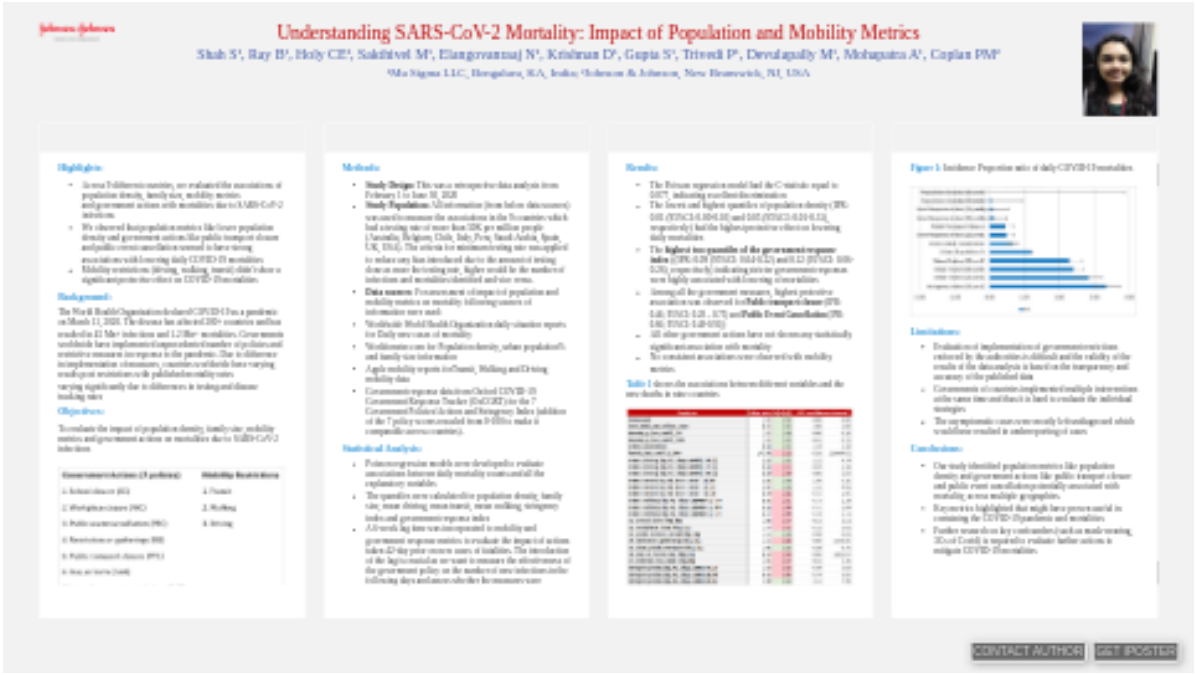
Understanding SARS-CoV-2 Mortality: Impact of Population and Mobility Metrics



Shah S[1], Ray B[1], Holy CE[2], Sakthivel M[1], Elangovanraaj N[1], Krishnan D[1], Gupta S[1], Trivedi P[1], Devulapally M[1], Mohapatra A[1], Coplan PM[2]

[1]Mu Sigma LLC, Bengaluru, KA, India; [2]Johnson & Johnson, New Brunswick, NJ, USA

PRESENTED AT:

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 forTransit, 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.

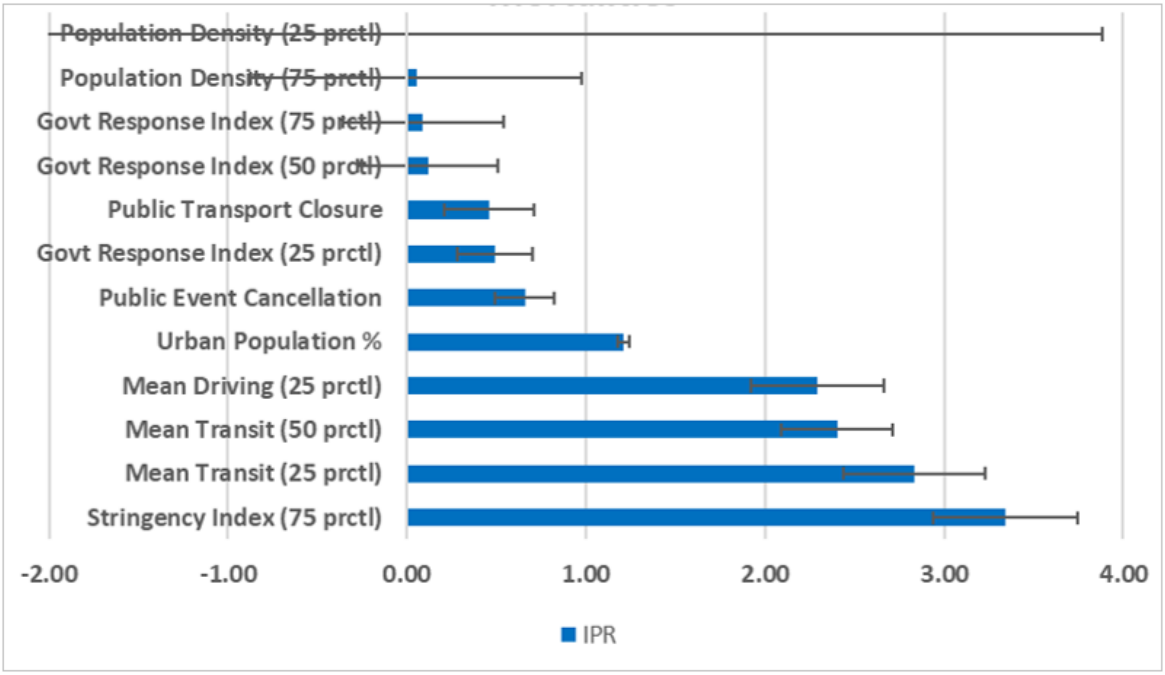
Results:

- 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 resrictions 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

AUTHOR INFORMATION

Linkedin: https://www.linkedin.com/in/shimoneeshah/ (https://www.linkedin.com/in/shimoneeshah/)

Email: shimonee.shah@gmail.com