

Understanding SARS-CoV-2 Mortality: Impact of Population and Mobility Metrics

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Highlights:

- Several epidemiological metrics are evaluated to investigate the association of population density, family size, mobility metrics, and government actions with mortality due to COVID-19 infections.
- We observed higher population metrics like lower population density and government actions like public transport closure and public event cancellations is correlated to low-mortality associated with lowering daily COVID-19 mortalities.
- Mobility restrictions (working, moving, meeting) data follow a specific sequence followed by COVID-19 fluctuations.

Background:

The World Health Organization declared COVID-19 as a pandemic on March 11, 2020. The disease has affected 200+ countries and more than 42.5 million infections and 1.2 million mortalities. Governments worldwide have implemented various control measures to reduce and contain the disease to its peak. One of the different government interventions, countries worldwide have varying and unique measures such as public health measures, varying significantly due to differences in testing and disease tracking rates.

Objectives:

To evaluate the impact of population density, family size, mobility metrics and government actions on mortality due to SARS-CoV-2 infection.

Methods:

- **Study Design:** This was an retrospective data analysis from February 1 to June 30, 2020.
- **Study Population:** Representative (from below discussed) were used to examine the association between the variables which had varying rates of more than 100 per million people (Australia, Belgium, Chile, Italy, Iran, Israel, Austria, Spain, UK, USA). The criteria for selecting countries was one-official to reduce any bias introduced due to the associated infection rates was increasing over time. Higher would be the number of infections and mortality associated with the virus.
- **Data sources:** Government statistics of population and mobility metrics on mortality information of information were used.
- **Mortality:** World Health Organization daily infection reports for day one source of mortality.
- **Mortality rate:** per population density, urban population, and family size were taken.
- **Applied mobility reports:** Working, moving and meeting data.
- **Government response:** Working/ School/ COVID-19 Government Response Tracker (GRT) [22] via the 7 Government Response Index (GRI) [23] via the 7 indicators of Index of Ease and Frequency Index [24] of the 7 policy score awarded from 0 (little index) to 4 (complete government action).

Statistical Analysis:

- **Post-hoc analysis:** multiple new descriptive evaluate association between daily mortality counts and the explanatory variables.
- The quantitative were calculated population density, family size, mean driving, mean travel, mean walking, stringency index and government response index.
- All trends lag were incorporated in modeling and government response metrics to evaluate the impact of action taken 42-day prior source rates of infection. The identification of the lag-mortality account to measure the effectiveness of the government policy on the number of new infections after following day and more effective for measure taken.

Results:

- The Pearson regression model had the R^2 statistic equal to 0.877, indicating excellent discrimination.
- The lower and higher quantify a population density (PR: 0.00, P<0.002) and 0.04-0.06, and 0.01 P<0.002, respectively) had the highest quantitative effect on lowering daily mortality.
- The higher negative quantity of the government response index (GRI: 0.00, P<0.002, 0.01-0.02) and 0.01 P<0.002, 0.00-0.02, respectively) indicating strong government response were highly associated with lowering daily mortality.
- Amongst all government measures, higher positive association was observed for Public Transport Closure (PR: 0.00, P<0.002, 0.01-0.02).
- All other government actions have not shown any statistically significant association with mortality.
- No consistent association was observed for the mobility metrics.

Table 1 describe the associations between different variables and the new deaths in the countries.

Country	Population Density	Family Size	Mean Driving	Mean Travel	Mean Walking	Stringency Index	GRI
Australia	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Belgium	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Chile	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Italy	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Iran	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Israel	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Austria	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Spain	1.0	1.0	1.0	1.0	1.0	1.0	1.0
UK	1.0	1.0	1.0	1.0	1.0	1.0	1.0
USA	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Figure 1

Limitations:

- Evaluation of implementation of government action reduced by the decision to identify and the validity of the results at the macroscopic is function on the transparency and accuracy of the published data.
- Governmental actions implemented through interventions will cause time and effort in hard to evaluate the individual strategies.
- The any systematic error occurred in technological and data collection resulted in underestimating cases.

Conclusions:

- Our study identified population metrics like population density and government action like public transport closure and public event cancellations strongly associated with mortality across multiple populations.
- Reasons are highlighted that might have prevented action in containing the COVID-19 epidemics and mortality.
- Further research on key variables such as mask wearing, social distancing is imperative to evaluate better action to contain COVID-19 fluctuations.

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Highlights:

- Across 9 different countries, we evaluated the associations of population density, family size, mobility metrics and government actions with mortalities due to SARS-CoV-2 infections
- We observed that population metrics like lower population density and government actions like public transport closure and public event cancellation seemed to have strong associations with lowering daily COVID-19 mortalities
- Mobility restrictions (driving, walking, transit) didn't show a significant protective effect on COVID-19 mortalities

Background:

The World Health Organization declared COVID-19 as a pandemic on March 11, 2020. The disease has affected 200+ countries and has resulted in 45 Mn+ infections and 1.2 Mn+ mortalities. Governments worldwide have implemented unprecedented number of policies and restrictive measures in response to the pandemic. Due to difference in implementation of measures, countries worldwide have varying results post restrictions with published mortality rates varying significantly due to differences in testing and disease tracking rates

Objectives:

To evaluate the impact of population density, family size, mobility metrics and government actions on mortalities due to SARS-CoV-2 infections

Government Actions (7 policies)	Mobility Restrictions
1. School closure (SC)	1. Transit
2. Workplace closure (WC)	2. Walking
3. Public event cancellation (PEC)	3. Driving
4. Restriction on gatherings (RG)	
5. Public transport closure (PTC)	
6. Stay at home (SAH)	
7. Internal movement restrictions (IMR)	

Methods:

- **Study Design:** This was a retrospective data analysis from February 1 to June 30, 2020
- **Study Population:** All information (from below data sources) was used to measure the associations in the 9 countries which had a testing rate of more than 50K per million people (Australia, Belgium, Chile, Italy, Peru, Saudi Arabia, Spain, UK, USA). The criteria for minimum testing rate was applied to reduce any bias introduced due to the amount of testing done as more the testing rate, higher would be the number of infections and mortalities identified and vice versa.
- **Data sources:** For assessment of impact of population and mobility metrics on mortality following sources of information were used:
 - Worldwide World Health Organization daily situation reports for Daily new cases of mortality
 - Worldometer.com for Population density, urban population% and family size information
 - Apple mobility reports for Transit, Walking and Driving mobility data
 - Government response data from Oxford COVID-19 Government Response Tracker (OxCGRT) for the 7 Government Policies/Actions and Stringency Index (addition of the 7 policy scores rescaled from 0-100 to make it comparable across countries).

Statistical Analysis:

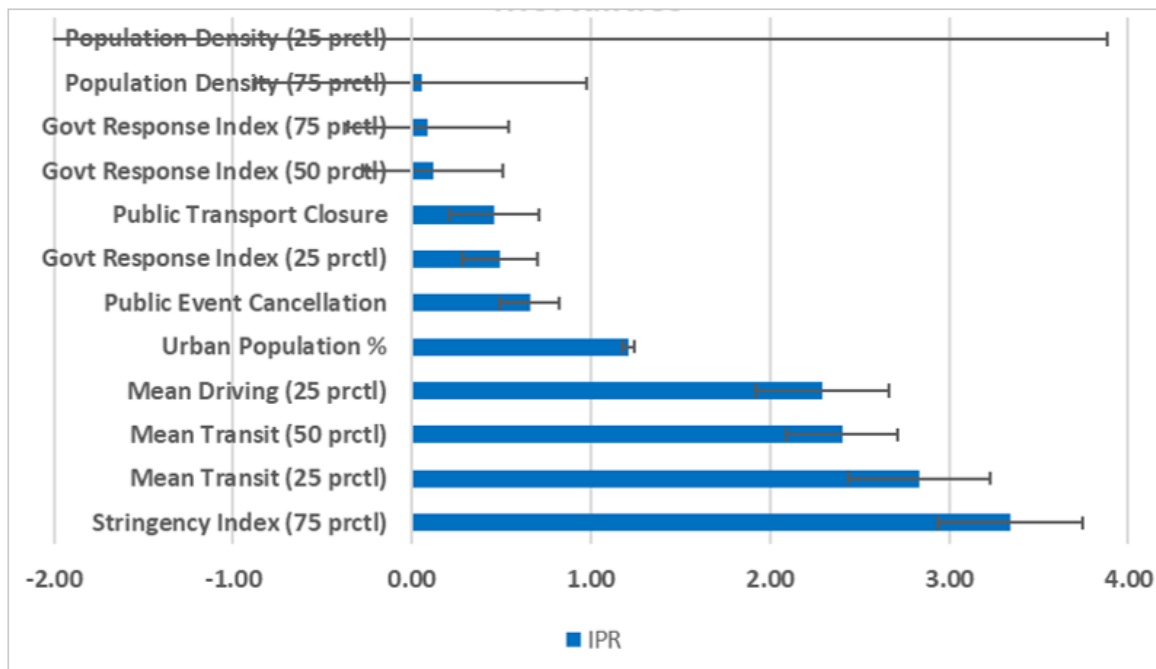
- Poisson regression models were developed to evaluate associations between daily mortality counts and all the explanatory variables
- The quantiles were calculated for population density, family size, mean driving, mean transit, mean walking, stringency index and government response index
- A 6-week lag time was incorporated to mobility and government response metrics to evaluate the impact of actions taken 42-day prior on new cases of fatalities. The introduction of the lag is crucial as we want to measure the effectiveness of the government policy on the number of new infections in the following days and assess whether the measures were protective or detrimental in managing the number of new mortalities.

Results:

- The Poisson regression model had the C-statistic equal to 0.877, indicating excellent discrimination
- The lowest and highest quantiles of population density (IPR: 0.01 (95%CI: 0.00-0.10) and 0.05 (95%CI: 0.01-0.31), respectively) had the highest protective effect on lowering daily mortalities
- The **highest two quantiles of the government response index** (IPR: 0.09 (95%CI: 0.04-0.22) and 0.12 (95%CI: 0.06-0.26), respectively) indicating stricter government responses were highly associated with lowering of mortalities
- Among all the government measures, highest protective association was observed for **Public transport closure** (IPR: 0.46; 95%CI: 0.28 – 0.75) and **Public Event Cancellation** (IPR: 0.66; 95%CI: 0.48-0.91)
- All other government actions have not shown any statistically significant association with mortality
- No consistent associations were observed with mobility metrics

Table 1 shows the associations between different variables and the new deaths in nine countries

Predictors	Odds ratio	Pr(> z)	95% confidence interval	
(Intercept)	0.00	0.00	0.00	0.00
new_tests_per_million_new	1.00	0.00	1.00	1.00
density_p_km_catPD_36	0.00	0.01	0.00	0.10
density_p_km_catPD_383	0.05	0.00	0.01	0.32
urban_population	1.21	0.00	1.14	1.29
family_size_catFS_2_500	178.91	0.18	0.10	329494.61
mean_driving_lag_42_days_catMD_38_33	2.29	0.03	1.11	4.74
mean_driving_lag_42_days_catMD_57_83	1.21	0.55	0.64	2.28
mean_driving_lag_42_days_catMD_80_82	1.24	0.34	0.80	1.93
mean_transit_lag_42_days_catMT_18_85	2.83	0.01	1.30	6.16
mean_transit_lag_42_days_catMT_25_25	2.40	0.01	1.31	4.42
mean_transit_lag_42_days_catMT_38_18	1.04	0.82	0.75	1.45
mean_walking_lag_42_days_catMW_37_58	1.33	0.35	0.73	2.39
mean_walking_lag_42_days_catMW_50_60	1.21	0.44	0.75	1.94
mean_walking_lag_42_days_catMW_65_14	1.17	0.44	0.79	1.72
c1_school_close_flag_lag	0.89	0.67	0.52	1.52
c2_workplace_close_flag_lag	0.57	0.05	0.32	1.01
c3_public_events_cancel_flag_lag	0.66	0.01	0.48	0.91
c4_restriction_gatherings_flag_lag	0.56	0.88	0.00	1070.95
c5_close_public_transport_flag_lag	0.46	0.00	0.28	0.75
c6_stay_at_home_req_flag_lag	1.09	0.98	0.00	2061.07
c7_internal_mov_restr_flag_lag	0.90	0.57	0.62	1.30
stringencyindex_lag_42_days_catSI_73_15	0.63	0.06	0.39	1.03
stringencyindex_lag_42_days_catSI_81_48	1.23	0.43	0.74	2.05
stringencyindex_lag_42_days_catSI_93_52	3.34	0.00	1.51	7.40
governmentresponseindex_lag_42_days_catGR_71_47	0.49	0.00	0.33	0.75
governmentresponseindex_lag_42_days_catGR_76_28	0.12	0.00	0.06	0.26
governmentresponseindex_lag_42_days_catGR_85_26	0.09	0.00	0.04	0.22

Figure 1: Incidence Proportion ratio of daily COVID-19 mortalities**Limitations:**

- Evaluation of implementation of government restrictions enforced by the authorities is difficult and the validity of the results of the data analysis is based on the transparency and accuracy of the published data
- Governments of countries implemented multiple interventions at the same time and thus it is hard to evaluate the individual strategies
- The asymptomatic cases were mostly left undiagnosed which would have resulted in underreporting of cases

Conclusions:

- Our study identified population metrics like population density and government actions like public transport closure and public event cancellation potentially associated with mortality, across multiple geographies.
- Key metrics highlighted that might have proven useful in containing the COVID-19 pandemic and mortalities
- Further research on key confounders (such as mask-wearing, 3Cs of Covid) is required to evaluate further actions to mitigate COVID-19 mortalities

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