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Rapid Communication

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Highlighting socio-economic constraints on mobility reductions during COVID-19 restrictions in France can inform effective and equitable pandemic response

Eugenio Valdano, PhD[1], Jonggul Lee, PhD[1], Shweta Bansal, PhD[2], Stefania Rubrichi, PhD[3], and Vittoria Colizza, PhD[1,4,*]

[1]Pierre Louis Institute of Epidemiology and Public Health, INSERM, Sorbonne Université, Paris, France, [2]Department of Biology, Georgetown University, Washington, DC, USA, [3]Orange Labs, Sociology and Economics of Networks and Services (SENSE), Chatillon, France and [4]Tokyo Tech World Research Hub Initiative, Institute of Innovative Research, Tokyo Institute of Technology, Tokyo, Japan

*To whom correspondence should be addressed. Email: vittoria.colizza@inserm.fr

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To fight COVID-19, mobility restrictions were in effect in France over a total of 132 days in 2020 (Figure 1). A nighttime curfew is currently in place, and future restrictions are likely. Regulations restricting mobility have been universally applied across France (with few limited-time exceptions), but the resulting mobility reductions have not. Differential reductions may represent a marker of structural differences in demography, economy, and social composition. Identifying these differences contributes to (i) understanding how control policies are constrained by the societal composition across geography; (ii) assessing whether specific population segments are associated with lower mobility reductions, increasing exposure to COVID-19 risk; (iii) adjusting current measures to improve social distancing and reduce inequalities.

We gathered socio-economic indicators (standard of living, job market structure, house crowding, retail store availability—Figure 1A–E; see SD1, available as Supplementary data at *JTM* online, for additional details on indicators). We estimated their association with mobility internal to French departments during restrictions: first lockdown in Spring, nighttime curfew in October, second lockdown in late Fall, nighttime lockdown in December (Figure 1F–I; SD1 available as Supplementary data at *JTM* online). Mobility was extracted from mobile phone data provided by the Orange service Flux Vision[1] (see SD1 available as Supplementary data at *JTM* online).

Average internal mobility was lowest during lockdowns: −61% (first lockdown), −25% (second lockdown) from pre-pandemic values. Reductions were smaller during curfews: −7% (October) and −16% (December). Summer, when no restrictions were in place, saw values comparable to pre-pandemic levels, albeit with large differences among departments, likely linked to holiday destinations.

We measured the association of mobility with socio-economic indicators using a Bayesian spatial autoregressive error model, estimating the correlation among residuals in neighbouring departments. We computed crude correlations (correlation of mobility with each indicator, separately), and adjusted correlations (correlation of mobility with each indicator, after adjusting for the values of the other indicators). SD2, available as Supplementary data at *JTM* online, contains a complete description of the statistical analysis.

Widespread evidence points at mobility being lower among the wealthier.[2,3] We observed the same crude association in France, notwithstanding the uniform enforcement of restrictions. Mobility was also lower in areas with a larger proportion of white-collar jobs (Figure 1J–M). This association between mobility and job market structure remained significant after adjustment, completely explaining income differences.

After adjustment, higher house crowding was associated to higher mobility during the first lockdown (Figure 1J); no such association was found in later restrictions. This should be interpreted in light of the first lockdown being the strictest, with schools and all but essential production sectors closed. House crowding is therefore associated to higher mobility only when restrictions are pervasive, leaving few-to-no reasons to leave home.

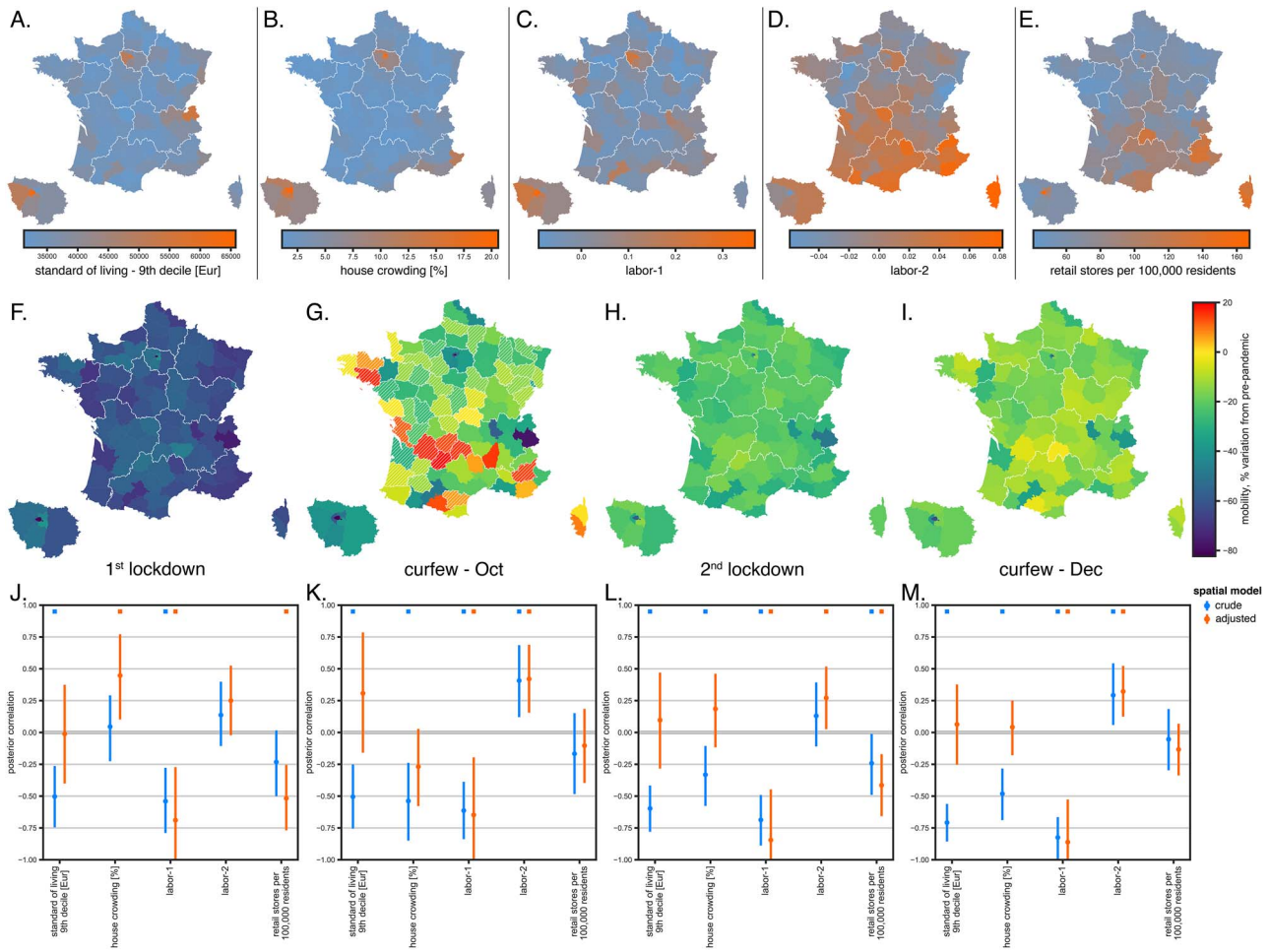

Figure 1. Population-level indicators, mobility variations during restrictions, and associated drivers. Panels A–E show the values of our socio-economic indicators, as defined by and acquired from the French National Statistical Institute (www.insee.fr). Indicators are used at the administrative spatial resolution of departments: 96 in mainland France. The borders of the 13 French regions are in white. (A) Ninth decile of the standard of living distribution. (B) House crowding. (C, D) The two principal component analysis components of the structure of job market: high labour-1 indicates high proportion of white collar jobs; high labour-2 indicates—among others—high proportion of workers in hospitality industry and commerce. (E) Number of retail stores per 100 000 residents. Indicators in panels A–E are detailed in SD1, available as Supplementary data at *JTM* online. (F) Internal mobility during the working days of the first two full weeks of the first lockdown (Mar 17—May 11). (G) Internal mobility during four working days (October 26–29) affected by nighttime curfew from 9 p.m. to 6 a.m. Cross-hatched departments were not under curfew, and excluded from the analysis. (H) Internal mobility during the working days of the first two full weeks of the second lockdown (October 30 to December 13). (I) Internal mobility during four working days (December 21–24) affected by nighttime curfew from 8 p.m. to 6 a.m. All France was under curfew. Throughout panels F–I, internal mobility is computed by department, as the relative difference in the number of trips starting and ending within each department, with respect to a pre-pandemic benchmark (February 3–7).[1] (J) The median posterior estimate of the crude (blue) and adjusted (orange) correlation coefficients between the indicators, and mobility during the first lockdown. Bars indicate 95% credible intervals. Coloured square dots above the bars indicate when zero correlation is outside the credible interval. (K) The same as panel J, for the October curfew (only departments under curfew are considered). (L) The same as panel J, for the second lockdown. (M) The same as panel J, for the December curfew.

After adjustment, a higher number of retail stores per capita was associated to lower mobility during both lockdowns (Figure 1J and L). Reachable outlets might thus reduce displacements across income classes, even accounting for the increase in e-commerce for groceries (see SD3 available as Supplementary data at *JTM* online).

Mobility during curfews was positively associated with hospitality and commerce (Figure 1K and M; SD1 available as Supplementary data at *JTM* online), likely caused by an activity boost during the concurrent school holidays, despite restrictions (see SD4 available as Supplementary data at *JTM* online).

Our model estimated a significantly positive spatial correlation during lockdowns (see SD5 available as Supplementary data at *JTM* online), stressing the need of spatially explicit models when studying the geography of mobility reductions.[4]

Job market structure emerged as the most consistent constraint on reducing mobility. This highlights an inherent inequity of movement restrictions, as some activities simply cannot be halted, or performed remotely. House crowding also showed that tighter restrictions tend to be more inequitable. Finally, the role of retail showed that reaching an equilibrium on stores' opening to improve their accessibility might actually help to reduce mobility. Together, these results show that achievable reductions reflect hard societal constraints. Reducing crowding,[5] and boosting testing and vaccination in communities achieving low mobility reductions could thus improve equity. Also, targeted closures of

key production sectors could improve epidemic control in areas with surging cases, e.g. due to new viral variants.

Supplementary data

Supplementary data are available at *JTM* online.

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Conflict of interest

The authors declare no competing interests.

Author contributions

E.V., S.R. and V.C. conceived of and designed the study. E.V. and J.L. analysed the data and performed the statistical analysis. E.V., J.L., S.B., S.R. and V.C. interpreted the results. E.V. wrote the article. E.V., J.L., S.B., S.R. and V.C. contributed to the critical revision of the final version of the article.

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References

1. Pullano G, Valdano E, Scarpa N *et al*. Evaluating the effect of demographic factors, socioeconomic factors, and risk aversion on mobility during the COVID-19 epidemic in France under lockdown: a population-based study. *Lancet Digit Health* 2020; **2**: e638–49.
2. Jay J, Bor J, Nsoesie EO *et al*. Neighbourhood income and physical distancing during the COVID-19 pandemic in the United States. *Nat Hum Behav* 2020; **4**:1294–302.
3. Garnier R, Benetka JR, Kraemer J, Bansal S. Socioeconomic disparities in social distancing during the COVID-19 pandemic in the United States: observational study. *J Med Internet Res* 2021; **23**:e24591.
4. Lee WD, Qian M, Schwanen T. The association between socioeconomic status and mobility reductions in the early stage of England's COVID-19 pandemic. *Med Rxiv* 2020. doi: 10.1101/2020.10.28.20221770 3 November 2020, preprint: not peer reviewed.
5. Chang S, Pierson E, Wei Koh P *et al*. Mobility network models of COVID-19 explain inequities and inform reopening. *Nature* 2020; **589**:82–7.