**Evaluating the effectiveness of Global Health Security Index in predicting countries' COVID-19 mortality outcomes in Pan American Health Organization region**

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Background:

The Global Health Security Index (GHSI) is a comprehensive assessment and benchmarking of health security and related capabilities of 195 countries that make up the States Parties to the International Health Regulations. The GHSI is a project of the Nuclear Threat Initiative and the Johns Hopkins Center for Health Security, and was developed jointly with The Economist Intelligence Unit [9] . The GHSI provides an index of preparedness based on the capacity gaps of countries in their potential response to a pandemic, such as COVID-19, which most countries are ill-positioned to combat [9,10]. The GHSI comprises six categories, 34 indicators and 85 sub-indicators based on 140 questions. We compared overall GHSI, to COVID-19 mortality rate in the country (death per million) or mortality outcome. The mean overall GHSI score is 40.2 out of 100. The high-income countries have an average score of 51.9 [9].

The Joint External Evaluation (JEE) are voluntary, externally validated, collaborative assessment of 19 technical areas required to validate country capacities to prevent, detect and rapidly respond to public health risks[11]. Unlike the GHSI which is an academic tool developed to allow inter-country comparisons on pandemic preparedness, the JEE is a formal component of the WHO IHR Monitoring and Evaluation Framework which all UN member states are committed to implementing. The JEE is not designed for making inter-country comparisons but instead is a tool created to support WHO member countries in establishing a quantitative baseline assessment of IHR core capacities from which they can then measure their own progress over time. While the intention of JEE scoring has never been to draw inter-country comparisons these have nonetheless occurred as politicians and national governments seek to assess their preparedness capacities against those of their neighbours or regional rivals. Ninety-six countries participated in the JEE scoring exercise and a ReadyScore, which is the average of 19 technical areas included in JEE presented by Shahpar et al [12] is used to represent JEE to get comparable score of . This ReadyScore is calculated using either JEE 1.0 or JEE 2.0, depending on which assessment the country completed. Unfortunately, only two countries from PAHO region (the USA and Canada) reported JEE score and thus could not compare JEE for country’s response to COVID-19 pandemic.

Objectives:

1. To evaluate the effectiveness of Global Health Security Index in predicting countries' COVID-19 mortality outcomes (deaths/million) in different phases of pandemic including a) December 31, 2020, b) June 30, 2021, c) December 31, 2021, d) July 15, 2022

**Data collection and statistical analysis:**

We collected data COVID-19 case, deaths, tests from Our World in Data. We collected further data mostly from United Nation’s sources including population density[17], population ages 65 and above of the national population (in percentage)[18], Human Development Index (HDI) [19], Gross Domestic Product (GDP) [20] and worldwide governance indicators (WGI) [21].

We performed negative binomial regression analysis to predict the impact of GHSI ~~[and JEE]~~ and other variables on countries’ mortality outcome on different phases of pandemic including December 31 2020, June 30, 2021, December 31, 2021 and July 15, 2022.

**Results:**

At the end of the first year of Pandemic, before commencement of COVID-19 vaccination, countries with higher GHSI scores including the USA, Mexico, Brazil and Argentina had higher mortality rate **(Fig 1)**. Some counties with GHSI scores less than 50 also had a higher mortality rate including Peru, Colombia and Ecuador. Vaccination of COVID-19 started in January/2021, however at a very slow rate initially in most of the countries. The patterns remain similar for most of the counties in the next 6 months (June 30, 2021). However, as the vaccine rollout improves counties with higher GHSI scores experiences lower mortality rate. By July 15, 2022, countries with higher mortality rate includes Argentina, Colombia, Mexico and Ecuador.

**Vaccination:**

Please fill up the vaccine and rCFR information in Table 1. I will fill write the results here.

**The correlation coefficient between vaccination rates and GHSI on 15 July 2021 was**

**Negative binomial model:**

In the negative binomial regression model, the GHSI remain a significant predictor of countries mortality rate on 31 December 2020, however, not the association was not opposite which was expected, ie.e the countries with higher GHSI score had higher mortality rate.

In the Negative binomial regression model, the GHSI remain significant predictor of countries mortality rate at the beginning of the pandemic [on 31 December 2020], but in an opposite direction than expected, i.e. countries with higher GHSI also had higher and positive predictive value for mortality rate. The GHSI lost it’s significant for predicting CVID-19 related mortality rate by the end of 2021 when vaccine rollout in high income countries (the USA, Canada etc) reached a very high level. On the other hand, “the percentage of the population aged 65 and above” was not an important predictor value during the first year of the pandemic in PAHO region. However, it become significant at the late pandemic [July 15, 2022] which indicate that, when most of the countries reached a high vaccination rate, the age structure become important. That is the high mortality is now seen in countries with higher percentage of older populations irrespective of their vaccination rate.

Fig. 1. The Global Health Security Index (GHSI) overall score vs. the countries’ mortality outcome due to COVID-19 (deaths/million). The countries with highest score in GHSI also had higher mortality rate due to COVID-19 (Argentina, Brazil, Canada, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Mexico, Peru, United States).

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\*a = December 31, 2020, b = June 30, 2021, c = December 31, 2021, d = July 15, 2022

**Table 2: The doses of COVID-19 vaccines and reported case-fatality rate (rCFR) of COVID-19 in the PAHO region during 5 Jan 2021 [Before vaccination started] and 8th May 2022 [ One and half year after vaccination).**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Overall PAHO region  Mean (IQRs) | Countries with overall GHSI <50 | Countries with overall GHSI >50 |
| Vaccination  doses/100 People  (31 July 2022) | **207.08 (139.54 – 274.63)** | **207.08 (139.54 – 274.63)** | **184.79 (51.06 – 318.52)** |
| Reported CFR by December 31, 2020 | **2.87 (2.13 – 3.62)** | **2.55 (1.82 – 3.29)** | **3.96 (1.50 – 6.43)** |
| Reported CFR by June 30, 2021 | **2.54 (1.86 – 3.23)** | **2.29 (1.63 – 2.96)** | **3.51 (0.99 – 6.03)** |
| Reported CFR by December 31, 2021 | **2.56 (1.96 – 3.17)** | **2.36 (1.76 – 2.96)** | **3.36 (1.10 – 5.62)** |
| Reported CFR by July 31, 2022 | **1.78 (1.40 – 2.17)** | **1.67 (1.28 – 2.07)** | **2.22 (0.84 – 3.6)** |
| Reported CFR dropped by (%) | 37.98% | 34.51% | 43.94% |
| p-value (for the differences of rCFR between 31 Dec 2020 and 31 July 2022) | <0.001 | 0.037 | 0.003 |
| Excess mortality (deaths/100,000) by December 28, 2020 | 0.31 (0.18 – 0.44) | 0.22 (0.13 – 0.31) | 0.64 (0.05 – 1.23) |
| Excess mortality (deaths/100,000) by June 28, 2021 | 0.49 (0.30 – 0.68) | 0.48 (0.26 – 0.70) | 0.53 (0.08 – 0.99) |
| Excess mortality (deaths/100,000) by December 27, 2021 | 0.25 (0.15 – 0.35) | 0.24 (0.12 – 0.37) | 0.28 (0.09 – 0.46) |
| Excess mortality (deaths/100,000) by July 26, 2022 | 0.26 (0.20 – 0.34) | 0.25 (0.18 – 0.33) | 0.32 (0.11 – 0.53) |
| Excess mortality dropped by (%) | 16.13% | 13.64% (rise) | 50.00% |
| p-value (for the differences of excess mortality between 31 Dec 2020 and 31 July 2022) | 0.537 | 0.548 | 0.180 |

Table 2. The linear regression and negative binomial regression models for COVID-19-related outcome and other explanatory variables including the GHSI

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Dates, until | December 31, 2020 | | June 30, 2021 | | December 31, 2021 | | July 31, 2022 | |
|  | IRR (95% CI) | P value | IRR (95% CI) | P value | IRR (95% CI) | P value | IRR (95% CI) | P value |
| GHSI | 1.04 (1.01 – 1.08) | 0.031 \* | 1.03 (1.01 – 1.06) | 0.043 \* | 1.01 (0.99 – 1.04) | 0.251 | 1.01 (0.99 – 1.04) | 0.249 |
| Total cases/million | 1.01 (1.01 – 1.02) | 0.005 \*\* | 1.01 (1.01 – 1.02) | 0.009 \*\* | 1.01 (1.01 – 1.02) | 0.034 \* | 1.01 (1.01 – 1.02) | 0.036 \* |
| The percentage of the population  aged 65 and above | 0.91 (0.72 – 1.15) | 0.351 | 0.90 (0.75 – 1.08) | 0.192 | 0.85 (0.74 – 0.99) | 0.024 \* | 0.85 (0.73 – 1.01) | 0.027 \* |
| WGIs | 1.32 (0.45 – 3.25) | 0.434 | 1.72 (0.78 – 3.46) | 0.067 | 2.45 (1.25 – 4.48) | 0.001 \*\* | 2.57 (1.31 – 4.72) | 0.001 \*\*\* |
| GDP | 0.99 (0.99 – 1.00) | 0.198 | 0.99 (0.99 – 1.00) | 0.356 | 0.99 (0.99 – 1.00) | 0.675 | 0.99 (0.99 – 1.00) | 0.907 |
| Population density | 0.99 (0.98 – 0.99) | 0.026 \* | 0.99 (0.99 – 1.00) | 0.127 | 0.99 (0.99 – 1.00) | 0.262 | 0.99 (0.99 – 1.00) | 0.175 |
| AIC | 435.57 | | 496.11 | | 529.35 | | 540.67 | |