A comprehensive set of mobility indicators to explore correlations of SARS-CoV-2 reproduction number with mobility

We estimated to what extent the Google COVID-19 Community Mobility Reports was constituting a comprehensive representation of population mobility. In this purpose, we used the methodology described in the main text (Methods) to analyze thoroughly the correlations between the mobility indicators themselves (Supplementary Material 2). We found that decreases in retail, grocery, transit, parks, and work mobility systematically correlated with an increase in residential mobility, for all countries/regions (Supplementary Material 2). Strong negative correlations between residential and other mobility indicators reflect the fact that, when not at home, people are somewhere else, and this somewhere else is captured in large parts by the Google subset of mobility indicators. In contrast, retail/work mobility positively correlated with transit mobility (Supplementary Material 2), reflecting the use of public transports to reach retail/workplaces. These control correlation analyses based only on the mobility dataset are very suggestive that the Google mobility data provides a comprehensive representation of population mobility. In addition, these results established the systematic anti-correlation between other mobility indicators and residential mobility. Hence, without loss of information, we could focus our attention on the latter in the main text of the manuscript.

Population density and repartition, health system capacities, or GDP/Development index are insufficient to fully explain inverted correlations

In an attempt to understand the origin of the inverted correlations between Rt and residential mobility (e.g. group 2 countries), we sought to examine other parameters that might dominate variations of the reproduction number, and therefore impinge on the correlations. These parameters included the population density and repartition, climate, lifestyles, the capabilities of the countries health systems and data recording policies. We also considered the possibility that economical and development parameters, as quantified by the Gross Domestic Product per capita (GDPpc) or the Human Development Index (HDI), might fully explain patterns of normal vs inverted Rt/residential mobility correlations [1].

Most European and North American countries belonged to Group 1, while Group 2 and Group 3 included many African and South/Central American countries. Group 1 was, thus, enriched in high-GDP countries. However, GDPpc alone was not sufficient to entirely explain the global repartition of normal vs inverted correlations. Sweden, one of the European countries with the highest GDPpc, was in group 3. Kuwait, Qatar, or Saudi Arabia with GDPpc larger than many European countries showed inverted correlations; Moldova, a European country with a GDPpc of about 3500 USD/capita, showed inverted correlations, while Philippines (with a similar GDPpc) showed normal correlations, as well as Burma where the GDPpc is 3 times lower than in Moldova. Uruguay and Chile were in Group 1, while Argentina was in Group 2 and both Trinidad & Tobago and Panama were in Group 3, all these countries showing, nonetheless, very similar GDPpc. Likewise, Malaysia and Mexico were in Group 1 while Kazakhstan was in Group 2, all three having comparable GDPpc, 3-10 times higher than Philippines or Burma.

To address the influence of population density and repartition, and to some extent lifestyle while keeping to a minimum the variations in other parameters, we took advantage of the fact that our curated viral infection data and mobility data were available separately for each of the US' states and territories (Puerto Rico), thereafter referred to as "regions". Although, US belonged to group 1, at the regional scale US regions belonged to groups 1 and 3 (Figure 2B). Arkansas even belonged to group 2. The sole existence of variability within US indicated that the quality of the health care/case reporting systems was insufficient to explain alone the sign of the Rt vs residential correlations. Likewise, US regions with a broad range of climates were found in groups 1 and 3 alike. Florida or Louisiana (group 1) and Mississippi or Alabama (group 3) both have semi-tropical/subtropical climate; Arizona (group 1) and New Mexico (group 3) are semi-arid/arid; Wyoming (group 1) and North-South Dakota (group 3) are dry continental; Michigan (group 1) and Wisconsin (group 3) humid continental …etc. Hence, climatic factors alone cannot fully explain the sign of Rt vs residential mobility correlations [2].

Group1 regions included both densely populated (400-450 inhabitants/ km^2 in New Jersey & Puerto Rico) and sparsely populated (~2.5 inhabitants/km^2 in Montana, Wyoming, and 0.5 in Alaska) regions.[3] The same was true for group 3-like regions (e.g. DC, 4000 in./km^2; Delaware, 187 in./km^2, to North & South Dakota, 4 in./km^2). Thus, the overall population density at the regional level is insufficient to explain the sign of Rt vs residential mobility correlations.

Moreover, US regions with a broad range of population structures [3] could be found in groups 1 and 2-3. Empty regions where 50-80% of the population live in 1-2 very big metropolitan areas showed both normal (e.g. Anchorage in Alaska, Las Vegas in Nevada) or inverted correlations (e.g. Minneapolis/St Paul in Minnesota). Likewise, regions with more homogeneous population distribution belonged to group 1 and 3 as, for instance, New England states (Vermont: group 1, Maine: group 3) or Midwest/Mountain states (Wyoming, Idaho, Montana: group 1; North-South Dakota, Iowa: group 3). Yet, most southeastern rural states (South Carolina, North Carolina, Alabama, Mississippi, Virginia, West Virginia, Tennessee, Arkansas), and Midwest states (Kentucky, Ohio, Minnesota, North & South Dakota, Iowa, Nebraska, Kansas), most of which show homogeneous population distributions and rural lifestyle [4], all belonged to groups 2-3. Hence, within US, group 2-3 regions are enriched in homogeneously populated, rural states. This analysis at the regional level indicated that particular features of territories, which may include the population repartition, affect how Rt may respond to mobility restriction and should be accounted for in policymaking.

References

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