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The effects of policy changes and human mobility on the COVID-19 epidemic in the Dominican Republic, 2020–2021

Patrick Maloney [a,*], Lyudmyla Kompaniyets [b], Hussain Yusuf [c], Luis Bonilla [a], Carmen Figueroa [a], Macarena Garcia [a]

[a] Centers for Disease Control and Prevention, Dominican Republic
[b] Centers for Disease Control and Prevention, Division of Nutrition, Physical Activity and Obesity, Obesity Prevention and Control Branch, Atlanta, GA, United States
[c] Centers for Disease Control and Prevention, Division of Health Information and Surveillance, Partnerships and Evaluation Branch, Atlanta, GA, United States

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ABSTRACT

Recent advances in technology can be leveraged to enhance public health research and practice. This study aimed to assess the effects of mobility and policy changes on COVID-19 case growth and the effects of policy changes on mobility using data from Google Mobility Reports, information on public health policy, and COVID-19 testing results. Multiple bivariate regression analyses were conducted to address the study objectives. Policies designed to limit mobility led to decreases in mobility in public areas. These policies also decreased COVID-19 case growth. Conversely, policies that did not restrict mobility led to increases in mobility in public areas and led to increases in COVID-19 case growth. Mobility increases in public areas corresponded to increases in COVID-19 case growth, while concentration of mobility in residential areas corresponded to decreases in COVID-19 case growth. Overall, restrictive policies were effective in decreasing COVID-19 incidence in the Dominican Republic, while permissive policies led to increases in COVID-19 incidence.

1. Introduction

Coronavirus disease (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was first identified in Hubei province, China, in December 2019. COVID-19 was declared a Public Health Emergency of International Concern in late January 2020. SARS-CoV-2 is significantly more infectious than other similar diseases (Linton et al., 2020). Increased transmissibility and a immunologically naïve population has led to the deadliest pandemic of the century (Wilder-Smith, 2021). COVID-19 spread rapidly around the globe. As of December 2022, there have been 655 million COVID-19 cases and 6.66 million COVID-19 deaths worldwide and 650,000 COVID-19 cases and 4,384 COVID-19 deaths in the Dominican Republic (DR), although these totals likely underestimate the true magnitude and burden of disease (Worldometer, 2022).

At the outset of the pandemic, there were no effective treatments, vaccines, or other pharmaceutical interventions to protect the public from the highly infectious and virulent novel coronavirus. As an early preventive strategy, local, provincial, and national governments implemented various measures designed to limit community-level transmission of SARS-CoV-2 (Hale et al., 2021). Initially, governments encouraged physical distancing, self-isolation or quarantine, and the practice of hand hygiene. More formal, often legally imposed measures followed. These measures—including school closures, restrictions on public gatherings/congregate settings, stay-at-home orders, travel bans—were designed to limit exposure to the virus through restricting mobility and limiting person to person contact.

The DR was no exception. At the outset of the pandemic, the DR implemented several policies designed to limit exposure to and spread of COVID-19. Many of these policies were designed specifically to limit human mobility, including curfews, border, business, and school closures, and restrictions on public transit, in-person work, public gatherings and events, and travel and tourism.

Tourism is the lifeblood of the economy in the DR. As a result, the DR was among the first countries to relax restrictions on international travel and mobility within the country, opening borders, hotels, and other tourism-related businesses.

Non-pharmaceutical interventions (NPIs) have been used in the prevention and control of epidemics for centuries. More recently, the effects of limiting mobility on transmission of infectious disease has

* Corresponding author at: University of Nebraska Medical Center, 984395 Nebraska Medical Center, Omaha, NE 68198-4395.
E-mail address: pamaloney@unmc.edu (P. Maloney).

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been shown in several studies (Mari et al., 2012; Gog et al., 2014; Sulyok and Walker, 2020). However, until recently, we have lacked the tools to examine this relationship on a large scale.

User information, including location information, is routinely recorded by internet and cell phone service providers, leading to the accumulation of large amounts of mobility data (Sulyok and Walker, 2020; Velasco et al., 2014). In the past, these data have been used to examine the relationship between mobility and infectious disease, including malaria, dengue, and cholera (Wesolowski et al., 2012; Finger et al., 2016; Bengtsson et al., 2015; Wesolowski et al., 2015).

In response to the global pandemic, Google released “Community Mobility Reports” (CMRs) (Google. COVID-19 Community Mobility Reports., 2022). The CMRs show changes in activity in select location groupings. These levels of activity are compared to baseline, pre-pandemic activity levels. This comparison allows inferences to be made about population-level mobility. These data have been used to examine the relationship between mobility and COVID-19 transmission and/or deaths in several studies since the beginning of the COVID-19 pandemic (Sulyok and Walker, 2020; Wesolowski et al., 2015; Nouvellet et al., 2021; Murphy et al., 2020; Basellini et al., 2021; Kishore et al., 2021; Stevens et al., 2022; Jeffrey et al., 2022).

The combination of mitigation policy implementation and relaxation makes the DR a unique case study, allowing an assessment of the effects of enhanced and relaxed mitigation measures on human mobility and COVID-19 transmission prior to wide-spread vaccination in the population. Additionally, the DR is an island nation. When the single land border was closed and air traffic ceased, the population was effectively closed, enabling precise identification effective control and prevention measures.

2. Methods

2.1. Study design

We sought to assess (1) the effects of mobility on COVID-19 case growth, (2) the effects of policy changes on COVID-19 case growth, and (3) the effects of policy changes on mobility. To assess these relationships, we used an ecological study design with aggregated measures of human mobility and COVID-19 case growth. The study period began on March 1, 2020, at the outset of the pandemic, and ended on February 28, 2021, prior to the first doses of COVID-19 vaccine being administered in March of 2021. The data and analyses are summarized below.

2.2. Data description

2.2.1. Google community mobility reports

CMRs are designed to provide insight on human mobility (Google. COVID-19 Community Mobility Reports., 2022). Google’s CMRs gathers geographic location data from those who access Google applications from a smartphone or handheld device and who allow recording of location history (Aktay, 2022). Locations are assigned to one of three categories: public places, workplaces, and places of residence. Public places are classified as retail, recreation, or eateries (collectively called “retail/recreation”), “groceries and pharmacies,” “transit,” and “parks.” Mobility in public places is counted as daily visits to the public areas defined previously. Mobility in workplaces is counted as days where more than one hour was spent in the workplace. Mobility in the place of residence was counted as the average daily hours spent in one’s place of residence (Aktay, 2022).

Presumably, increases in time spent in one’s residence would indicate decreased mobility, as this suggests less time is being spent outside the home. Increases in time spent around parks, groceries/pharmacies, retail/recreation, transit, and workplaces would conversely suggest increased mobility.

The CMRs show the percentage change in each location type, in each region of the represented country. The percentage change is based on comparison with corresponding baseline activity measured pre-pandemic. These percentages represent the absolute change in activity when compared to baseline values. Missing values were assigned when activity was too low and failed to reach the threshold for anonymity of individuals.

2.2.2. Implemented policy measures

The first case of COVID-19 in the DR was documented on March 5th, 2020. Soon after, the DR implemented an array of policy measures designed to limit the spread of COVID-19.

Many of these efforts attempted to reduce transmission specifically through the limitation of human mobility. These measures included, but were not limited to curfews, border, business, and school closures, restrictions on public transit, in-person work, public gatherings, events, and travel/tourism, among others.

We identified the interventions linked most closely with mobility and included them in this analysis. These interventions included curfew hours (implemented 3/20/2020), border control (implemented 3/19/2020), the closure of hotels (implemented 3/23/2020), and the suspension of in-person education and public gatherings (implemented 3/17/2020). Broadly, this set of policy measures can be defined as “closure” policy measures.

Curfews and the suspension of in-person and public gatherings continued throughout the study period. However, the DR relaxed other restrictions, including reopening hotels (opened 7/1/2020) and border control (staggered openings beginning 5/20/2020). These measures were part of a strategy to reduce restrictions on tourism and travel and increase the economic output of the DR. Broadly, this set of policies can be defined as “opening” policies.

Each of these measures were treated as time-varying exposures. Curfew hours were treated continuously, with number of curfew hours per day treated as the “exposure.” Each of the other mitigation measures were coded as 1/0 if the policy measure was in place or suspended, respectively.

2.2.3. COVID-19 infections

The Ministry of Health in the DR releases daily situation reports detailing information on COVID-19 testing and the number of new COVID-19 related infections, hospitalizations, and deaths (Publica, 2022). Data were pulled from these reports and used to create a COVID-19 database. The number of new daily infections were used to calculate COVID-19 case growth in the DR and chart the trajectory of the COVID-19 epidemic. For the purposes of analysis, “new infections” were counted from the day of a positive test.

2.2.4. Computing COVID-19 case growth

To model the impact of implemented mitigation measures and mobility on the course of the COVID-19 pandemic in the DR, crude COVID-19 case counts were transformed into a measure termed “COVID-19 case growth,” which was calculated by taking the difference of the natural logarithms of the number of COVID-19 cases day over day.

We chose to include varying levels of lag into the advanced case growth metric. COVID-19 has a potentially lengthy incubation period of 2–14 days. As a result, immediate changes in COVID-19 case growth will not be observable as policy and mobility change. To fully assess the impacts of mobility and policy changes on case growth, we considered 7-, 14-, and 21-day lags in COVID-19 case growth in each set of models (described below).

2.3. Statistical analysis

Three sets of variables were used in this analysis: (1) case growth, (2) mobility indicators (retail and recreation, grocery and pharmacy, parks, transit stations, workplaces, residential), and (3) variables representing closure and opening policies (curfew hours, border control reopening, hotel closures, hotel re-openings, school closures and public gathering bans).

These variables were used in three distinct sets of linear regression models assessing (1) the effects of policy changes (exposures) on human mobility within the DR (outcomes), (2) the effects of mobility (exposures) on COVID-19 case growth (outcome), and (3) the effects of policy changes (exposures) on COVID-19 case growth (outcome). Each model set is described in Supplemental Table 1. Initially, each exposure set (either all policy or all mobility indicators) were included in a single model with each outcome. However, because of a high degree of multicollinearity, each policy measure or mobility indicator was assessed individually through separate linear regression models with each outcome variable and time trend.

Analyses were restricted to the period that extended from March 1st, 2020 to February 28th, 2021. All data used in this study were publicly available and aggregated at the national level and therefore did not involve human subjects or access to individual-level data and is exempt from ethical compliance. All analyses were conducted using Stata version 15.1 (StataCorp).

3. Results

Tables 1-3 show the results from each of the three sets of regression models: (1) The effects of mitigation measures on human mobility, (2) the effects of human mobility on COVID-19 case growth, and (3) the effects of mitigation measures on COVID-19 case growth in the DR from March 1st, 2020 to February 28th, 2021. These effects are measured through regression coefficients produced in the bivariate models examining the association between each set of factors. Negative regression coefficients indicated a negative association, while positive coefficients indicated a positive association. Additionally, levels of significance were noted through asterisks following the regression coefficient. A single asterisk ("*"), two asterisks ("**"), and three asterisks ("***") indicated significance levels of 0.05, 0.01, and 0.001, respectively. Supplemental Tables 1, 2, and 3 show adjusted R-squared metrics for each model set. Policy measures were treated as time-varying covariates. Curfew hours were measured continuously, representing the number of hours curfew in effect each day. Other measures were either universally implemented or suspended. Coefficients represent the association between active policy measures and human mobility (Table 1), human mobility and case growth (Table 2), and policy measures and case growth (Table 3).

Table 1 shows the effects of policy measures on human mobility in the DR. The implementation of closure policy changes (curfews, hotel closures, and school closures/restrictions on public gatherings) saw decreases in mobility in public spaces (retail/recreation, grocery/

Table 2
The effect of mobility on advanced case growth in the Dominican Republic. March 1, 2020-February 28, 2021.

Mobility Indicator	7-Day Advanced Case Growth	14-Day Advanced Case Growth	21-Day Advanced Case Growth
Retail and Recreation	0.00075*** [0.00041, 0.0011]	0.0016*** [0.0012, 0.0019]	0.0012*** [0.00098, 0.0015]
Grocery and Pharmacy	0.0011*** [0.00068, 0.0014]	0.0016*** [0.0013, 0.0019]	0.0012*** [0.00096, 0.0015]
Transit Stations	0.0011*** [0.00075, 0.0014]	0.0018*** [0.0016, 0.0021]	0.0014*** [0.0012, 0.0016]
Workplaces	0.00056** [0.00022, 0.00091]	0.0013*** [0.0011, 0.0017]	0.0010*** [0.000744, 0.00126]
Parks	0.00084*** [0.00045, 0.0012]	0.0017*** [0.0014, 0.0021]	0.0014*** [0.0011, 0.0016]
Residential	−0.0021*** [-0.0029, −0.0013]	−0.0039*** [-0.0047, −0.0032]	−0.0029*** [-0.0035, −0.0023]

*Significance Level $p < 0.05$.
**Significance Level $p < 0.01$.
***Significance Level $p < 0.001$.

Table 3
The effect of policy changes on advanced case growth in the Dominican Republic. March 1, 2020-February 28, 2021.

Mitigation Measure	7-Day Advanced Case Growth	14-Day Advanced Case Growth	21-Day Advanced Case Growth
Curfew Hours	−0.0067*** [-0.00837, −0.00498]	−0.0087*** [-0.010, −0.0072]	−0.0064*** [-0.00770, −0.00511]
Border Control Reopening	0.00026 [-0.000072, 0.00059]	0.00059*** [0.00026, 0.00092]	0.00050*** [0.000238, 0.000761]
Hotel Closure	−0.013*** [-0.015, −0.012]	−0.0065*** [-0.0083, −0.0048]	−0.0027*** [-0.0042, −0.0012]
Hotel Opening	−0.0027*** [-0.0042, −0.0012]	0.00030*** [0.00013, 0.00048]	0.00026*** [0.00011, 0.00041]
School Closures and Restrictions of Public Gatherings	−0.017*** [-0.020, −0.015]	−0.018*** [-0.020, −0.016]	−0.0070*** [-0.0092, −0.0048]

*Significance Level $p < 0.05$.
**Significance Level $p < 0.01$.
***Significance Level $p < 0.001$.

Table 1
The effect of policy changes on mobility in the Dominican Republic, March 1, 2020-February 28, 2021.

Mitigation Measure	Retail and Recreation	Grocery and Pharmacy	Transit Stations	Workplaces	Parks	Residential
Curfew Hours	−4.148*** [-4.472, −3.824]	−3.715*** [-4.031, −3.399]	−4.651*** [-5.002, −4.300]	−3.447*** [-3.848, −3.046]	−3.231*** [-3.561, −2.901]	1.587*** [1.440, 1.733]
Border Control Reopening	0.572*** [0.494, 0.650]	0.441*** [0.363, 0.519]	0.518*** [0.424, 0.612]	0.511*** [0.430, 0.593]	0.477*** [0.408, 0.547]	−0.205*** [-0.238, −0.171]
Hotel Closure	−1.429*** [-1.973, −0.885]	−1.743*** [-2.234, −1.252]	−2.323*** [-2.876, −1.770]	−1.629*** [-2.173, −1.084]	−1.159*** [-1.636, −0.682]	0.853*** [0.639, 1.067]
Hotel Opening	0.084** [0.030, 0.138]	0.0592* [0.011, 0.108]	0.135*** [0.080, 0.190]	0.0432 [-0.011, 0.097]	0.0770** [0.030, 0.124]	−0.0241* [-0.0453, −0.003]
School Closures and Restrictions of Public Gatherings	−4.458*** [-5.185, −3.731]	−3.909*** [-4.596, −3.223]	−5.915*** [-6.646, −5.183]	−4.232*** [-4.971, −3.494]	−3.892*** [-4.528, −3.257]	2.048*** [1.766, 2.329]

*Significance Level $p < 0.05$.
**Significance Level $p < 0.01$.
***Significance Level $p < 0.001$.

pharmacy, transit stations, workplaces, and parks) and increases in mobility in residential areas. Each of these associations were exceedingly strong ($p < 0.001$). The opposite was true of the implementation of opening policies. As opening policies (border control and hotel reopening) were implemented, mobility increased in public areas and decreased in residential areas. All these associations were statistically significant ($p < 0.05$).

Table 2 shows the effects of mobility on case growth in the DR from March 1st, 2020 to February 28th, 2021. Increases in mobility in public places (retail/recreation, grocery/pharmacy, transit stations, workplaces, and parks) was universally associated with 7-, 14- and 21-day case growth in the DR, meaning that case growth 7-, 14-, and 21-days after changes in mobility was increased. Conversely, increased mobility in residential areas was associated with decreased 7-, 14-, and 21-day case growth. All these associations were highly significant ($p < 0.01$ for workplaces/7-day case growth, $p < 0.001$ for all others).

Table 3 shows the effects of policy changes on advanced case growth from March 1st, 2020 to February 28th, 2021. Each of the three closure policies (curfews, hotel closures, and closures of schools and restrictions on public gatherings) demonstrated a negative association with 7-, 14-, and 21-day case growth, indicating that closure policies reduced COVID-19 case growth. Border control reopening showed a positive association with 7-, 14-, and 21-day case growth, while hotel openings showed a positive association with 14-day and 21-day case growth and a negative association with 7-day advanced case growth.

4. Discussion

In the absence of effective medical interventions to prevent and control epidemics, the implementation of NPIs can effectively mitigate the spread of disease and limit population-level impact. Many countries, including the DR, implemented NPIs specifically designed to limit mobility, thereby reducing the transmission of the SARS-CoV-2 virus.

Closure policies were implemented during the first month of the COVID-19 pandemic. The suspension of in-person education and public gatherings, closure of hotels, border closures, and implementation of curfews were all implemented within the same week (3/17/2023–3/24/2023). During that week, diagnosed cases of COVID-19 jumped from 34 to 392 and PCR percent positivity increased from 19 % to 57 %. The DR also recorded first death attributed to COVID-19.

Staggered border control reopening began on 5/20/2020, during a period where incident cases (7 day moving average = 334 cases), hospitalizations (7 day moving average = 132 hospitalizations), and deaths (7 day moving average = 4 deaths) had stagnated. There was a steady increase in cases (7 day moving average = 722 cases), hospitalizations (7 day moving average = 200 hospitalizations), and deaths (7 day moving average = 10 deaths) between border control reopening and the reopening of hotels on 7/1/2020. The DR experienced the first COVID-19 peak shortly thereafter (7/7/2020–8/18/2020). Despite the peak in COVID-19 morbidity and mortality, borders and hotels were not closed.

In the past, due to technological limitations, it has been difficult to evaluate the impact of NPIs. However, with the mass proliferation of electronic devices and GPS technology, we have been given a unique opportunity to assess the effects of mitigation practices on mobility and, in turn, on disease transmission.

The data indicate that the implementation of restrictive, closure policies limited mobility around public places and increased mobility around residential areas. Conversely, opening policies increased mobility in public areas while simultaneously decreasing mobility in residential areas. These results show that public policy changes impacted human mobility in the DR, both in limiting and increasing mobility, depending on the policy. This further indicates that the public in the DR adhered to restrictive and permissive public policies.

Increased mobility in public places was associated with increased 7-, 14-, and 21-day advanced COVID-19 case growth, indicating that increased mobility and increased transmission of disease were linked. On the other hand, increased mobility in residential areas was associated with decreased 7-, 14-, and 21-day COVID-19 case growth, indicating that increased mobility in residential areas was linked with decreased transmission of disease. Additionally, restrictive closure policies were associated with decreased COVID-19 case growth, while permissive opening policies were associated with increased case growth.

These results support the hypothesis that reduced mobility contributes to reduced disease transmission and overall burden of disease. Furthermore, these results support the notion that restrictive closure policies reduce mobility and disease transmission. These results are consistent with previous literature (Sulyok and Walker, 2020; Wesolowski et al., 2015; Nouvellet et al., 2021; Murphy et al., 2020; Basellini et al., 2021; Kishore et al., 2021; Stevens et al., 2022; Jeffrey et al., 2022).

There has been extensive research relating mobility to COVID-19 morbidity and mortality. The results described in this paper are unique in several ways. The DR provides a unique case study to examine the relationships between NPIs, mobility and case growth. (1) The economy of the DR is dependent almost entirely upon tourism. As a result, the DR was among the first countries to relax closure policies, allowing extended period of follow-up to evaluate the impact of reopening policies. Previous studies evaluating reopening policies focused on other regions of the world or examine policies in the aggregate (Stevens et al., 2022; Jeffrey et al., 2022). (2) While other studies within and outside the region relied on publicly available data, we worked directly with the DR's Ministry of Health, securing accurate, reliable, and robust data for inclusion in this study (Murphy et al., 2020; Kishore et al., 2021). (3) Finally, we used what we believe is a more accurate measure of COVID-19 transmission. Our calculated metric of COVID-19 case growth has two advantages. For one, it is a more accurate measure of COVID-19 transmission than either hospitalization or death, as COVID-19 variants have drastically different levels of severity. For another, there is significant lag between infection and hospitalization and/or death. Using COVID-19 case growth allows more accurate estimation of the impacts of NPIs and mobility using events closer to the actual time of infection.

There are several limitations specific to this study. For one, the measures used in this study were all at the country level. There are likely differences in COVID-19 transmission, human mobility, and adherence to policy interventions by districts, cities, and communities, and potential associations could not be examined at those levels. Additionally, COVID-19 testing was not freely available to all persons within the DR. This likely discouraged testing, artificially suppressing the true number of reported cases of COVID-19. However, despite overall case counts being underestimated, trends in number of identified cases (in effect the case growth measure) is still a useful metric to assess impacts of mitigation strategies. Finally, this study utilized a series of bivariate models to test for association between exposure and outcome. Ideally, a form of multivariate analyses would be performed to account for additional explained variance.

5. Conclusions

There is a clear association between implementation of mitigation-related public policies and mobility and COVID-19 case growth. Mobility limiting policies are associated with reductions in mobility in public places and COVID-19 case growth, while permissive policies are associated with increases in mobility in public places and COVID-19 case growth.

Additional studies can build on this research by studying the effects of policy changes and mobility on COVID-19 at smaller geographic levels, such as regional, district, local, or otherwise. Also, additional models should be built to assess the mutual, concurrent effects of mobility and policy on COVID-19 transmission.

6. Ethical considerations

The research conducted by investigators did not involve human subjects. As such, ethical approval was not required.

7. Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of Centers for Disease Control and Prevention.

CRediT authorship contribution statement

Patrick Maloney: Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. **Lyudmyla Kompaniyets:** Methodology, Formal analysis, Writing – review & editing. **Hussain Yusuf:** Conceptualization, Investigation, Supervision, Writing – review & editing. **Luis Bonilla:** Conceptualization, Data curation, Writing – review & editing. **Carmen Figueroa:** Writing – review & editing. **Macarena Garcia:** Conceptualization, Data curation, Methodology, Project administration, Validation, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2023.102459.

References

Aktay AB, S; Cossoul, G; Davis, J; Desfontaines, D; Fabrikant, A; Gabrilovich, E;Gadepalli, K;Gipson, B; Guevara, M;Kamath, C; Kansal, M; Lange, A; Mandayam, C; Oplinger, A; Pluntke, C; Roessler, T; Schlosberg, A; Shekel, T; Vispute, S; Vu, M; Wellenius, G; Williams, B; Wilson, RJ. Google COVID-19 community mobility reports: anonymization process description. *arvix*. 2022.

Basellini, U., Alburez-Gutierrez, D., Del Fava, E., et al., 2021. Linking excess mortality to mobility data during the first wave of COVID-19 in England and Wales. SSM - Population Health. 14, 100799.

Bengtsson, L., Gaudart, J., Lu, X., et al., 2015. Using mobile phone data to predict the spatial spread of cholera. Sci. Rep. 5 (1), 8923.

Finger F, Genolet T, Mari L, et al. Mobile phone data highlights the role of mass gatherings in the spreading of cholera outbreaks. Proceedings of the National Academy of Sciences. 2016;113(23):6421-6426.

Gog, J.R., Ballesteros, S., Viboud, C., et al., 2014. Spatial transmission of 2009 pandemic influenza in the US. PLoS Comput. Biol. 10 (6), e1003635–e.

Google. COVID-19 Community Mobility Reports. 2022; 17. Available at: https://www.google.com/covid19/mobility/?hl=en. Accessed March, 2022.

Google. COVID-19 Community Mobility Reports. 2022; https://www.google.com/covid19/mobility/?hl=en. Accessed March 7, 2022.

Hale, T., Angrist, N., Goldszmidt, R., et al., 2021. A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker). Nat. Hum. Behav. 5 (4), 529–538.

Jeffrey, F., Bertrand, G., Carlos, M.-G., Manasa, P., Sebastian, W., 2022. Reopening strategies, mobility and COVID-19 infections in Europe: panel data analysis. BMJ Open 12 (2), e055938.

Kishore, K., Jaswal, V., Verma, M., Koushal, V., 2021. Exploring the utility of google mobility data during the COVID-19 pandemic in India: digital epidemiological analysis. JMIR Public Health Surveill. 7 (8), e29957.

Linton, N.M., Kobayashi, T., Yang, Y., et al., 2020. Incubation period and other epidemiological characteristics of 2019 novel coronavirus infections with right truncation: a statistical analysis of publicly available case data. J. Clin. Med. 9 (2), 538.

Mari, L., Bertuzzo, E., Righetto, L., et al., 2012. Modelling cholera epidemics: the role of waterways, human mobility and sanitation. J. R. Soc. Interface 9 (67), 376–388.

Murphy, M.M., Jeyaseelan, S.M., Howitt, C., et al., 2020. COVID-19 containment in the Caribbean: the experience of small island developing states. Research in Globalization. 2, 100019.

Nouvellet, P., Bhatia, S., Cori, A., et al., 2021. Reduction in mobility and COVID-19 transmission. Nat. Commun. 12 (1), 1090.

Publica MdS. Boletines Sobre el COVID-19. 2022; https://www.msp.gob.do/web/?page_id=6948. Accessed March 25, 2022.

Stevens, N.T., Sen, A., Kiwon, F., Morita, P.P., Steiner, S.H., Zhang, Q., 2022. Estimating the effects of non-pharmaceutical interventions and population mobility on daily COVID-19 cases: evidence from Ontario. Can. Public Policy 48 (1), 144–161.

Sulyok, M., Walker, M., 2020. Community movement and COVID-19: a global study using Google's Community Mobility Reports. Epidemiol. Infect. 148, e284.

Velasco, E., Agheneza, T., Denecke, K., Kirchner, G., Eckmanns, T., 2014. Social media and internet-based data in global systems for public health surveillance: a systematic review. Milbank Q. 92 (1), 7–33.

Wesolowski, A., Eagle, N., Tatem, A.J., et al., 2012. Quantifying the impact of human mobility on malaria. Science 338 (6104), 267–270.

Wesolowski, A., Qureshi, T., Boni, M.F., et al., 2015. Impact of human mobility on the emergence of dengue epidemics in Pakistan. PNAS 112 (38), 11887–11892.

Wilder-Smith, A., 2021. COVID-19 in comparison with other emerging viral diseases: risk of geographic spread via travel. Tropical Diseases, Travel Medicine and Vaccines. 7 (1), 3.

Worldometer. COVID-19 Coronavirus Pandmeic. 2022; https://www.worldometers.info/coronavirus/. Accessed December 14, 2022.