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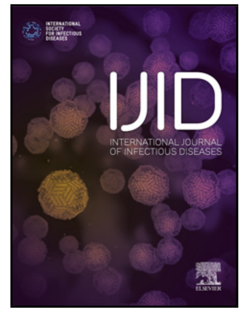

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Identical trends of SARS-Cov-2 transmission and retail and transit mobility during non-lockdown periods

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Highlights

- We document a strong relationship between SARS-Cov-2 transmission and mobility during the time period between the two first waves.
- The trends of both mobility and viral transmission evolve almost in parallel during this time period.
- This suggests that the evolution of mobility patterns would help Public Health authorities to anticipate transmission increases.
- This result is important from a Public Health perspective when relaxing control measures.

Abstract

Recent literature strongly supports the idea that mobility reduction and social distancing play a crucial role in transmission of SARS-Cov-2 infections. It was shown during the first wave that mobility restrictions reduce significantly infection transmission. Here we document another relationship and show that, in the period between the first two COVID-19 waves, there exists a high positive correlation between the trends of SARS-Cov-2 transmission and mobility. These two trends oscillate simultaneously and increased mobility following lockdown relaxation has a significant positive relationship with increased transmission. From a public health perspective, these results highlight the importance of following the evolution of mobility when relaxing mitigation measures to anticipate the future evolution of the spread of the SARS-Cov-2.

Keywords: SARS-Cov-2

Transmission

Effective Reproduction Number

Mobility

Mobility of hosts and/or vectors has always had a large impact on the propagation of the transmission of diseases (Tizzoni et al., 2014). This is once again the case for the Covid-19 pandemic (Kraemer et al., 2020).

Recent literature strongly supports the idea that mobility reduction and social distancing played a crucial role in the reduction of SARS-CoV-2 infections during the first wave. Some studies concluded that mobility patterns correlate with the prevalence of COVID-19 and that travel reduction had a positive effect on reducing the transmission of SARS-CoV-2 (Badr et al., 2020; Chang et al., 2020). Some other works have used the changes in mobility patterns to estimate the effect of mitigation measures on the reproductive number. They showed that the drop in mobility, overlapping with the introduction of mitigation measures induced a sharp reduction in transmission (Lemaitre et al., 2020; Park et al., 2020). But all these interesting results are limited to the first wave, before and during the lockdown period.

Nevertheless, it remains unknown if mobility increases following lockdown relaxation is actually associated with an enhanced transmission of SARS-Cov-2. Lockdowns impact a myriad of dimensions in our society, and not only on mobility patterns. This makes it difficult to draw a causal link between mobility and viral transmission from lockdown data. Instead, to better understand this link, we propose investigating this link in the period between lockdown periods, to potentially use mobility data as an early signal for implementing public health measures.

Here for the first time, to the best of our knowledge, we document a high correlation between the trends of SARS-Cov-2 transmission and mobility in the period between the first two Covid-19 waves in some French regions and in Ireland. Our aim was to compare different geographical settings with similar population size. We quantified the change in transmission of SARS-CoV-2 by computing the effective reproduction number $R_{eff}(t)$. The effective reproduction number is defined by the average number of secondary cases at time *t* arising from a primary infected case. It is an important metric for measuring time-varying transmissibility and assessing the effectiveness of different interventions. The classical statistical methods for estimating $R_{eff}(t)$ have many shortcomings due to the characteristics of the transmission of this virus: silent transmission and major time variation in the reporting of cases due to lack of timely or appropriate testing (Gostic et al., 2020). Thus we used an original mechanistic method based on a stochastic model (Fig. A1 and eqs A1-A3) with time-varying parameters (Cazelles et al., 2018) and inferred with a Bayesian method using hospital data (Cazelles et al., 2021). We used daily mobility data provided by Google, which is a proxy for real-time trends in movement patterns and human behavior (Google, 2020). These mobility data measure the percentage of change relative to the pre-pandemic baseline mobility and measure visits and the time spent in: retail and recreation, grocery and pharmacy, transit stations, workplace and residential.

Our analysis revealed that trends in transmission as estimated from well documented hospital data correlate strongly with trends in mobility patterns within and between the observed first and second epidemic waves for retail and recreation mobility, as well as transit station mobility. The $R_{eff}(t)$ increased and oscillated with mobility with a highly significant correlation between the 15th of May and thee 15th of October, with Pearson correlation coefficients above 0.5 (Figure). We show that these relationships are strong, particularly for retail and recreation mobility and transit station mobility. Additionally, we computed the Cross-Correlation Functions for these datasets that revealed the correlations were maximal for a delay between 0 and 10 days, and that this delay varied depending on the region (Figs A2-A3).

Earlier findings showed that mobility reductions can dramatically reduce infections, our results now confirm the reverse relationship; increased mobility following lockdown relaxation has a significant, positive relationship with increased transmission. This suggests the importance of following the evolution of mobility data at different spatial resolutions to anticipate the future evolution of the spread of the SARS-Cov-2 and to guide public health policy.

Additionally, the strong relationship between retail and recreational mobility and increased transmissibility suggests that a return to baseline human activity poses a significant risk of increased infection. Moreover, even if a direct causal link cannot be drawn, these strong correlations indicate that an increase in retrial and recreational mobility promote high-intensity contact between people and also interaction between people of different households, resulting in increased SARS-CoV-2 transmission. This strong relationship is in total agreement with those of Chang et al. (2020) who have also demonstrated that mobility network models can inform the reopening of society.

Our findings illustrate the importance of mobility at defined regional levels and perhaps more importantly, they highlight that mobility measures of transit and retail are more strongly correlated with transmission than other forms of mobility. These findings will aid the refinement of future possible lockdown policies and mitigation measures as we await the roll out of imminent vaccines.

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Ethical approval

Not required.

Conflict of interest

None.

Declaration of interests

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

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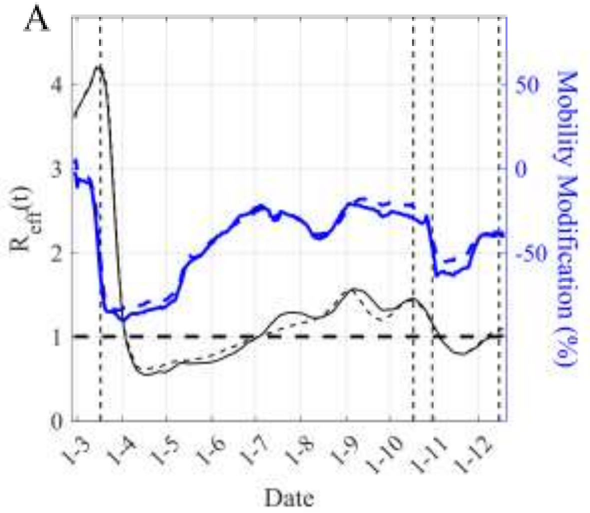
Figure. Time evolution of the estimated $R_{eff}(t)$ (black lines) and Google Mobility (retail and recreation mobility (continuous blue lines) and transport mobility (dashed blue lines)) in Ile-de-France region (A) and in Ireland (B). The mobility time series have been smoothed using moving average over a 7 days window. In A/ $R_{eff}(t)$ is computed for two different models with or without accounting for hospital discharges. Pearson Correlation in Ile-de-France (model with hospital discharges) with retail and recreation mobility 0.70 and with transport mobility 0.77. Pearson Correlation in Ile-de-France (model without hospital discharges) with retail and recreation mobility 0.64 and with transport mobility 0.70. Pearson Correlation in Ireland with retail and recreation mobility 0.86 and with transport mobility 0.56. Figs A2-A3 display the significance of the Cross-Correlation functions (CCF). Vertical dashed lines are main mitigation measures (lockdown and curfew) and the horizontal dashed lines are the threshold limit for $R_{eff}(t)$.


A
B
$R_{eff}(t)$
Mobility Modification (%)
Date
0
1
2
3
4
50
0
-50
1-3
1-4
1-5
1-6
1-7
1-8
1-9
1-10
1-11
1-12