Science, Public Health Policy, and the Law

Volume 4:196–207
September, 2023
Clinical and Translational Research

An Institute for Pure and Applied Knowledge (IPAK)

Public Health Policy Initiative (PHPI)

Article

Access to Hydroxychloroquine Is Associated with Reduced COVID-19 Mortality: A Cross-Country Analysis

Hideki Toya[1] and Mark Skidmore[2]

Abstract

Over the last two and a half years the world experienced the severe acute respiratory syndrome coronavirus 2 (COVID-19) pandemic coupled with unprecedented policy responses. In this article we examine the determinants of COVID-19 infections and fatalities in a cross-country analysis. While our primary objective is to evaluate the role of hydroxychloroquine (HCQ), we also control for other factors that determine vulnerability. We find that countries that are more obese, less urban, older, have fewer hospital beds, less sunshine, and greater freedom experienced greater fatalities. Generally, policies such as lockdowns, travel restrictions, or mask requirements are unassociated with fatalities. Polymerase chain reaction (PCR) testing is positively associated with reported infections but is unassociated with fatalities. Controlling for a variety of other determinants of COVID-19 fatalities, we find a robust negative relationship between access to HCQ and fatalities. Estimates indicates that if all countries where HCQ access was restricted had made HCQ available, COVID-19 fatalities would have been reduced by about 520,000.

Keywords
Pandemic, COVID-19, Fatalities, Policies, hydroxychloroquine, HCQ

Dedication
This article is dedicated to my longtime friend, collaborator, and coauthor, Professor Hideki Toya. Professor Toya passed away unexpectedly in 2023. Professor Toya was an insightful and creative researcher. It was a joy to work with him and to count him as a dear friend and colleague.

1 Nagoya City University, Faculty of Economics, Nagoya, Aichi, JP; toya@econ.nagoya-cu.ac.jp; 81-52-872-5737.

2 Michigan State University, Agricultural, Food and Resource Economics, East Lansing, MI, USA; mskidmor@msu.edu; 517-353-9172.

Contents

1 Introduction

As the severe acute respiratory syndrome coronavirus 2 (COVID-19) pandemic emerged in late 2019 and spread across the globe, countries differed greatly in terms of infections and fatalities. This variability offers an opportunity to explore factors associated with lower rates of infections and fatalities. Socioeconomic and political characteristics and pandemic policy responses varied from country to country. Some countries imposed nationwide travel restrictions, mandatory lockdowns, and mask requirements, whereas others did not. Developed countries relied on polymerase chain reaction (PCR) testing to determine infection rates, whereas less-developed countries did not. In some countries hydroxychloroquine (HCQ) is available, which, according to some studies, is effective against COVID-19 if administered early, whereas other countries discouraged its use. Controlling for the underlying socioeconomic, political, and geographic factors, this article examines the degree to which different policies helped to save lives, with a focus on HCQ.

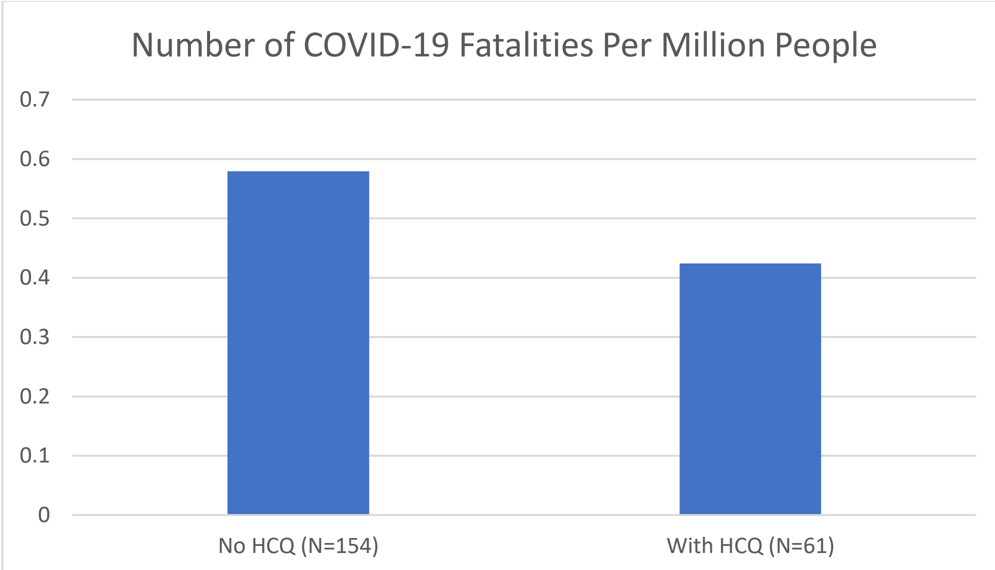
As the pandemic unfolded, we learned that the elderly, obese, and those with underlying health conditions are vulnerable, whereas younger healthy people are more resilient. In the United States (US) the survival rate for those 70 years and older is 94.6%, but is 99.997% for those aged 19 and under [1]. Our evaluation of the determinants of COVID-19 infections and fatalities follows research on disaster vulnerability that has shown that developed countries tend to be safer from disasters because they are able to devote greater resources to safety [2, 3]. This article contributes to this literature by examining the degree to which socioeconomic, political, geographic, and policy-related factors explain variability in infections and fatalities.

While our primary objective is to evaluate the role of HCQ, it is important to control for other factors that determine vulnerability. For example, income [4] is important; those with limited resources may not have access to essential health-care services. Demographic factors are also important. The elderly are more vulnerable to the illness, and urbanicity may play a role in the spread of COVID-19. The overall health of the population is also a factor. Geographic factors such as degree of isolation (island states) may also be important. Finally, government policies implemented in response to the outbreak may be important. Many countries restricted travel and imposed lockdowns in varying degrees, and many countries required masks. In some countries HCQ was accessible, whereas other countries restricted its use.

The simple illustration in Figure 1 (overleaf) shows that COVID fatalities are 38% higher in countries that did not use HCQ. Note that HCQ is accessible in countries where malaria is present. Thus, malaria is potentially a valid instrument for examining and addressing the potential endogeneity of HCQ [5].

There are several studies that examine the underlying determinants of COVID-19 fatalities in a cross-country analysis. This research focused on contact tracing [6], air pollution, obesity, strategies aimed at achieving herd immunity [7], and intergenerational residence patterns [8]. To our knowledge, there are no cross-country studies that have examined the role HCQ has in potentially reducing COVID-19 fatalities. Medical research provides evidence that HCQ is effective in early treatment of COVID-19 [9]. The present study contributes to this research by examining whether access to HCQ helped reduce COVID-19 fatalities in a cross-country context.

Figure 1. COVID-19 Fatalities in Non-HCQ and HCQ Countries



2 Materials and Methods

COVID-19 infection and fatality data come from the World Health Organization (WHO) [10]. We merge these data with socioeconomic, political, geographic, and policy information from several sources as shown in Appendix Table A. The country is the unit of analysis, where we examine COVID-19 infections per 10 million and fatalities per 100,000 for 128 to 137 countries, depending on data availability.

To evaluate the role of HCQ in reducing infections and fatalities, we control for socio-economic, political, and geographic factors (real gross domestic product [GDP] per capita, obesity, urbanization, proportion of population aged 65 and older, number of hospital beds, degree of freedom, amount of sunshine [11], island country, an indicator variable for whether a country belongs to the Organization for Economic Cooperation and Development [OECD], and policies including PCR testing, travel restrictions, lockdowns, and mask wearing). We expect countries with lower income, fewer hospital beds, higher urbanicity and proportions of elderly, more freedom, and less sunshine to have more infections and fatalities. Controlling for other policy measures helps to isolate the role HCQ may have in reducing fatalities. These measures are prominent policies that have been used differentially across countries.

HCQ is used in many African countries for the treatment of malaria, and thus the medication is widely available. In contrast, North American and European countries discouraged HCQ use during the COVID-19 pandemic. Appendix Table B provides summary statistics for all variables, and Appendix Table C provides a list of countries included in the evaluation.

Rising COVID-19 infections and fatalities spur countries to implement policies, thus potentially confounding coefficient estimates generated from standard regression analysis. Valid instruments are needed to evaluate and address potential endogeneity. A valid instrument must be a significant determinant of the policy instrument but be unassociated with COVID-19 fatalities. While we are unable to examine the potential endogeneity of all the policy variables, we are able to examine the potential endogeneity of HCQ using a valid instrument. HCQ is used in many countries to treat malaria. Detailed data on countries where malaria is present is available from the US Center for Disease Control and Prevention (CDC) [12]. In regression estimates that are available upon request, a malaria indicator variable is a positive and statistically significant determinant of HCQ [13] but not a significant predictor of COVID-19 fatalities; malaria is therefore a valid instrument.

We conduct a Hausman specification test to examine the potential endogeneity of HCQ [14]. In the first stage of the Hausman test we estimate a regression where HCQ is the dependent variable that is a function of the malaria indicator and the other control variables. The residual from the HCQ regression is included as a regressor in a COVID-19 fatality regression. If the residual from the HCQ regression is a significant determinant in the fatality regression, then endogeneity is present [15]. In estimates that are available upon request, the residual from HCQ regression is statistically insignificant in the fatality regression. There is no evidence of endogeneity; a two-stage least squares (2SLS) estimation is unnecessary [16]. However, for comparison we report 2SLS regressions using a generalized method of moments estimator.

To reduce concerns about endogeneity of the other policy variables, these variables measure status before April 2020 so that they can be interpreted as predetermined. Travel restrictions may be adopted in places where COVID-19 infections and fatalities are growing. Further, policies adopted later are less likely to have been implemented in time to have had a large effect on COVID-19 infections and fatalities during the period of analysis (December 8, 2019 – May 8, 2021). Several countries began to administer Ivermectin and Remdesivir in late 2020, but approval and subsequent dissemination takes time and thus may not have had large impacts during the period of analysis. Though this approach is imperfect, note that the primary focus is in evaluating the role of HCQ.

Robust multivariate regressions are estimated to determine the relationship between the policy and control variables and COVID-19 infections and fatalities. The regressions are characterized by the equations below, where infections and fatalities are the total number of COVID-19 infections per ten million and deaths per one hundred thousand in country i between December 8, 2019 and May 8, 2021, respectively. Policies_{ki} is vector of k policy variables including PCR testing, travel restrictions (complete and partial), lockdowns (mandatory national, mandatory local, recommended national, recommended local), and mask recommended. Controls_{ji} represents a vector of j control variables that may determine infections and fatalities. Finally, HCQ is an indicator variable that is equal to 1 if HCQ is accessible in a country, and 0 otherwise.

$$\text{Infections}_i = \alpha_1(\text{HCQ}_i) + \alpha_m(\text{Controls}_{ji}) + \alpha_n(\text{Policies}_{ki}) + e_i$$

$$\text{Deaths}_i = \beta_1(\text{HCQ}_i) + \beta_m(\text{Controls}_{ji}) + \beta_n(\text{Policies}_{ki}) + e_i$$

3 Results

Tables 1 and 2 (pages 201 and 202) present five infection and fatality regressions, respectively. The adjusted R2 in Table 1 ranges from 0.582 to 0.630, signifying that the regressions capture a significant proportion of the cross-country variation in infections. The control variables show that countries with greater obesity, older populations, fewer beds, more freedom, and less sunshine had higher rates of infection. Though not shown in the regression, we also find that isolated island countries experienced fewer infections. Countries with recommended local lockdowns also experienced fewer infections, but the other lockdown measures, travel restrictions, and mask wearing were unassociated with infections. PCR testing is a positive determinant of infections, while HCQ was unassociated with infections.

Turning to Table 2, the fatality regressions also capture a significant portion of the cross-country variation in Covid-associated deaths. Countries with greater obesity, fewer beds, more freedom, more elderly, and less sunshine experienced more fatalities. Higher income and more urbanized countries experienced fewer fatalities. Island countries also experienced fewer fatalities. With the exception of HCQ, the policy variables are generally not statistically significant, though recommended local lockdowns were helpful, as shown in column 4. The availability of HCQ consistently reduces fatalities in all regressions. According to the coefficient estimate on HCQ in column 2, if the United States had made HCQ widely available, recorded COVID-19 fatalities during the study period would have been reduced from 515,000 to 420,000 [17]. The 2SLS estimation in columns 3 and 5 also have a statistically significant coefficients on HCQ that are roughly twice as large, but the column 2 or 4 estimations are more appropriate given that we find no evidence of endogeneity. Extending the analysis beyond the United States to all countries where HCQ access was restricted/unavailable, COVID-19 fatalities would have been reduced by about 520,000 if HCQ had been accessible.

In contrast to the significant positive coefficient on PCR testing in the infection regressions, the coefficient on PCR testing was insignificant in the fatality regressions. This seeming inconsistency may be due to the high rate of false positives generated by the PCR test [18]. These estimates are robust to the inclusion of continent indicator variables. While the coefficient estimates on the other policy variables may be biased due to potential endogeneity, it is important to include these factors to isolate the HCQ effect.

4 Discussion

This evaluation offers new evidence regarding the potential role that HCQ has played in the COVID-19 crisis in countries where it was available. However, several caveats are in order. First, the study measures only whether HCQ is available and not whether it was used specifically for COVID-19 in ways the medical literature suggests is most effective. Second, with cross-country analyses it is possible that confounding factors are not fully accounted for. However, the two-stage least squares analysis reduces this concern to some degree. Third, this type of evaluation should only be considered a supplement to clinical research; clinical research is a more direct approach to examining the efficacy of any medical treatment [19]. Nevertheless, the evaluation offers an important broader perspective on this question.

In addition to the primary interest in assessing the role of HCQ, the evaluation also indicates that other factors are important determinants of COVID-19 fatalities. Specifically, the evaluation suggests that societal health as proxied by obesity and sunshine are important factors. Somewhat surprisingly, countries with greater freedom experienced more fatalities. Countries with stronger health care systems, as proxied by hospital beds

Table 1: Determinants of COVID-19 Infections (December 8, 2019 – May 8, 2021)

Dependent variable: Total confirmed cases per 10 million as of May 8, 2021

	OLS 1	OLS 2	GMM 3	OLS 4	GMM 5
Log GDP per capita	0.011	0.009	0.046	-0.036	-0.037
	(0.218)	(0.172)	(1.007)	(-0.580)	(-0.692)
Obesity	0.009***	0.009***	0.009***	0.009***	0.010***
	(4.926)	(4.903)	(4.985)	(4.005)	(5.243)
Aged 65 and above	0.030***	0.030***	0.031***	0.028***	0.024***
	(4.390)	(4.374)	(4.793)	(3.655)	(3.459)
Beds per 1000 people	-0.023**	-0.023**	-0.028***	-0.018	-0.014
	(-2.439)	(-2.360)	(-3.193)	(-1.572)	(-1.230)
Urbanization	0.004	0.004	-0.037	-0.118	-0.142
	(0.028)	(0.026)	(-0.292)	(-0.760)	(-1.037)
Not free	-0.096**	-0.099**	-0.102**	-0.096**	-0.131***
	(-2.669)	(-2.751)	(-2.998)	(-2.591)	(-3.295)
Sunshine high	-0.069	-0.068	-0.131**	-0.118	-0.132**
	(-1.024)	(-1.007)	(-2.208)	(-1.636)	(-2.178)
Sunshine middle-high	-0.138**	-0.138**	-0.147**	-0.143**	-0.121**
	(-2.206)	(-2.196)	(-2.610)	(-2.184)	(-2.218)
Sunshine middle-low	-0.108*	-0.107*	-0.154**	-0.139**	-0.150**
	(-1.730)	(-1.718)	(-2.814)	(-2.045)	(-2.529)
HCQ		0.012	-0.052	0.018	0.021
		(0.348)	(-0.628)	(0.456)	(0.292)
PCR test				0.147*	0.202**
				(1.756)	(2.553)
Mandatory national lockdown				-0.024	0.062
				(-0.469)	(1.094)
Mandatory local lockdown				-0.065	0.000
				(-1.232)	(0.005)
Recommended national lockdown				-0.061	0.037
				(-0.640)	(0.480)
Recommended local lockdown				-0.288***	0.523
				(-3.350)	(0.721)
Travel closed				0.046	0.075
				(0.765)	(1.439)
Travel partial				-0.021	-0.035
				(-0.486)	(-0.947)
Mask				0.067	0.022
				(0.490)	(0.197)
Number of Countries	137	137	136	129	128
Adjusted.R^2	0.630	0.628	0.610	0.638	0.582

Notes: Numbers in parentheses are t-values. Other independent variables not reported here are Constant and Dummy variables for countries that belong to the OECD, Low-income economies, Lower-middle-income economies, Upper-middle-income economies, and Island countries. *Indicates statistically significant at the 10% level. ** Indicates statistically significant at the 5% level. ***Indicates statistically significant at the 1% level.

Table 2: Determinants of COVID-19 Fatalities (December 8, 2019 - May 8, 2021)

Dependent variable: Total confirmed deaths per 100000 as of May 8, 2021

	OLS 1	OLS 2	GMM 3	OLS 4	GMM 5
Log GDP per capita	-0.218**	-0.189*	-0.136	-0.244*	-0.172*
	(-1.986)	(-1.758)	(-1.438)	(-1.977)	(-1.668)
Obesity	0.021***	0.021***	0.020***	0.022***	0.020***
	(6.293)	(6.648)	(7.474)	(5.283)	(5.522)
Aged 65 and above	0.069***	0.070***	0.072***	0.067***	0.060***
	(4.185)	(4.232)	(5.102)	(3.746)	(4.347)
Beds per 1000 people	-0.047**	-0.050**	-0.060***	-0.043*	-0.043**
	(-2.052)	(-2.338)	(-3.535)	(-1.910)	(-2.419)
Urbanization	-0.633*	-0.629*	-0.609**	-0.722*	-0.649*
	(-1.907)	(-1.883)	(-2.001)	(-1.933)	(-1.810)
Not free	-0.391***	-0.359***	-0.325***	-0.306***	-0.290***
	(-5.129)	(-5.183)	(-5.394)	(-3.627)	(-4.130)
Sunshine high	-0.312**	-0.330**	-0.412***	-0.368**	-0.433**
	(-2.277)	(-2.415)	(-3.075)	(-2.287)	(-2.970)
Sunshine middle-high	-0.325**	-0.334**	-0.416***	-0.336**	-0.396**
	(-2.372)	(-2.435)	(-3.214)	(-2.219)	(-2.926)
Sunshine middle-low	-0.248*	-0.268*	-0.386**	-0.305*	-0.406**
	(-1.727)	(-1.865)	(-2.851)	(-1.813)	(-2.745)
HCQ		-0.184**	-0.323**	-0.152*	-0.346**
		(-2.570)	(-2.010)	(-1.891)	(-2.343)
PCR test				0.018	0.017
				(0.179)	(0.179)
Mandatory national lockdown				0.113	0.132
				(1.001)	(1.019)
Mandatory local lockdown				0.040	0.009
				(0.365)	(0.070)
Recommended national lockdown				0.147	0.010
				(0.864)	(0.072)
Recommended local lockdown				-0.470**	-0.285
				(-2.516)	(-0.299)
Travel closed				-0.002	0.023
				(-0.015)	(0.191)
Travel partial				-0.084	0.002
				(-0.754)	(0.020)
Mask				0.302	0.278
				(1.335)	(1.485)
Number of Countries	137	137	136	129	128
Adjusted.R^2	0.630	0.642	0.631	0.625	0.603

Notes: Numbers in parentheses are t-values. Other independent variables not reported here are Constant and Dummy variables for countries that belong to the OECD, Low-income economies, Lower-middle-income economies, Upper-middle-income economies, and Island countries. *Indicates statistically significant at the 10% level. ** Indicates statistically significant at the 5% level. ***Indicates statistically significant at the 1% level.

experienced fewer fatalities. The findings also suggest that while PCR testing was positively associated with infection rates, testing was not associated with fatalities. With the exception of recommended local lockdowns, we find little evidence that the other policy variables such as lockdowns and travel restrictions helped to reduce fatalities. While we suggest caution in assigning causality to these coefficient estimates, it is important to include these factors as control variables in order to assess the role that HCQ has played in potentially helping to save lives. Further, we note that an R^2 of over 0.6 is high for cross-country analyses, indicating that the analyses capture much of the cross-country variation in both infection rates and fatalities.

5 Conclusions

This article offers a cross-country analysis of factors associated with COVID-19 infections and fatalities. Countries with greater obesity, fewer hospital beds, more freedom, more elderly, and less sunshine experienced greater fatalities. PCR testing was positively correlated with recorded infections but was unassociated with fatalities, and recommended local lockdowns reduced infections and fatalities. Other policy factors were unassociated with infections or deaths. Of primary interest in this study, we find that HCQ is negatively associated with fatalities. This evaluation offers a useful contribution to the research evaluating the COVID-19 pandemic policies generally, and specifically provides new evidence that HCQ helped reduce Covid fatalities in countries where it was accessible.

6 References

1. Center for Disease Control and Prevention. https://www.cdc.gov/coronavirus/2019-ncov/hcp/planning-scenarios.html. Accessed 3/31/2021.

2. Kahn M. 2005. The death toll from natural disasters: The role of income, geography, and institutions. *Review of Economics and Statistics* 87: 271-284.

3. Toya H, Skidmore M. 2007. Economic development and the impacts of natural disasters. *Economics Letters* 94: 20-25.

4. Helliwell JF, Huang H, Wang S, Norton M. 2021. Chapter 2, World happiness, trust and deaths under COVID-19 in *World Happiness Report*. https://worldhappiness.report/ed/2021/happiness-trust-and-deaths-under-covid-19/.

5. In regression analysis, it is often assumed that explanatory variables are exogenous in that they cause changes in the variable of interest, in this case COVID-19 fatality. However, sometimes causality can run both ways which leads to endogeneity, which results in biased estimates. A solution is to use an instrumental variable estimation procedure, wherein the ‘instrument’ is a variable that is correlated with the endogenous variable of interest. The procedure here is as follows. In Step 1, the potentially endogenous variable (HCQ) is regressed on the instrument (malaria) and other explanatory variables in a stage-one regression. Step 2: A predicted value for HCQ is generated from the stage-one regression. Step 3: Estimate the second-stage regression where COVID-19 fatalities are regressed on predicted HCQ and the other explanatory variables. If malaria is a valid instrument, this procedure will provide an unbiased estimation. See Kennedy for more detail.

Kennedy P. 2008. *A Guide to Econometrics* (Sixth ed.). Malden: Blackwell. p. 139. ISBN 978-1-4051-8257-7.

6. Abdullah Y, Basbug G, Elgin C, Galvani AP. 2021. Cross-country evidence on the association between contact tracing and COVID-19 case fatality rates. *Scientific Reports*, Article Number 2145. https://www.nature.com/articles/s41598-020-78760-x.

7. Bretschger L, Grieg E, Welfins PJJ, Xiong T. 2020. COVID-19 infections and fatalities developments: Empirical evidence for OECD countries and newly industrialized economies. *International Economics and Economic Policy* 17: 801-847. https://link.springer.com/article/10.1007/s10368-020-00487-x.

8. Fenoll AA, Grossbard S. 2020. Intergenerational residence patterns and Covid-19 fatalities in the EU and the US. *Economics and Human Biology* 39: December, 100934. https://www.sciencedirect.com/science/article/abs/pii/S1570677X20302045.

9. See https://c19hcq.com/ for a real-time database and meta-analysis of 551 HCQ studies. The website indicates that 425 are peer reviewed, and 408 compare treatment and control groups. HCQ is not effective when used very late with high dosages over a long period. Effectiveness improves with earlier usage and improved dosing. Early treatment consistently shows positive effects. Negative evaluations typically ignore treatment time, often focusing on a subset of late-stage studies.

10. See https://covid19.who.int/table

11. We include degree of sunshine as a proxy for vitamin D in the population. Research shows that those with insufficient vitamin D are more susceptible to COVID-19. Skin needs adequate exposure to the sun to produce vitamin D. Otherwise, supplements may be required.

12. See https://www.cdc.gov/malaria/travelers/country_table/a.html

13. The coefficient and t-value on the malaria variable in the first-stage HCQ regression is 0.38 and 2.51, respectively. The full set of estimates are available upon request.

14. A Hausman specification test is used to detect endogenous explanatory variables.

15. See [5] for a description of the Hausman specification test.

16. We examine endogeneity by including several weak instruments in addition to malaria as the strong instrument. These weak instruments include a tropics indicator variable and indicator variables for primary religion (Christian, Muslim, Buddhist, and Hindu).

17. To calculate this reduction, multiply the coefficient in column 2 of Table 1 (-0.184) by 0.515 (COVID-19 deaths per 100,000). According to this calculation, fatalities are reduced by 94,760, dropping from 515,000 to about 420,000.

18. Mandavilli (2021) offers a discussion of PCR test false positives depending on cycle threshold, referring to studies indicating that up to 90% of PCR tests generate false positives where 'infected' individuals are neither sick nor contagious. See also Wernike et al. (2020).

Mandavilli A. 2021. Your coronavirus test is positive. Maybe it shouldn't be. *New York Times*. https://www.nytimes.com/2020/08/29/health/coronavirus-testing.html. Accessed April 8, 2021.

Wernike K, Keller M, Conraths FJ, Mettenleiter TC, Groschup MH, Beer M. 2020.

Pitfalls in SARS-CoV-2 PCR diagnostics. *Transboundary and Emerging Diseases*. doi: 10.1111/tbed.13684. Epub ahead of print. PMID: 32536002; PMCID: PMC7323359.

19. Emerging evidence suggests that Ivermectin and vitamin D are also effective treatments for COVID-19.

    Real-time Database and Meta Analysis of 551 COVID-19 Studies. https://c19early.com/. Accessed on April 6, 2021.

7 Author Statements

Funding and conflict of interest information: This work was supported by Grant-in-Aid for Research in Nagoya City University Grant Number 2113032. The authors have no conflict of interest.

8 Appendix

Data Sources

WHO: World Health Organization https://covid19.who.int/table

WDI: World Bank Indicators https://databank.worldbank.org/reports.aspx?source=world-development-indicators#

OWD: Our World in Data https://ourworldindata.org/grapher/share-of-adults-who-are-overweight

FH: Freedom House https://freedomhouse.org/report/freedom-world

WIKI SD: https://en.wikipedia.org/wiki/List_of_cities_by_sunshine_duration

@CovidAnalysis: https://c19early.org/adoption.html

BBC: https://www.bbc.com/news/world-52103747

WIKI: https://en.wikipedia.org/wiki/COVID-19_pandemic_by_country_and_territory#Timeline_of_first_confirmed_case_by_country

KAYAK: https://www.kayak.com/travel-restrictions

MASKS: https://masks4all.co/what-countries-require-masks-in-public/

Appendix Table A: Definitions and Sources of Variables

Variables	Definition	Source
Deaths	Total confirmed deaths per 100,000 as of April 1, 2021	WHO
Cases	Total confirmed cases per 10 million as of April 1, 2021	WHO
Log GDP per capita	Logarithm of real GDP per capita in 2010	WDI
Obesity	Share of adults that are overweight or obese in 2015	OWD
Aged 65 and above	Population aged 65 and above of 2010 (% of total population)	WDI
Beds per 1000 people	Hospital beds per 1,000 people in 2015	WDI
Urbanization	Population in the largest city (% of total population) in 2015	WDI
Not free	Dummy for not free country	FH
OECD	Dummy for OECD country	
Island	Dummy for island country/area/territory	
Sunshine high	Dummy for high sunshine duration	WIKI SD
Sunshine middle-high	Dummy for middle-high sunshine duration	WIKI SD
Sunshine middle-low	Dummy for middle-low sunshine duration	WIKI SD
HCQ	Dummy for HCQ used widely	@CovidAnalysis
PCR test	The number of tests performed for the country/area/territory per 1 trillion people	WHO
Mandatory national lockdown	Dummy for nationwide mandatory lockdown on April 1, 2020	BBC, WIKI
Mandatory local lockdown	Dummy for mandatory local lockdown on April 1, 2020	BBC, WIKI
Recommended national lockdown	Dummy for recommended national lockdown on April 1, 2020	BBC, WIKI
Recommended local lockdown	Dummy for recommended local lockdown on April 1, 2020	BBC, WIKI
Travel closed	Dummy for travel only for citizens, residents returning home, or people in other special circumstances may enter the country.	KAYAK
Travel partial	Dummy for entrance into a country may depend on the traveler's citizenship, point of origin, or other specific regulations.	KAYAK
Mask	Dummy for mask recommended	MASKS

Appendix Table B: Summary of Statistics Variables

	Mean	Standard Deviation	Number of Observations
Deaths	0.315	0.335	137
Cases	0.609	0.733	137
Log GDP per capita	8.467	1.510	137
Obesity	46.90	17.56	137
Aged 65 and above	8.581	6.239	137
Beds per 1000 people	2.839	2.487	137
Urbanization	0.191	0.133	137
Not free	0.314	0.466	137
OECD	0.146	0.354	137
Island	0.109	0.313	137
Sunshine high	0.161	0.368	137
Sunshine middle-high	0.350	0.479	137
Sunshine middle-low	0.292	0.456	137
HCQ	0.409	0.493	137
PCR test	0.347	0.515	129
Mandatory national lockdown	0.473	0.501	129
Mandatory local lockdown	0.287	0.454	129
Recommended national lockdown	0.109	0.312	129
Recommended local lockdown	0.008	0.088	129
Travel closed	0.178	0.384	129
Travel partial	0.581	0.495	129
Mask	0.961	0.194	129

Appendix Table C: List of Countries Included in the Study

Afghanistan	Dominican Republic	Kuwait	Qatar
Albania	Ecuador	Kyrgyz Republic	Romania
Algeria*	Egypt, Arab Rep.	Lao PDR	Russian Federation
Argentina	El Salvador	Latvia	Saudi Arabia
Armenia	Equatorial Guinea	Lebanon	Senegal
Australia	Estonia	Liberia	Serbia
Austria	Ethiopia	Libya	Sierra Leone
Azerbaijan	Finland	Lithuania	Singapore
Bahrain	France	Madagascar	Slovak Republic
Bangladesh	Gabon	Malawi	South Africa
Belarus	Gambia, The	Malaysia	Spain
Belgium	Georgia	Mali	Sri Lanka
Benin	Germany	Mauritania	Sudan*
Bolivia	Ghana	Mexico	Sweden
Bosnia and Herzegovina	Greece	Moldova	Switzerland
Brazil	Guatemala	Mongolia	Tajikistan*
Bulgaria	Guinea	Morocco	Tanzania*
Burkina Faso*	Guinea-Bissau	Mozambique	Thailand
Burundi	Haiti	Myanmar	Togo
Cambodia	Honduras	Namibia	Trinidad and Tobago
Cameroon	Hungary	Nepal	Tunisia
Canada	India	New Zealand	Turkey
Central African Republic	Indonesia	Nicaragua*	Turkmenistan*
Chile	Iran, Islamic Rep.	Niger	Uganda
China	Iraq	North Macedonia	Ukraine
Colombia	Ireland	Norway	United Arab Emirates
Congo, Dem. Rep. *	Israel	Oman	United Kingdom
Costa Rica	Italy	Pakistan	United States
Cote d'Ivoire	Jamaica	Panama	Uruguay
Croatia	Japan	Paraguay	Uzbekistan
Cuba	Jordan	Peru	Venezuela, RB
Czech Republic	Kazakhstan	Philippines	Vietnam
Denmark	Kenya	Poland	Yemen, Rep.
Djibouti	Korea, Rep.	Portugal	Zambia
			Zimbabwe

Notes: *Indicates not included in the 137 sample.