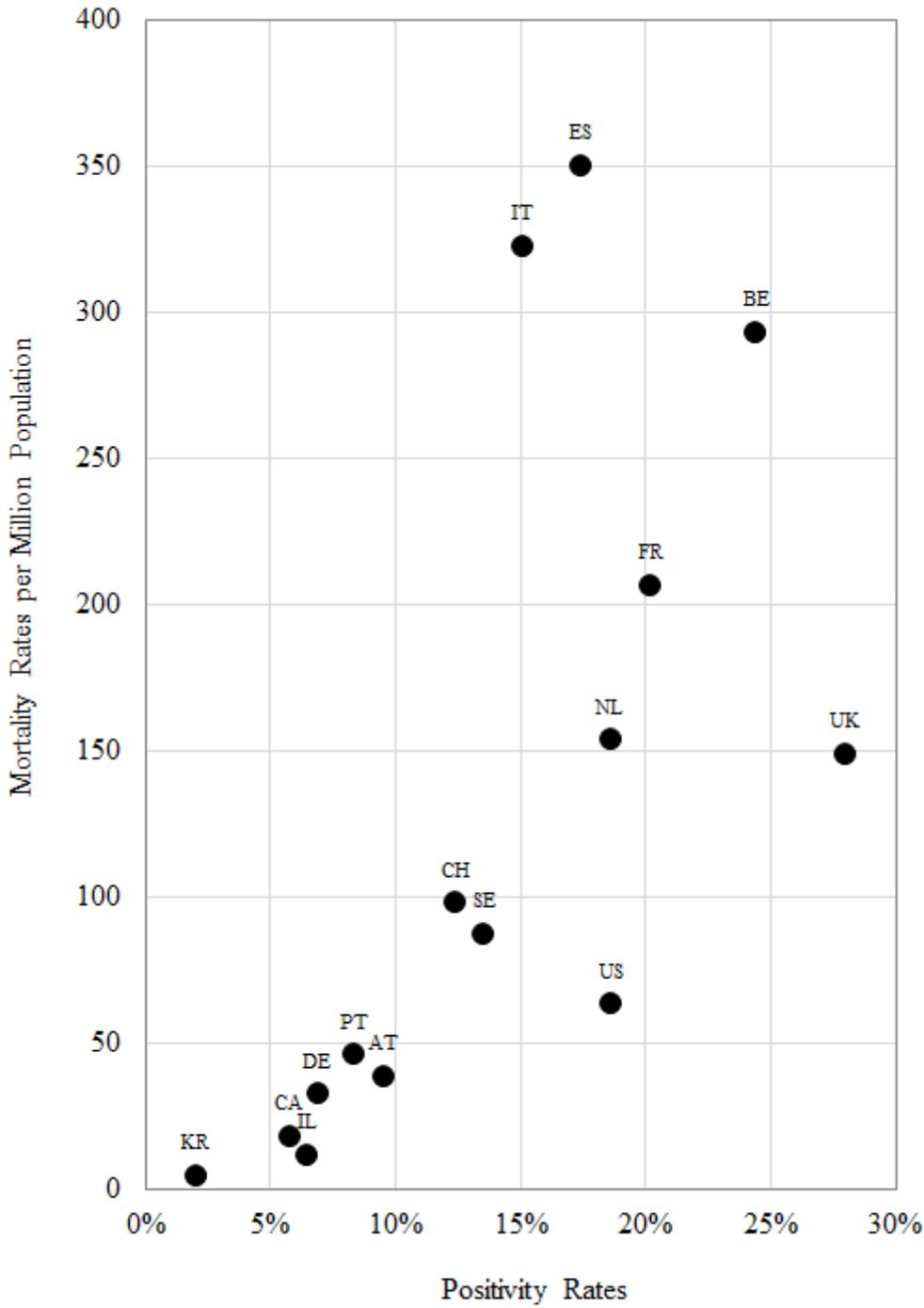


Figure 4

Correlation between COVID-19 mortality rates and positivity rates as of 12 April 2020 (ES: Spain; IT: Italy; BE: Belgium; FR: France; NL: Netherlands; UK: United Kingdom; CH: Switzerland; SE: Sweden; US: United States; PT: Portugal; AT: Austria; DE: Germany; CA: Canada; IL: Israel; KR: South Korea).