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Short Communication

Policy determinants of COVID-19 pandemic–induced fatality rates across nations

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ABSTRACT

Objectives: Coronavirus disease 2019 (COVID-19) is the most devastating pandemic to affect humanity in a century. In this article, we assessed tests as a policy instrument and policy enactment to contain COVID-19 and potentially reduce mortalities.
Study design: A model was devised to estimate the factors that influenced the death rate across 121 nations and by income group.
Results: Nations with a higher proportion of people aged 65+ years had a higher fatality rate ($P = 0.00014$). Delaying policy enactment led to a higher case fatality rate ($P = 0.0013$). A 10% delay time to act resulted in a 3.7% higher case fatality rate. This study found that delaying policies for international travel restrictions, public information campaigns, and testing policies increased the fatality rate. Tests also impacted the case fatality rate, and nations with 10% more cumulative tests per million people showed a 2.8% lower mortality rate. Citizens of nations who can access more destinations without the need to have a prior visa have a significant higher mortality rate than those who need a visa to travel abroad ($P = 0.0040$).
Conclusion: Tests, as a surrogate of policy action and earlier policy enactment, matter for saving lives from pandemics as such policies reduce the transmission rate of the pandemic.

As of July 29, 2020, severe acute respiratory syndrome coronavirus 2, which causes coronavirus disease 2019 (COVID-19), has already infected more than 16.6 million people, causing 658,861 mortalities globally.[1] The majority of deaths have occurred in the 65+ years age-group, with most having medical preconditions.[2,3] Policies for social distancing, lockdowns, testing, isolating, and tracking are necessary to contain the spread of the virus, although they come with a cost of an economic recession with its negative side-effects.[4]

Here, we assessed tests as a policy instrument and the start of policy enactment to contain COVID-19 and potentially reduce mortalities across 121 nations. To achieve this, a cross-sectional ecological study was conducted for numerous nations around the world, and a model was estimated to explain the pattern of the crude case fatality rate (CFR)[5] as of July 21, 2020. The objective was to estimate, using regression analysis, the direction and strength of the association with the death rate, as the response variable, controlling for (1) the percentage of the population aged 65+ years, (2) the delay in enacting policies, which was measured as the number of days from January 1, 2020, until the stringency index, which is composed of all containment policies, which took on a positive value showing that policy action was taken by the nation on that date, (3) tests per million people (i.e. the COVID-19 test rate) conducted as a surrogate of policy action to contain the spread of COVID-19, and (4) the freedom of nations' citizens to travel abroad as measured by the number of destinations a citizen of a nation has access to without the need for a visa. Citizens of rich countries can travel abroad and visit other destinations relatively more easily. This is supported by a strong positive correlation between gross domestic product per capita and the Henley Passport Index. The pairwise Pearson correlation (r) was 0.763 (95% confidence interval [CI] = 0.676, 0.828). This freedom to travel abroad heightens the risk of infection or transmission. In turn, mortality being a function of the incidence of infections, should be significantly higher relative to nations whose citizens are restricted from entering other

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nations, controlling for all other factors. We also controlled for tourist arrivals and the presence of city-states, such as Bahrain, Kuwait, Hong Kong, Qatar, and Singapore, to determine if the fatality rate was lower in city-states relative to that of nations that is composed of many cities (Supplementary file). Elasticities were estimated, showing the percentage change in the response variable for a 1% change in the explanatory variable, for all variables with a log-log specification model to account for non-linear associations. Details of the data sources and definitions may be found in the Supplementary file.

A total of 121 nations were assessed: 46 high-income nations, 36 upper-middle-income nations, and 39 low-income nations (Supplementary Table S1). As expected, high-income nations were affected the most by the pandemic relative to the other two groups in terms of deaths per million people, i.e. crude death rate (CDR), and in terms of CFR. The CDR for the high-income group was 2.16 times higher than that for the upper-middle income group (i.e. 166 vs 77 deaths per million people, respectively) and 6.1 times higher than that of the low-income nations (i.e. 166 vs 27 deaths per million people, respectively). The difference in CFR for high-income nations relative to that for the other two groups combined was 1.98% ($P = 0.007$, 95% CI = 0.0057, 0.034).

High-income nations conducted significantly more tests per million people than the other two income groups (i.e. 3.87 and 9.9 times more than upper-middle-income and low-income nations, respectively). In addition, high-income nations had 15%, middle-income nations had 9%, and low-income nations had 4.6% of their population aged 65+ years. High-income nations reacted earlier on average than the other nations in terms of social distancing, lockdowns, and testing as they were hit harder by the virus.

The regression results are shown in Table 1, which includes all 121 nations, and also divide them into the three income groups. Supplementary Table S2 shows the regression with deaths per million people (CDR) as a response variable, and Supplementary Table S3 shows results with tourist arrivals and city-states added as explanatory variables. For all nations grouped together, the results show that the COVID-19 test rate is statistically significant, affecting CFR negatively ($P < 0.0001$, 95% CI = -0.367, −0.186). A 10% higher COVID-19 test rate results in a 2.8% lower CFR. Age of 65+ years is also significant, with a positive impact on CFR ($P = 0.0001$, 95% CI = 0.273, 0.758). A 10% increase in the percentage of the population with an age more than 65 years results in a 5.2% increase in CFR. The policy variable (days since first policy enactment) is positive and significant on CFR ($P = 0.0013$, 95% CI = 0.148, 0.594). A 10% delay in enacting policy results in a 3.7% higher CFR. To illustrate this, a 7-day/one full week delay (30-day/a month delay) relative to a nation that enacted policies from day 1 represents a 600% (2900% for a one-month delay) increase in delay time, which resulted in a 3.23-fold (11.76-fold for a one-month delay) higher fatality rate relative to those nations that enacted policies from day 1. During a worldwide pandemic, delaying to act has a significant effect on the infection rate. An example would be to delay restrictions on international travel from and to high-risk nations or other policies to contain the spread of the virus such as testing policies. Access to destinations around the world using as a surrogate, namely, the Henley Passport access numbers, also had a positive and significant effect on CFR ($P = 0.004$, 95% CI = 0.194, 0.996). For the high-income nations, the percentage of the population aged 65+ years positively impacted CFR ($P = 0.0017$) and had a significantly positive impact from days since first policy enactment ($P = 0.012$), with the COVID-19 test rate having a negative impact on CFR ($P = 0.041$). For the upper-middle-income nations, the days to first policy enactment and passport access were the significant variables explaining CFR across these nations ($P = 0.0002$ and $P = 0.0126$, respectively). For the low-income nations, conducting more tests per million people was also an important factor explaining the pattern of CFR across these nations ($P = 0.0003$) and the age more than 65 years variable ($P = 0.0463$). Supplementary Table S2 shows that one cannot reject the null hypothesis that deaths per million people have an elasticity equal to unity with respect to cases per million people. As a result, the remaining confounding factors affected CDR in a very similar way to their effect on CFR, as shown in Table 1. Supplementary Table S3 shows that the number of tourist arrivals may have positively impacted fatality rate as measured by CDR or CFR ($P = 0.11$), but was especially significant for the high-income nations ($P = 0.029$). City-states had a lower fatality rate relative to the rate observed at the national level ($P = 0.007$).

The results show that more tests per million people lead to a lower CFR relative to other nations that conduct less tests per million people. Because tests remain an important policy instrument for COVID-19, conducting tests acts as a surrogate of policy action. It is true that more tests lead to more cases being reported, so more deaths will be observed as a result. However, the aforementioned findings suggest that mortalities will increase by a lower percentage than the percentage increase in cases when a nation conducts more tests per million people relative to other nations that do not. Robust testing allows COVID-19 to be detected earlier, which in turn allows a health system to provide some assistance to patients by reducing their risk of premature death,

Table 1
Least squares estimation of CFR as of July 21, 2020, and by income group.

Explanatory variables	All nations		High-income nations		Upper-middle-income nations		Low-income nations	
	Coefficients	*P*-values	Coefficients	*P*-values	Coefficients	*P*-values	Coefficients	*P*-values
Constant	−6.1261	0.0000	−8.5644	0.0013	−7.5655	0.0001	−5.0814	0.0002
Age more than 65 years (% of the population)	0.5154	0.0001	0.6160	0.0017	−0.1622	0.5180	0.4833	0.0463
Days for first policy enactment	0.3711	0.0013	0.5959	0.0115	0.5300	0.0002	0.1721	0.2051
Cumulative tests per million	−0.2766	0.0000	−0.2436	0.0410	−0.1820	0.1303	−0.2719	0.0003
Passport access	0.5952	0.0040	0.8123	0.2014	0.8599	0.0126	0.5259	0.1260
Number of nations		121		46		36		39
Standard error		0.782		0.847		0.719		0.716
Adjusted R^2		0.406		0.533		0.285		0.265
Overall F-test		21.47		13.82		4.49		4.42
P-values for F-test		0.0000		0.0000		0.0056		0.0055

CFR = case fatality rate.
Estimation was conducted using the Eviews 11 software with Huber-White-Hinkley (HC1) heteroskedasticity-consistent standard error and covariance terms being reported. Delaying was measured as the number of days since the enactment of first policy as per the stringency index. Passport access was measured as the number of destinations a citizen can visit without the need of a visa.

thereby potentially reducing CFR. Delay in taking action to contain the spread of the virus also matters. Nations that acted earlier have a lower CFR. Nations that delayed the implementation of policies, international travel restrictions, public information campaigns, and testing policies showed a higher mortality rate than those nations that did not delay the enactment of international travel restrictions, public information campaigns, and testing policies (Supplementary Table S4). In contrast, across 50 countries that had the highest COVID-19 cases, mortality was impacted by the prevalence of obesity and gross domestic product, but evidence for rapid border closures, full lockdowns, and widespread testing was inconclusive.[6] In a sample of 185 nations, tourist numbers were associated with COVID-19 mortality.[7]

There are a number of limitations in this research. First, the issue of ecological fallacy cannot be ignored. This ecological study was performed at the level of nations, and inference of these results at the individual level cannot be made. In the future, it would be worthwhile to examine data at the city level rather than at the nation level. The second issue is the potential of missing other important confounding factors (e.g. obesity levels, smoking prevalence[8]), which could be correlated with the variables of this study. Their omission could cause the estimated coefficients of this study to be biased. However, when we estimated the factors that influence the number of deaths per million people, controlling for cases per million people, we found that the estimated coefficients were relatively stable and that the factors explained more than 80% of the variation of the mortality rate (see Supplementary Table S2). The third issue is that the reported fatality rates can be biased and may cause overestimation or underestimation of estimates.[5,9,10] However, using data across nations, the bias should not affect the main results of the study, provided the bias occurs in a similar fashion across all nations around random noise. Furthermore, the data were taken from the public domain, which may not be accurate or not be confirmed by nations' public health units. What is a confirmed COVID-19 case between different nations can also vary. This study was conducted for the outcomes of COVID-19 as of July 21, 2020. The size effects and the significance of these factors could be influenced if the study is reassessed in the future. Cognizant of such limitations, this study shows that more tests and earlier policy enactment matter and can save lives from pandemics because such policies reduce the transmission rate of the pandemic.

Author statements

Author contributions

The authors, who are co-corresponding authors, contributed equally to the intellectual discussion underlying this article; literature exploration; data analysis; and writing, reviews, and editing and accept responsibility for its content.

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Competing interests

The authors declare no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2020.08.008.

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