Short Communication

Predictors of COVID-19 testing rates: A cross-country comparison

Megan E. Marziali[a,b], Robert S. Hogg[a,c], Oluwamayowa A. Oduwole[c], Kiffer G. Card[c,d,*]

[a] Epidemiology and Population Health Program, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada
[b] Mailman School of Public Health, Columbia University, New York City, NY, USA
[c] Faculty of Health Sciences, Simon Fraser University, Burnaby, Canada
[d] School of Public Health and Social Policy, Faculty of Human and Social Development, University of Victoria, Victoria, Canada

A B S T R A C T

Objectives: Cross-country comparisons of coronavirus disease (COVID-19) have largely been applied to mortality analyses. The goal of this analysis is to explore predictors of COVID-19 testing through cross-country comparisons, to better inform international health policies.
Methods: Testing and case-based data were amassed from Our World in Data, and information regarding predictors was gathered from the World Bank. We investigate Human Development Index (HDI), health expenditure, universal health coverage (UHC), urban population, service industry workers (%), and air pollution as predictors. We explored testing data through July 31, 2020, or most recently available, using case-indexing methods, which involve synchronizing countries by date of first reported COVID-19 case as an index date and normalizing to the cumulative tests 25 days post-index date. Three multivariable linear regression models were built in a stepwise fashion to explore the association between the indexed number of COVID-19 tests and HDI scores.
Results: A total of 86 countries were included in the final analytical sample, excluding countries with missing data. HDI and urban population were found to be significantly associated with testing levels.
Conclusions: Results suggest that social conditions and government capacity remain consistently salient in the consideration of testing rates. International efforts to assist low-HDI countries are needed to support the global COVID-19 response.

Introduction

Infection and mortality rates due to COVID-19 continue to surge; nearly one million (990,586) lives have been lost due to COVID-19 and 32, 662, 857 cases have been documented (Dong et al., 2020). Robust testing systems are necessary to prevent localized outbreaks and forward transmission. Cross-country comparisons have been carried out largely to investigate COVID-19 mortality. Previous research has identified healthcare spending to be associated with higher mortality (Squalli, 2020), likely resulting in enhanced documentation of COVID-19 deaths. A negative association between mortality and testing exists as a function of government effectiveness (Liang et al., 2020), which suggests that the national policy plays a large role. Previous research has demonstrated that health expenditure and Human Development Index (HDI) scores have been associated with

enhanced disease control (Tsai and Tipayamongkholgul, 2020), factors that may be associated with COVID-19 testing. Additionally, countries may perceive their population to be at a higher risk of respiratory diseases, which results from factors such as the proportion of the workforce classified as essential workers (The Lancet, 2020), which may influence the establishment of testing programs. There remains a gap in research regarding factors associated with testing to better understand national testing rates. The goal of this analysis is to explore predictors of COVID-19 testing, to better inform international health and development policies.

Methods

Data sources

Testing and case-based data were amassed from Our World in Data, an online repository of testing indicators per country (Our World in Data, 2020). Information with regard to predictors was gathered from The World Bank (2020). Data from the most recent year available were collected (2017–2019). HDI scores (2018) were

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retrieved from the United Nations Development Programme (UNDP) (2019). All data were publicly available.

Explanatory measures

HDI was assessed as a predictor due to the hypothesized relationship between governmental policy in relation to health and COVID-19 testing. HDI includes multiple dimensions, compiled of sociodemographic measures such as life expectancy, education, and income, and is often employed to compare development, which results from national policies (United Nations Development Programme, 2019). We hypothesized health expenditure per capita (USD), universal health coverage (UHC), urban population (% of total population), people employed in the service industry (% of total labor force), and air pollution (mean annual exposure) would impact testing capacity, and thus were included as predictors. Health expenditure and UHC were included due to a hypothesized relationship between these factors and availability and accessibility of testing programs. Countries that allocate a greater number of resources to population health may have a greater capacity to handle pandemic conditions and the implementation of testing programs through response readiness and existing health systems. With regard to UHC, existing or perceived cost of testing may create a barrier for access. Additionally, the proportion of the population residing in urban areas was investigated as the virus is transmitted with close proximity (The Lancet Respiratory Medicine, 2020); we did not investigate overall population size, because of potential collinearity with the proportion of urban population. We investigated the proportion of the population in the service industry to assess a measure of the number of essential workers, who are at a higher risk of getting infected with COVID-19 (The Lancet, 2020). Additionally, air pollution has been found to increase COVID-19 mortality (Wu et al., 2020). We hypothesized that the latter three predictors, which may indicate a population at greater risk for infection, would result in higher testing rates if governing bodies recognized greater risk among the population. All variables were operationalized as continuous measures.

Statistical analysis

This analysis explored testing data most recently available until July 31, 2020. To facilitate country comparisons, we employed case-indexing methods as measuring absolute numbers can lead to bias due to varying population sizes (Middelburg and Rosendaal, 2020). This method involves synchronizing the epidemic across countries by using the date of the first reported COVID-19 case(s) as an index date and subsequently normalizing to cumulative cases 25 days

postindex date (Middelburg and Rosendaal, 2020). As adapted here, we normalized to cumulative tests 25 days postindex date. This resulted in an indexed number of tests that allowed for comparisons independent of temporal variation (Middelburg and Rosendaal, 2020). Analyses were restricted to countries which had: available testing data, information regarding first reported COVID-19 case, and the number of cases in the country exactly 25 days following its first case. Countries with missing data for predictors were excluded.

Three multivariable linear regression models were built in a stepwise fashion to explore the association between the indexed number of COVID-19 tests and the HDI scores of each country. All three models included urban population, percentage of labor force in the service industry, and mean air pollution exposure. Confounders were minimized because of high correlation between national predictors. The model fit was assessed by using Q-Q plots to test normality, variable inflation factors to detect multi-collinearity, and residual plots to test for heteroscedasticity.

Results

A total of 87 countries were considered for inclusion; the final analytical sample included 86 countries. As shown in Table 1, we found that HDI and urban population were significantly associated (p < 0.05) with testing. The effect of HDI was not excluded because of either UHC or health expenditure.

Discussion

This analysis explored the potential predictors of COVID-19 testing; HDI and urban population were the only significant predictors of COVID-19 testing. The association between HDI and testing suggests that countries with a lower HDI may experience a disproportionate burden conducting high volume testing, and that inequities in testing exist on a global scale. These results may suggest that low HDI countries may be facing barriers to control the epidemic, imposing serious limitations on the global COVID-19 response. Taken a step further, these results speak of the importance of government capacity for the creation of testing interventions. In countries that are not able to establish robust testing programs, foreign assistance may be warranted, at the discretion of local governance.

Our results have implications for the course of the pandemic and strategies for worldwide eradication or management. The possibility of eradication of COVID-19 bears similarities to smallpox in that worldwide cooperation and efforts will be required (Heymann and Wilder-Smith, 2020). Countries that have

Table 1
Bivariable and multivariable linear regression models exploring predictors of COVID-19 testing at the country-level (N = 86).

Variable	Bivariable models			Multivariable models								
				Model 1 (Health expenditure only)			Model 2 (UHC only)			Model 3 (Health expenditure and UHC)		
	$\hat{\beta}$	SE	Z-value	$\hat{\beta}$	SE	Z-value	$\hat{\beta}$	SE	Z-value	$\hat{\beta}$	SE	Z-value
HDI	8.05***	1.95	4.13	7.62*	3.73	2.04	9.07*	3.60	2.52	10.22*	4.06	2.52
UHC	0.06***	0.02	3.40	–	–	–	−0.06	0.04	−1.58	−0.06	0.04	−1.53
Health expenditure (USD)	0.00016***	0.00	3.33	−0.00007	0.00	−0.74	–	–	–	−0.00006	0.00	−0.63
Urban population (% of total population)	0.05***	0.01	4.38	0.04*	0.02	2.21	0.05**	0.02	2.64	0.04*	0.02	2.55
Service industry (% total employment)	0.05***	0.01	3.88	−0.02	0.03	−0.68	−0.02	0.03	−0.55	−0.01	0.03	−0.42
Air pollution (ug/m³)	−0.02	0.01	−1.87	−0.01	0.01	−0.796	−0.01	0.01	−1.13	−0.01	0.01	−1.15

UHC: Universal Health Coverage; HDI: Human Development Index; and SE: Standard Error.
* p-value < 0.05.
** p-value < 0.01.
*** p-value < 0.0001.

successfully managed COVID-19 in conjunction with high testing coverage should consider, within their capacities, lending aid to countries experiencing high testing burdens with the discretion of local governance. This is particularly relevant to consider as we look forward to vaccine distribution, as countries with either lower testing rates or that have struggled with testing implementation as a function of limited resources should prepare for challenges with vaccine distribution. While testing should remain the focus of preventative efforts to detect and trace COVID-19 cases, it is crucial to simultaneously look ahead and effectively plan for equitable vaccine distribution among countries with lower HDI scores and in resource-limited settings. Governing officials should consider experiences from their unique communities with regard to testing, to tailor vaccination strategies.

Limitations of this analysis include the relatively few predictors included due to challenges with complete data. Countries with lower testing capabilities did not meet inclusion criteria, creating bias toward countries with more robust systems. Results should be interpreted with caution.

Conclusions

Significant predictors of COVID-19 testing include HDI and percentage of urban population. While results demonstrate the heterogeneity of national data, they also suggest that social conditions and government capacity remain consistently salient in the consideration of testing rates. International cooperation is needed to support low-HDI countries in order to assist in the global COVID-19 response.

Conflict of interest

None of the authors list potential conflicts of interest.

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Ethical approval

No ethics approval was required as the data were publicly available.

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