The COVID-19 Pandemic: The Case Fatality Rate

Kyrill Shraberman

The waves of infection and death over the past two and a half years as a result of COVID-19, both in Israel and in other countries, is well known. Following every increase in morbidity and mortality there was a temporary flattening of the curve until there appeared a new variant of the virus which in turn led to a repetition of the process. In response to the waves of infection, at least during the second half of 2021, many governments adopted a kind of *accordion policy* which included preventive measures (limited entry into the country, restrictions on social congregation, lockdowns, etc.), although the timing and intensity of the measures varied significantly from country to country (Haug et al., 2020).

However, there is less known about the trends over time in the case fatality ratio (CFR), i.e., the rate of mortality due to the virus out of total confirmed cases. As can be seen from Figure 1, particularly in Europe, the CFR was higher at the beginning of the pandemic, although toward the fall of 2020, it fell to a level that characterized the rest of the world and stabilized there. From that point until the end of 2021, the CFR remained almost unchanged, regardless of the waves of infection. At the beginning of 2022, the CFR worldwide declined, due to the fact that the dominant virus variant at that point (Omicron) was more infectious but less fatal. These characteristics significantly raised the number of confirmed cases, but the number of fatalities increased much less.

Figure 1 describes the CFR out of total confirmed cases in Israel and other regions. It clearly shows that Israel is ranked in the lower part of the distribution. Beginning in July 2020, the CFR in Israel did not exceed 1%, which is less than half the average of Europe and North America. Essentially, for most of the pandemic period (until the end of May 2022), only three countries had a lower CFR than Israel (Iceland, Qatar, and the UAE). They were joined by Norway in March 2021 and New Zealand in October 2021 (see Appendix Figure 1), and several other countries in the early months of 2022.

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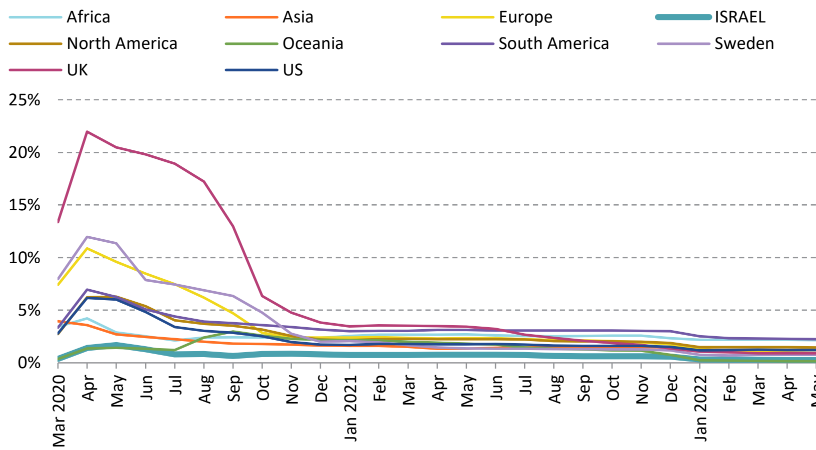
Figure 1. The fatality rate out of total confirmed cases in Israel and selected other regions



Source: Kyrill Shraberman, Taub Center | Data: Our World in Data, Johns Hopkins University

The main empirical goal of this research is to explain the variation in the outcomes of the various countries based on an analysis of the CFR's variance from March 2020 until May 2022 and then to examine where Israel stood after controlling for a variety of characteristics that were found to explain that variance. The study is based on a comparative analysis of the CFR in 96 countries (the selection of the sample will be described below).

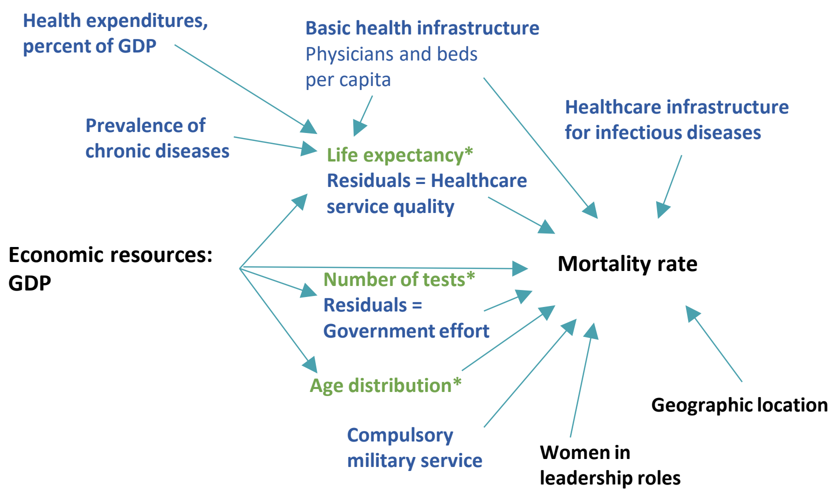
The research provides two important findings. The first is specific to Israel: relative to other countries, Israel stands out in its superior outcomes during the pandemic. During most of the pandemic months and after controlling for the explanatory characteristics, the CFR in Israel was almost a standard error below the model's predicted average CFR. In other words, Israel showed better-than-expected results.

The second finding is more general. During the course of the pandemic, there were significant changes in the explanatory power of certain variables. In one group of variables, which includes the resources available to the government (GDP per capita) and quality of the healthcare system, the explanatory power rose. In the other, which includes compulsory military service and an index of health security,[1] explanatory power declined. This pattern points to the importance of investment in public health and supports the assumption that rich countries have a greater ability to respond to crises, at least following the initial shock.

The model outline

Figure 2 presents the outline of the model. In order to estimate the dependent variable, i.e., the cumulative CFR, we used data on fatality and morbidity from the Center for Systems Science and Engineering (CSSE,) Johns Hopkins University.[2]

Figure 2. The model outline



Note: * indicates dependent variables in the first stage equations; blue text indicates components of health capital.
Source: Kyrill Shraberman, Taub Center

1 The Global Index of Health Security was developed by the Johns Hopkins Center for Health Security at the Bloomberg School of Public Health and the Nuclear Threat Initiative, in partnership with Economist Impact. The index, which was first published in October 2019, measures the preparedness for outbreaks of infectious disease in 195 countries. For further details, see Global Health Security Index.

2 We would mention that the quality of the data varies across countries. This will be discussed further on in this paper.

The decision to measure the cumulative CFR over time was based on two factors. The first is the variation in the waves of infection and deaths across countries; a model focusing on only one period, i.e., on the CFR in a specific month out of total confirmed cases in that month, does not provide a full picture of the variation over the entire pandemic. The second factor is related to the fact that there may be a disconnect between deaths and infections (Faes et al., 2020). Due to the persistence of the illness, some fatalities were liable to be recorded in the month following the infection, thus increasing the number of fatalities in the subsequent month and reducing them in the previous one to which they actually belong according to the date of infection. In order to avoid this bias, we use cumulative rather than monthly data. The models used to measure the CFR with lagged variables (number of fatalities in a given month or total confirmed cases in the previous month) did not yield meaningful results and weakened the model's explanatory power significantly.

The explanatory variables are divided into four main categories: economic resources, health capital, government effort, and political culture. Table 1 presents the descriptive statistics for each variable.

Economic resources: GDP per capita represents the country's average amount of resources, some of which are used to provide healthcare services, particularly in an emergency. It is important to mention that the relationship between GDP per capita and life expectancy is not linear. Thus, in countries with GDP per capita of more $20,000 (PPP), there is almost no connection. It can be assumed that the availability of resources in wealthier countries expands the possibilities for response and the room to maneuver for policy makers during an emergency (acquisition of equipment, the ability to borrow in international markets, and so on).

Health capital: This is one of the more important categories in the research and includes five components (marked in blue in Figure 2). The first four are direct indices, which commonly appear in the research literature, while the fifth is indirect.

1. Basic healthcare infrastructure: *Production* of indirect healthcare services that require a skilled workforce — physicians, nurses, and other hospital staff in hospitals with operating rooms who use a large variety of instruments and equipment (capital-intensive). In the absence of data on all of the infrastructures and human resources in the healthcare system, the variables used included number of hospital beds per 1,000 population and current expenditures on healthcare as a percentage of GDP.

2. Prevalence of chronic diseases in the population: From the beginning of the pandemic, it was clear that the risk of dying from infection was greater among individuals suffering from a chronic disease. Therefore, we used the most common indices for various chronic diseases, all of which are adjusted according to the population's age profile. The data source is the Global Burden of Disease (GBD) project at the University of Washington. Among the specific diseases are cardiovascular disease, diabetes, respiratory diseases, neurological diseases, gastrointestinal diseases, diseases related to malnutrition, and cancer.
3. Infrastructure for coping with infectious diseases: The Global Health Security Index (GHSI) was published in the autumn of 2019 and includes about 80 indicators of preparedness to deal with the outbreak of an infectious disease.
4. Availability of additional manpower: Beyond the regular manpower within the system, governments have available to them additional human resources due to compulsory military service. Military service trains ordinary manpower for discipline and the carrying out of assignments during an emergency. This type of manpower is temporary and some of them have undergone basic medical training.
5. Quality of the healthcare system: A classic index of health is life expectancy at birth, which is represented by the average length of a person's life by country. Essentially, in countries with high-quality healthcare systems, the expectation is that there is a higher percentage of chronic patients in their population (Gruenberg, 1977). Furthermore, additional factors affect life expectancy directly, such as the availability of medical infrastructure, the level of economic development, and environmental conditions (Linden & Ray, 2017; Weinreb, 2016). The model of life expectancy at birth, which controls for the prevalence of chronic diseases and other variables, essentially explains the variance in life expectancy that is the result of the variance in needs (the prevalence of chronic diseases) and the variance in the means available to the healthcare system in each country (economic variables). The unexplained part of life expectancy, namely the calculated errors, will reflect all of the factors and inputs that are correlated with life expectancy but are not controlled for as part of the model (including the skills of medical workers, the various medical practices, the frequency of diagnostic processes and their quality). Most of these factors can serve as

an indication of the quality of the healthcare system, since the calculated errors in the model can be easily interpreted. For example, if in a particular country there is a longer life expectancy than that expected given the prevalence of chronic diseases and the amount of resources available, then there are other factors in this country (apart from the factors controlled in the proposed model) which contribute to the increased life expectancy. In contrast, a shorter than expected life expectancy is evidence of factors that are negatively correlated with a long life.[3]

Government effort: The average weekly number of new COVID-19 tests per 1,000 population.[4] This is the only explanatory variable that does not remain fixed. Since rich countries are able to purchase more tests — the cost of a PCR test ranges from $15 to $60 — we used the calculated errors from the regression, which measures the effect of GDP per capita on the number of new weekly tests per 1,000 people. If more tests are carried out (positive calculated errors), it can be concluded that the country invested more resources in documenting the pandemic. We assume that there is a positive correlation between this investment and the general effort to control the pandemic and reduce the CFR. Furthermore, and as will be described further on, this variable has another important role, namely to control for differences between countries in the quality of data on rates of morbidity and mortality in general.

Women in leadership roles (political culture): This variable relates to the way in which policy makers evaluate information, make decisions, and implement them. In view of the large amount of literature on the differences between male and female leaders with respect to decision making and choosing policy measures (Paxton et al., 2021), particularly during the pandemic (Garikipati & Kumbhampati, 2021; Sergent & Stajkovic, 2020), an index of women in leadership roles was used.[5] That is, a dummy variable for whether a women had served in the country's most senior political position (prime minister in parliamentary systems or president in a presidential regime) for at least one year since 2000 was used. This variable can indicate two things: a political

3 For a ranking of countries according to the size of the calculated error in the regression of life expectancy at birth, see Appendix Table 2.

4 For further details on the number of weekly tests per 1,000 population, see the Appendix.

5 More general indices of regime type, such as Polity IV, did not contribute to the performance of the model.

culture in which leadership skills are more important than the identity of the leaders, such that the voters in countries with women leaders are more prepared to cooperate with the government; and the style of the leadership which is characterized by the choice of a lower-risk policy for a public response to an emergency, which is more characteristic of women than men (Charness & Gneezy, 2012).

There are two other important factors that are relevant in explaining COVID-19 fatalities. One is the percentage of the population over the age of 65. From the start of the pandemic, it was clear that the risk of death from the virus among the elderly was much higher than among younger patients (Liu et al., 2020). However, since there is a strong correlation between the share of the population aged 65 and over and GDP per capita, it is difficult to use these variables together in the same regression. Since the relative share of the elderly in the population is also correlated with medical infrastructure, such as current healthcare expenditure and number of hospital beds per 1,000 population, we used the calculated errors of a regression of the share of the population aged 65 and over on GDP per capita, the share of current healthcare expenditures in GDP, and the number of hospital beds per 1,000 population.[6]

The second factor is geographic location, which is measured by the geometric center point of each country with respect to latitude and longitude. This variable is meant to help identify gross environmental differences between countries that are the result of their unique location and very possibly also genetic differences, even if only on a partial level (Pickrell & Reich, 2014).[7]

6 For more on this see Appendix Table 3.

7 There are those who claim that a unique coding of antibodies to cytokines (proteins with a decisive role in the regulation of functioning and the multiplication of cells in the blood and immune system) and an error in the coding of proteins at the attachment sites of viruses are likely to increase the risk of becoming ill and dying from a serious disease (Bastard et al., 2020). Others claim that the population who originate from Southern Asia are more likely to experience the disease more intensely than other populations due to a genetic failure in the epithelial cells (tissue cells that cover the eternal surfaces of the body's organs and are found on the boundary between their external and internal environments) of the lungs, and the respiratory system in general, which leads to greater moisture and faster breakdown of the respiratory cell tissue (Downes et al., 2021). Finally, the phenomenon of discordant couples, namely couples who live together and only one of them is infected despite prolonged intimate contact, strengthens the claim regarding the effect of genetics on morbidity in general and on the seriousness of morbidity in particular (Castelli et al., 2021).

Table 1. Explanatory variables, descriptive statistics

Variable	No. of observations	Mean	Standard deviation	Minimum	Maximum
GDP per capita 2019 ($1,000 PPP)	96	31.04	22.797	1.22	113.94
GDP per capita 2020 ($1,000 PPP)	96	29.46	22.125	1.20	110.26
Acute care beds per 1,000 population (2015–2019, latest data available)	96	3.16	2.39	0.33	12.98
Current health expenditure, as a % of 2019 GDP	96	7.04	2.55	2.32	16.89
Share of population 65+ (%)	96	11.91	6.696	1.16	28.00
Life expectancy at birth (years)	96	76.89	4.88	62.42	84.36
Quality of healthcare	96	0.00	2.136	-6.22	6.16
Latitude (degrees)	96	26.39	24.381	-42.63	64.76
Longitude (degrees)	96	10.03	65.935	-109.43	177.97
Compulsory military service (18+ months of service)	96	0.22	0.416	0.00	1.00
Woman in leadership roles (for at least 1 year since 2000)	96	0.27	0.447	0.00	1.00
GHS index	96	48.51	13.81	23.20	83.50

Source: Kyrill Shraberman, Taub Center | Data: World Bank; Nunn & Puga, 2012; Global Health Security Index, October 2019

The full model

In view of the differences across countries in the quality of the data on rates of morbidity and mortality due to COVID-19, the analysis would ideally include only countries with reliable healthcare data (based on, for example, the World Health Organization Data Quality Index). However, since restricting the analysis to a small and varying sample of tests each month[8] would have significantly weakened the model's statistical power, we expanded the sample to countries for which there is data on the variables appearing in Figure 2 above. As a substitute for the World Health Organization Data Quality Index, we used data on the number of hospital beds per 1,000 population and thus limited the sample to 96 countries.

8 According to the World Health Organization, a *moderate* testing policy is 1–2 new tests per week per 1,000 population and an *adequate* policy is more than 2. Between March 2020 and March 2022, the number of countries adopting a moderate policy changed significantly and even more so in the case of those who adopted an adequate policy. For further details, see the Appendix.

As a result of the skew to the right of the dependent variable, we chose to estimate the model by means of a Gini regression, which makes it possible to overcome the bias resulting from asymmetry in the distribution (Yitzhaki & Schechtman, 2012, 2013),[9] rather than using an OLS regression.

Finally, the latest observations for the explanatory variables are for 2019, while the rate of fatality series begins in March 2020 and ends in March 2022. The use of past data for the explanatory variables makes it possible to avoid endogenous effects between CFR and these variables.

First stage: Estimating the indirect indices

Prior to estimating the full model, it was necessary to carry out a number of indirect estimations in order to deal with methodological issues and create instrumental variables. The estimation results for the models that measure the quality of the healthcare system and government effort, number of beds per 1,000 population and the share of the population aged 65+ will be described below.[10]

In the regression of life expectancy at birth, the explanatory variables explain 89% of the observed variance between countries. Appendix Table 2 presents a list of the 25 countries with the largest calculated errors and the 25 with the smallest calculated errors or in other words the 25 countries with the highest-quality healthcare services and the 25 with the lowest-quality healthcare services. As expected, Israel is in the former group.[11]

Among the other instrumental variable regressions, especially noticeable is the model of number of new weekly tests per 1,000 population. About 70% of the variance in the number of new weekly tests is explained by GDP per capita alone. The findings show that the wealthier a country is, the higher is

9 See the Appendix for further details.

10 See Appendix Table 3 for detailed results.

11 Specifically, the model found that an increase of 1% in the prevalence of cardiovascular disease in the population and diseases related to nutrition is correlated with a drop of 1.2 and 0.2 years in life expectancy, respectively. In contrast, it was found that every increase of 1% in the prevalence of various types of cancer in the population is correlated with an increase of 3.3 years in life expectancy. At first glance this is a surprising finding. However, the explanation is straightforward: the earlier that cancer is diagnosed, the higher will be the rate of cancer patients in the population, and, at the same time, the higher will be the survival rate the disease. Therefore, it can be said that early diagnosis contributes to an increase in life expectancy, which necessarily is an indication of a better healthcare system. The full results are presented in Appendix Table 3.

the number of new tests per week per 1,000 population. Here again, Israel has on average positive calculated errors, which indicates a larger than expected government effort given the country's GDP per capita.

Second stage: The CFR model over time

The findings of the analysis indicate that the pandemic can be divided into two main periods: the adjustment period which lasted from March 2020 to August 2020 (the two first waves of the pandemic) and the period of stability from September 2020 until the end of the sample period. Table 2 presents the results of the model for each month, from March 2020 until May 2022, with the goal of detecting changes in the relationships between the various explanatory variables and the rate of fatality during the period. It is important to note that there are differences in the model's explanatory power during these two years, although it is usually higher during the period of stability. Beginning in November 2021, the share of the explained variance did not fall below 65%, while during the adjustment period it did not exceed 60%. These differences are consistent with the slopes in Figure 1: the variation between countries in the rate of fatality within total confirmed cases declined over time.

During the adjustment period (March–August 2020), the connection between the rate of fatality and the two variables that are considered to be the most important — GDP per capita and the quality of the healthcare system — is usually not significant. Thus, in wealthier countries with better performance according to the public health indices, the rate of fatality from COVID-19 in May and June 2020 was not lower — at least not to a statistically significant degree — than in poorer countries or countries with lower performance in public health. Only in July and August 2020, towards the end of the adjustment period and the beginning of the period of stability, is there a return to the expected path according to these variables, such that they become significant and remained so until May 2022. In other words, it can be said that only after the initial shock at the outset of the pandemic and with the increased burden on hospitals was the response of countries to the pandemic affected by the country's quantity of resources and the quality of its healthcare system.

The link between the fatality rate and the three other components of health capital, i.e., government effort, percentage of the population over 65, and the country's geographic location, also changed over time. The GHSI coefficient was positive and significant from April 2020 until

November 2021 and was particularly high in the summer of 2020, which marked the end of the adjustment period. In other words, the higher a country is ranked according to the Global Health Security Index, the less successful it was in reducing the CFR up until the end of 2021. This finding is consistent with the poor performance measured by rate of morbidity and fatality reported at the beginning of the pandemic (Abbey et al., 2020; Aitken et al., 2020). It is very possible that when examining a country's preparedness to deal with an outbreak of an infectious disease, political and constitutional barriers may have been encountered in the attempt to implement policy measures that limit individual rights, such as freedom of movement and freedom to congregate.

A country's effort to deal with the pandemic — as reflected in the number of new weekly tests per 1,000 population — has a negative and significant connection to the CFR in most months of the pandemic. In other words, the larger the number of tests, the lower is the CFR. Due to a methodological difficulty, it is not possible to test the relation between the number of tests and the number of confirmed cases, although a possible and relatively direct explanation is that a large number of tests makes it possible to identify infected individuals at an earlier stage and therefore to prevent the deterioration of their condition and even their death.[12]

The relationship between the fatality rate and the share of the population over the age of 65 is positive, as expected, but is not statistically significant at any stage. It may be that other explanatory variables which are positively correlated with the share of the elderly in the population (see Table 2) weaken the connection of this variable with the fatality rate from COVID-19.

Finally, during the pandemic, there was a negative relationship between longitude and the CFR, and it was significant until December 2021. During the initial months of the pandemic, the connection between latitude and the CFR was also negative and significant. These two findings together indicate that the CFR was lower in the southeastern quarter of the globe, i.e., the Far East and Oceania. The fact that only the coefficient of longitude remains negative and significant until December 2021 points to the relative success of the countries in Southeast Asia, Australia, and New Zealand in coping with the pandemic, primarily when compared to the countries in the western half of the globe (and in particular the South American countries).

12 For further details on testing policy, see the Appendix.

With respect to the women in leadership variable, which is meant to control for political culture or which implies a greater chance of making decisions with low public risk, it was found that there is a negative and significant correlation between it and the CFR throughout the pandemic. In other words, the rate of fatality was lower in countries with a woman in the highest political office for at least a year during the past 20 years, particularly during the adjustment period but also during the period of stability. Essentially, *this is the only variable in the model which has a statistically significant correlation with the CFR over all 25 months of the sample*. A similar finding was arrived at in a parallel study of morbidity and mortality rates (Weinreb, forthcoming).

Unlike women in leadership, the correlation between compulsory military service[13] and the CFR was more limited. Thus, only during the adjustment period (summer–spring 2020) was the correlation negative and significant, while during the period of stability it was positive but not statistically significant. In other words, countries with compulsory military service were characterized by a lower rate of fatality at the beginning of the pandemic while during the period of stability they had no significant advantage over other countries. This finding strengthens the hypothesis that compulsory military service makes it possible to better deal with medical emergencies and emergencies in general.

13 Compulsory military service of at least 18 months.

Table 2. The estimation results for the fatality rate out of total confirmed cases at the end of every month, March 2020 to May 2022

	GDP 2019–2020 ($1,000 PPP)	Latitude (degrees)	Longitude (degrees)	Healthcare service quality: Residuals from life expectancy equation	GHSI: Readiness for infectious diseases	Government effort: New weekly tests per 1,000 population (residuals)	Share of those aged 65+ (residuals share equation)	Compulsory military service	Political culture: Women in leadership roles	Intercept	No of observations	GR^2 (coefficient GR^2)
March 2020	-0.08***	-0.01	-0.01	-0.33	0.03	0.37	0.09	0.11	-1.84*	5.60***	84	0.365
April	-0.05**	0.02	-0.03***	-0.10	0.10**	-0.12	0.01	-1.80**	-2.17**	2.34	95	0.386
May	-0.03	0.0388	-0.02***	-0.06	0.12***	-0.11	0.08	-2.12***	-2.33***	-0.01	95	0.468
June	-0.03	0.03**	-0.02***	-0.19	0.13***	-0.13*	0.10	-1.85***	-2.42***	-0.50	95	0.552
July	-0.03	0.02*	-0.01***	-0.25*	0.12***	-0.08	0.13	-1.48**	-2.23***	-0.45	96	0.581
August	-0.03**	0.01	-0.01**	-0.27**	0.10***	-0.06	0.14	-0.93*	-1.94***	-0.17	96	0.466
September	-0.04***	-0.002	-0.01***	-0.23**	0.08***	-0.02	0.09	-0.50	-1.44***	0.75	96	0.389
October	-0.04***	-0.01	-0.01**	-0.20**	0.05***	-0.03*	0.04	0.02	-1.07***	1.79***	96	0.461
November	-0.04***	-0.01	-0.01**	-0.19**	0.04**	-0.03*	0.03	0.16	-0.92***	2.11***	96	0.542
December	-0.04***	-0.004	-0.006**	-0.18**	0.04**	-0.03**	0.03	0.15	-0.78**	1.93***	96	0.524
January 2021	-0.05***	-0.001	-0.005**	-0.20***	0.04**	-0.02**	0.004	0.17	-0.72**	1.68***	96	0.557
February	-0.05***	-0.002	-0.005*	-0.23***	0.04**	-0.008*	0.005	0.12	-0.72**	1.66***	96	0.560
March	-0.05***	-0.001	-0.005**	-0.22***	0.04**	-0.006*	0.002	0.14	-0.72**	1.66***	96	0.587
April	-0.05***	-0.001	-0.005**	-0.23***	0.04**	-0.007**	0.01	0.19	-0.71**	1.74***	96	0.619
May	-0.05***	-0.001	-0.005**	-0.21***	0.04**	-0.008**	0.02	0.23	-0.74**	1.88***	96	0.612
June	-0.045***	-0.002	-0.005**	-0.20**	0.04**	-0.009*	0.008	0.21	-0.78**	1.91***	96	0.599
July	-0.05***	-0.005	-0.005**	-0.21***	0.04**	-0.009*	0.01	0.22	-0.79**	2.05***	96	0.630

Table 2 (continued). The estimation results for the fatality rate out of total confirmed cases at the end of every month, March 2020 to May 2022

	GDP 2019–2020 ($1,000 PPP)	Latitude (degrees)	Longitude (degrees)	Healthcare service quality: Residuals from life expectancy equation	GHSI: Readiness for infectious diseases	Government effort: New weekly tests per 1,000 population (residuals)	Share of those aged 65+ (residuals share equation)	Compulsory military service	Political culture: Women in leadership roles	Intercept	No of observations	GR^2 (coefficient GR^2)
August	-0.05***	-0.004	-0.004*	-0.20***	0.04**	-0.01**	0.009	0.27	-0.72**	2.08***	96	0.624
September	-0.05***	-0.004	-0.004	-0.21***	0.03**	-0.009**	0.02	0.30	-0.74**	2.18***	96	0.630
October	-0.05***	-0.005	-0.004*	-0.20***	0.03*	-0.01**	0.02	0.34	-0.76**	2.30***	96	0.637
November	-0.05***	-0.005	-0.004*	-0.20***	0.03*	-0.007**	0.02	0.32	-0.74**	2.42***	96	0.658
December	-0.05***	-0.005	-0.004*	-0.20***	0.02	-0.006**	0.02	0.34	-0.70**	2.52***	96	0.661
January 2022	-0.04***	-0.003	-0.002	-0.18***	0.01	-0.004**	0.01	0.39	-0.51*	2.33	96	0.676
February	-0.04***	-0.003	-0.002	-0.17***	0.01	-0.003*	0.009	0.31	-0.51**	2.39***	96	0.679
March	-0.04***	-0.004	-0.003	-0.19***	0.006	-0.003*	0.02	0.36	-0.48**	2.52***	96	0.721
April	-0.04***	-0.004	-0.003*	-0.18***	0.005	-0.006	0.01	0.35	-0.45*	2.51***	96	0.711
May	-0.04***	-0.004	-0.003*	-0.19**	0.007	-0.005	0.01	0.3	-0.45*	2.44***	96	0.699

Note: Significance levels: *p < 0.10; **p < 0.05; ***p < 0.01.
Source: Kyrill Shraberman, Taub Center | Data: Our World in Data, Johns Hopkins University; World Bank; Nunn & Puga, 2012; Global Health Security Index, October 2019; Global Burden of Diseases, 2019

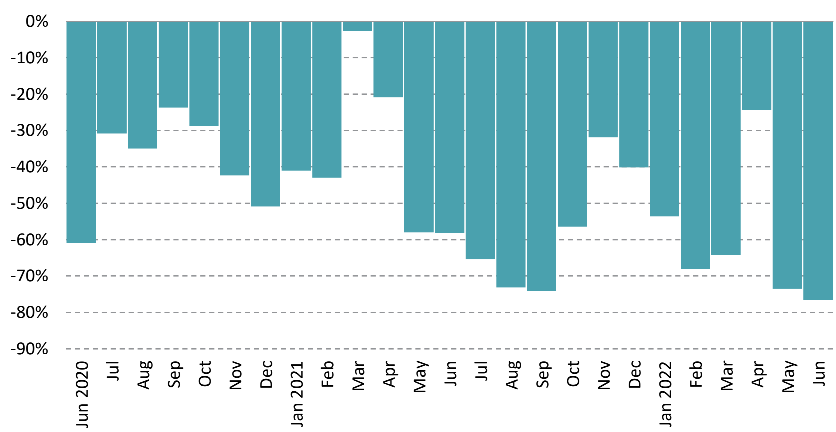
How much did Israel deviate from expectations during the pandemic?

In order to assess Israel's performance during the pandemic, it is important to differentiate between results due to characteristics like the population's age profile, the quality of the healthcare system, and GDP per capita on the one hand, and results explained by factors external to the model on the other hand. Figure 4 presents the calculated relative disparity between the actual and predicted fatality rate in Israel. The result of this calculation cannot be explained by the variables in the model, but it can provide an answer to the question asked above: How much did Israel deviate from expectations during the pandemic?

Overall, it can be said that Israel did surprisingly well. During all the months of the pandemic, the gap between the actual CFR and the CFR predicted by the model was negative. It is important to remember that the calculated gap is relative and dependent on the performance of the other 95 countries.

Figure 4. The gap between the actual and predicted rates of fatality in Israel

Standard deviation units



Source: Kyrill Shraberman, Taub Center | Data: World Bank; Nunn & Puga, 2012; Global Health Security Index, October 2019; Global Burden of Diseases, 2019

Conclusion

This study examined the variance in the fatality rate due to the pandemic out of total confirmed cases (the case fatality ratio — CFR) in Israel over a period of two years (March 2020 to March 2022) and relative to other countries. The model we constructed included a variety of explanatory variables, some of them direct, such as GDP per capita, a health security index, geographic location, women in a leadership role, and compulsory military service, while others were indirect, such as quality of the healthcare system and government effort. According to the results, the pandemic can be divided into two periods: March 2020 to August 2020, which we refer to as the adjustment period, during which the CFR was high worldwide; and September 2020 to March 2022, which we refer to as the period of stability, during which the CFR fell to and remained at a level that was specific to each country.

During the adjustment period, the variables that were correlated with a low CFR were compulsory military service, women in leadership, and geographic location. Compulsory military service apparently made available a reserve of a relatively well-trained workforce in response to the medical emergency and perhaps it also contributed to the compliance of the population with the restrictive policies that were adopted. According to the literature, women in senior positions of leadership tend to make decisions involving less public risk than their male peers and indeed the correlation between a woman serving in the highest political office during the 20 years prior to 2020 and the CFR was found to be negative and significant. Essentially, women in leadership is the only variable whose correlation was statistically significant throughout the period of the pandemic, although during the second period its correlation was weaker and its explanatory power declined. Finally, a statistically significant correlation was found between a country's geographic location and the CFR during the first period, apparently due to the closing of borders adopted by many countries. In the countries of Southeast Asia and Oceania, the observed CFR was lower. As in the case of other variables, the connection between geographic location and the CFR became weaker during the period of stability and its explanatory power declined.

During the period of stability, the correlation between the CFR and GDP per capita and that between the CFR and the quality of the healthcare system were negative and statistically significant. This finding implies that after the initial shock at the outset of the pandemic, a country was better able to care for confirmed COVID-19 patients if it had more resources and a high-quality healthcare system (in terms of additional years of life expectancy which are not explained by the prevalence of chronic diseases or resources available to the state prior to the pandemic). The analysis also indicates that the explanatory power of variables with a statistically significant correlation with the CFR during the adjustment period diminished later on and in many cases so did their statistical significance. The share of the explained variance within the total variance of the CFR rose consistently during the entire pandemic: in March 2020, the model explained about 36.5% of the variance in the fatality rate, and this increased to 72.5% in March 2022.

The findings of the study indicate that the performance of the healthcare system in each country during the pandemic was influenced by the economic resources available to it prior to the onset of the pandemic and by the quality of its healthcare system. Therefore, in order to optimally respond to medical and general emergencies, a country should pursue a policy of sustainable growth and invest in its healthcare system and particularly in a skilled workforce.

In Israel, the fatality rate out of total confirmed cases was lower than expected. Since the model takes into account both the number of new tests per 1,000 population and GDP per capita, it is not possible to attribute Israel’s performance to the relatively large number of tests carried out or its economic prosperity prior to the pandemic. The medical workers in Israel who constituted a human shield against the pandemic — which often meant personal risk and sacrifice — are indeed the real heroes of the pandemic and Israel’s success can be attributed primarily to them.

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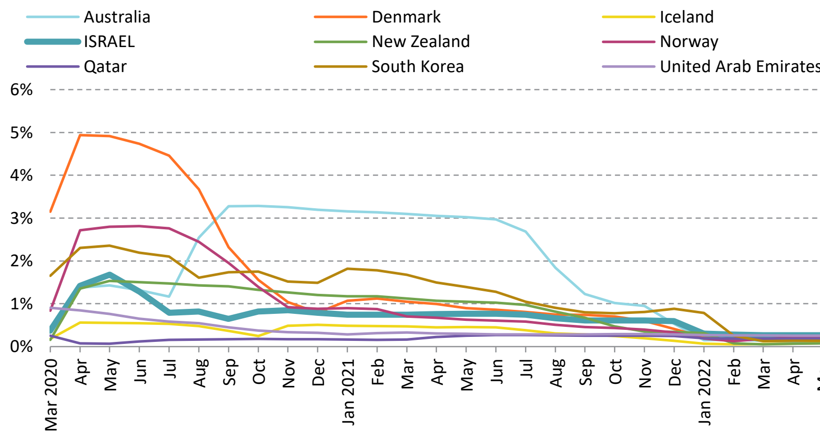
Appendix

Appendix Figure 1. Fatality rate out of total confirmed cases, selected countries



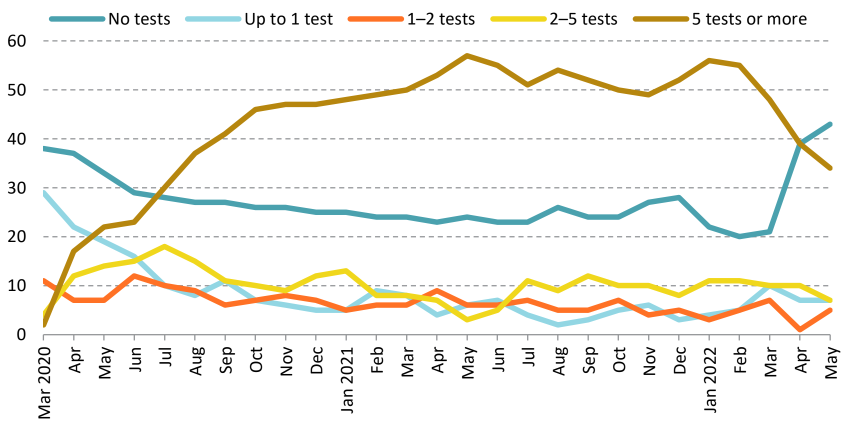
Source: Kyrill Shraberman, Taub Center | Data: Our World in Data, Johns Hopkins University

Testing policy

According to guidelines published by the World Health Organization in the summer of 2020 (WHO, 2020), the definition of testing policy is determined by the number of new weekly tests per 1,000 population. Thus, when the number is lower than 1, the policy is defined as *limited*; when it is in the range of 1 to 2 the policy is defined as *reasonable*; and when it is 2 or more the policy is defined as *adequate*. An examination of the weekly testing figures showed that there is a group of countries in which the number of new weekly tests per 1,000 population exceeded 5 and in many of them it was even higher. In this group of countries, the policy has been defined as *optimal for purposes of this study*. We would emphasize that this category is not that of the WHO and does not appear in their guidelines.

A mapping of all 96 countries and territories in the sample from March 2020 until November 2021 shows that the number of countries with an optimal testing policy was lower than at the beginning of the pandemic and rose gradually during 2020. In January 2021, this group of countries was already the largest and the drop in their number began only in February 2022, the period that corresponds to the end of the Omicron wave. The number of countries that adopted an adequate testing policy remained fairly constant over time and thus also the number of countries that adopted a moderate, limited, or other type of policy. In view of the high cost of testing — the price of a PCR test ranges from $15 to $60 — and as indicated by the data, it can be assumed with a fairly high level of certainty that there is a close relationship between testing policy and GDP per capita. In order to avoid the bias that originates from correlation between these explanatory variables in the final model, we used the calculated error from the regression that explains the number of weekly tests per 1,000 population using GDP per capita.

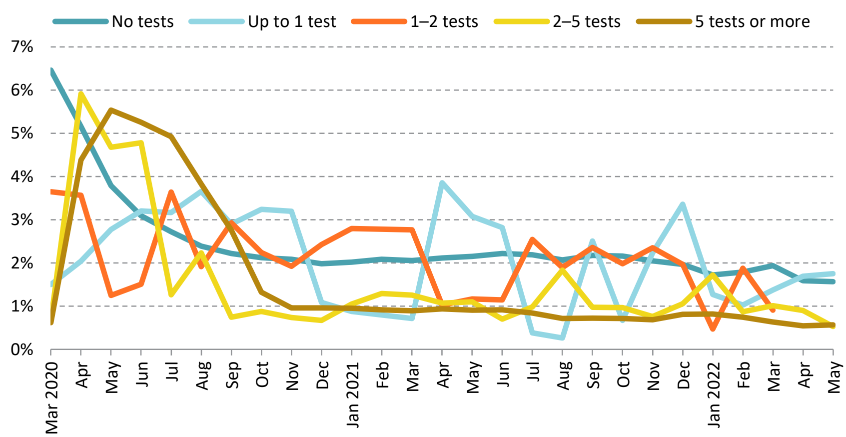
Appendix Figure 2. Number of countries by testing policy, March 2020 to May 2022



Source: Kyrill Shraberman, Taub Center | Data: Our World in Data, Johns Hopkins University

A mapping of CFR by testing policy (Appendix Figure 3) shows a downward trend in the CFR over time, regardless of which policy was adopted. As shown by the results of the model, government effort, i.e., the calculated error from the regression explaining the number of new weekly tests per 1,000 population by means of GDP per capita — indeed reduces CFR, but it is statistically significant primarily in the second period of the pandemic, when the number of countries adopting an optimal policy reached its peak. Furthermore, the coefficient itself was fairly small and therefore significantly reducing the CFR required a very large number of tests. For example, in October 2020 to reduce the CFR by 1% required an average of 33 weekly tests per 1,000 population in the sample countries. Only in seven of the 96 countries was the number of weekly tests greater than that. In other words, there was only a relatively small number of countries who managed to reduce the CFR significantly by increasing their rate of testing. The main factor explaining the reduction in the fatality rate from COVID-19 was not a high rate of testing but rather the fact that patients were diagnosed at an early stage, which made it possible to lower the risk of deterioration in their situation and even their rate of death by providing them with appropriate care.

Appendix Figure 3. Fatality rate out of total confirmed cases, by testing policy, March 2020 to May 2022



Source: Kyrill Shraberman, Taub Center | Data: Our World in Data, Johns Hopkins University

Contribution of the variables to explaining the variance

In order to analyze the explanatory power of the variables in the model over the course of the pandemic, partial determination coefficients were calculated (partial R^2) using the least squares method for an estimation of the model. The main reason that a method based on least squares was chosen, and not a Gini regression, is the difficulty of interpretation of a Gini regression. It should be noted that the findings from the least squares analysis are less complete than a Gini regression, but despite this drawback, they indicate the main trends from the analysis that also are found using the Gini regression.[14]

The amount of resources available to the country (GDP per capita) and the quality of the healthcare system are the most important variables in the model. Appendix Figure 4 shows that during the first stage of the pandemic (May–October 2020), the explanatory power of the GDP per capita was only 0.3% of the variance, but at the beginning of the stability period the increase began, from 14.7% of the variance in November 2020 to a high of 31% by May 2022. A similar upward trend in the explanatory power was observed for the quality of the healthcare system variables: in May 2020, it was 0.2%, in November 2020, it was 4.8%, it rose to a level of 7.1% of the variance in March 2022, and to 8.5% by May 2022.

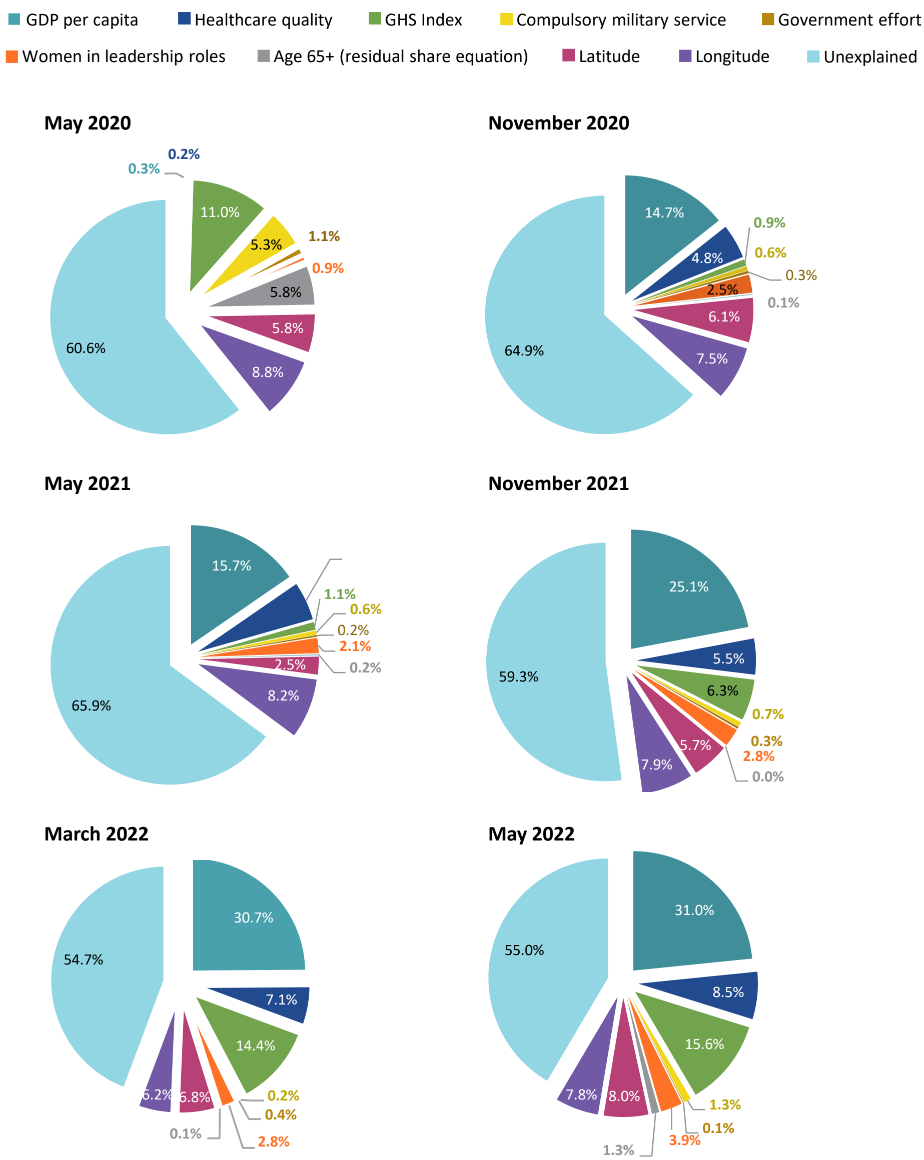
The variable whose explanatory power declined over time was compulsory military service. In May 2020, this variable explained 5.3% of the variance in CFR; by the beginning of the second period, though, the significance of its explanatory power decreased and nearly disappeared (0.6% of the variance in November 2020 and 0.8% in May 2022). This finding supports the conclusion that compulsory military service contributed to bringing down the CFR during the adjustment period, while during the later phase of routine and stability, it had little effect.

An additional variable that contributed to explaining variance is the global health security index (GHSI). In May 2020, the explanatory value of this variable was 11%, while in November 2020, it declined to 0.9%. Towards the end of the analysis period, it again had more of an influence. In November 2021, its explanatory value rose to 6.3% and, by May 2022, it reached levels of 15.6% of the variance.

14 For a more detailed explanation regarding similarities and differences between the two methods, see Yitzhaki and Schechtman, 2013, p. 21.

Variables of longitude and latitude were quite significant in the adjustment period and their values decreased somewhat during the routine period. In May 2020, latitude explained 5.8% of the variance and longitude about 8.8%. In May 2022, their explanatory power was 8% and 7.8%, respectively. A possible explanation for this result can be found in tourism and the timing of country's border closings. Countries whose economies depend heavily on tourism tended to try not to close their borders due to fears of serious harm to their economies. As a result, the spread of the virus was faster and resulted in a heavier impact on their healthcare systems, and, in the end, to a rise in the COVID-related mortality rate. Another possible explanation is that countries in the Far East and Oceania learned the lessons from their previous experience with the SARS pandemic in 2003 coupled with their greater enforcement capabilities.

Figure 3. Breakdown of the variance in the fatality rate according to the explanatory power of the model variables



Source: Kyrill Shraberman, Taub Center | Data: World Bank; Nunn & Puga, 2012; Global Health Security Index, October 2019; Global Burden of Diseases, 2019

Appendix Table 1. Normal distribution test: Life expectancy at birth and the fatality rate out of total confirmed cases

				Joint test	
	No. of observations	Pr (skewness)	Pr (kurtosis)	Adjusted chi^2 (2)	Prob> chi^2
Life expectancy at birth	96	0.0049	0.5098	7.55	0.0229
Incidence of death					
March 2020	84	0	0	53.38	0
April	95	0	0.017	20.32	0
May	95	0	0.1141	16.68	0.0002
June	95	0	0.0123	23.13	0
July	96	0	0.0016	29.31	0
August	96	0	0.0021	27.80	0
September	96	0	0.0013	28.12	0
October	96	0	0.0001	33.45	0
November	96	0	0	38.88	0
December	96	0	0	38.64	0
January 2021	96	0	0	38.78	0
February	96	0	0	42.03	0
March	96	0	0	44.77	0
April	96	0	0	46.92	0
May	96	0	0	47.26	0
June	96	0	0	47.09	0
July	96	0	0	42.68	0
August	96	0	0	40.32	0
September	96	0	0	40.09	0

Source: Kyrill Shraberman, Taub Center | Data: World Bank; Global Burden of Diseases, 2019; Our World in Data, Johns Hopkins University

Appendix Table 2. Healthcare service quality in the 25 highest-ranked countries and the 25 lowest-ranked countries

Top 25 countries		Bottom 25 countries	
Morocco	6.16	Romania	-1.41
Oman	4.53	Guyana	-1.44
Sweden	3.96	Iraq	-1.63
Iran	3.94	Lithuania	-1.71
Bangladesh	3.76	Latvia	-1.82
Belize	3.53	Bulgaria	-1.82
Sri Lanka	3.25	Saudi Arabia	-1.83
Costa Rica	2.99	Mexico	-1.90
India	2.90	Canada	-1.98
Slovenia	2.80	Hungary	-1.99
Japan	2.50	The Bahamas	-2.01
Spain	2.41	Ireland	-2.05
Malaysia	2.33	Bolivia	-2.12
Italy	2.24	Luxembourg	-2.13
United Arab Emirates	2.14	**US**	**-2.23**
Tunisia	2.00	Germany	-2.48
Singapore	1.81	Myanmar	-2.51
Chile	1.76	El Salvador	-2.76
Malta	1.74	Brunei Darussalam	-2.95
Norway	1.68	New Zealand	-2.96
ISRAEL	**1.64**	Sudan	-3.40
Antigua and Barbuda	1.61	Fiji	-3.72
Djibouti	1.56	Russian Federation	-4.44
Peru	1.54	Afghanistan	-5.06
Iceland	1.53	Niger	-6.22

Source: Kyrill Shraberman, Taub Center | Data: World Bank; Global Burden of Diseases, 2019

Appendix Table 3. First stage regressions

Variable	Life expectancy at birth (quality of healthcare system)	Number of new test weekly per 1,000 population (government effort)	Number of hospital beds per 1,000 population	Share of population age 65+
GDP per capita, 2019 ($1,000 PPP)	0.577***	0.577***	0.039***	0.106***
Current health expenditure, as a % of 2019 GDP			0.246**	1.461***
Hospital beds per 1,000 population (calculated error)	0.49**			1.847***
Prevalence of heart and vascular diseases (% in population, adjusted for age distribution)	-1.20***			
Prevalence of respiratory diseases (% in population, adjusted for age distribution)	0.03			
Prevalence of diabetes (% in population, adjusted for age distribution)	0.04			
Prevalence of digestive system diseases (% in population, adjusted for age distribution)	0.20*			
Violence (% in population, adjusted for age distribution)	0.23			
Prevalence of nervous system diseases (% in population, adjusted for age distribution)	0.14			
Prevalence of nutritional disorders (% in population, adjusted for age distribution)	-0.23***			
Prevalence of cancers (% in population, adjusted for age distribution)	3.34***			
Latitude (degrees)	-0.02			
Longitude (degrees)	0.01			
Constant	69.12***	-2.153*	0.229	-1.667*
N	96	97	96	96
R^2	0.8911	0.7022	0.3047	0.7868

Significance levels: *p < 0.10; **p < 0.05; ***p < 0.01.
Source: Kyrill Shraberman, Taub Center | Data: World Bank; Global Burden of Diseases, 2019