

Mobility patterns in Paris before, during, and after lockdown

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From March 17 to May 10, 2020, France was on lockdown, in an effort to hamper the surge of COVID-19-related hospitalizations. The same mobility limitations were enforced across the country, but their impact was different in different areas. The mobility re-adjustments that followed lockdown were also heterogeneous. Our previous report [1] described mobility during lockdown all over France. It revealed that Paris and its region (Île-de-France) warrant special attention for their outlying behavior, as well as socioeconomic importance: they account for 1/3 of French GDP, and 1/5 of its population. Also, the area was witnessing a rampaging epidemic at the beginning of lockdown, with hospitals and ICUs at near saturation. In this report, we analyze mobility within Paris city limits, among its 20 arrondissements (neighborhoods), and incoming traffic from Paris to its surrounding region. Assessing the impact of movement restrictions and its re-adaptation to lifted restrictions in the densest European urban area can help planning ahead in case of additional epidemic waves.

DATA

We used travel flows reconstructed from anonymized mobile phone trajectories provided by the Orange Business Service Flux Vision. These data were available on all of France and recorded numbers of trips among all possible pairs of ~1500 administrative subunits. Administrative subunits are EPCI (Établissements Publics de Coopération Intercommunale). Spatial resolution was higher inside Paris, reaching the arrondissement (neighborhood) level. A trip was defined as a displacement between two consecutive locations in which a user spent at least 1 hour. Data were stratified by age, and adjusted by the data provider to be representative of the general population.

Mobile phone data were previously anonymized in compliance to privacy requirements, reviewed and approved by the French National Commission for Data Protection (CNIL, Commission Nationale de l'Informatique et des Libertés), ruling on all matters related to ethics, data, and privacy.

MOBILITY WITHIN PARIS

Figure 1 shows the evolution over time of the total number of trips among the 20 arrondissements of Paris (Fig. 1a) and all over France (Fig. 1b) with daily resolution, from January 6 to June 7, 2020. Focusing on the mobility within Paris four stages naturally appear:

- 1) **unperturbed mobility**: until around March 12 the epidemic did not seem to affect mobility. Mid-February reduction is due to school holidays.
- 2) **pre-lockdown adaptation**: during the days preceding lockdown enforcement (March 17) traffic dropped sharply. This might be partially due to the fact that on March 16 and the morning of March 17 many people left the city to spend lockdown elsewhere (see also Ref. [1]).
- 3) **lockdown**: mobility was generally stable during lockdown - and markedly lower than the unperturbed stage. A slight upward trend starting mid-April is visible, possibly signaling a relaxation in population compliance, as recommendations did not change over this period.
- 4) **post-lockdown**: mobility has been increasing since authorities started lifting containment measures on May 11. The phase-out of lockdown is occurring in successive phases, each lasting 3 weeks, however no sharp jump from phase 1 to phase 2 was reported. The increase in mobility documented in Paris is lower than the national average. This discrepancy may be due to: (i) a lower population during lockdown and exit phases, compared to pre-lockdown conditions, as a fraction of Parisians left the city to spend this period in other regions (about 11 % on lockdown enforcement, with one third going back in the exit phases); (ii) stricter regulations on the use of public transport specific to Île-de-France region; (iii) a larger fraction of jobs impacted by restrictions (e.g. restaurants, cinemas, sport and leisure activities) coupled with a larger availability of doing telework [1]; (iv) a higher perception of risk in the population given the larger epidemic burden experienced in the region [1] and the current epidemic levels that are higher compared to other regions.

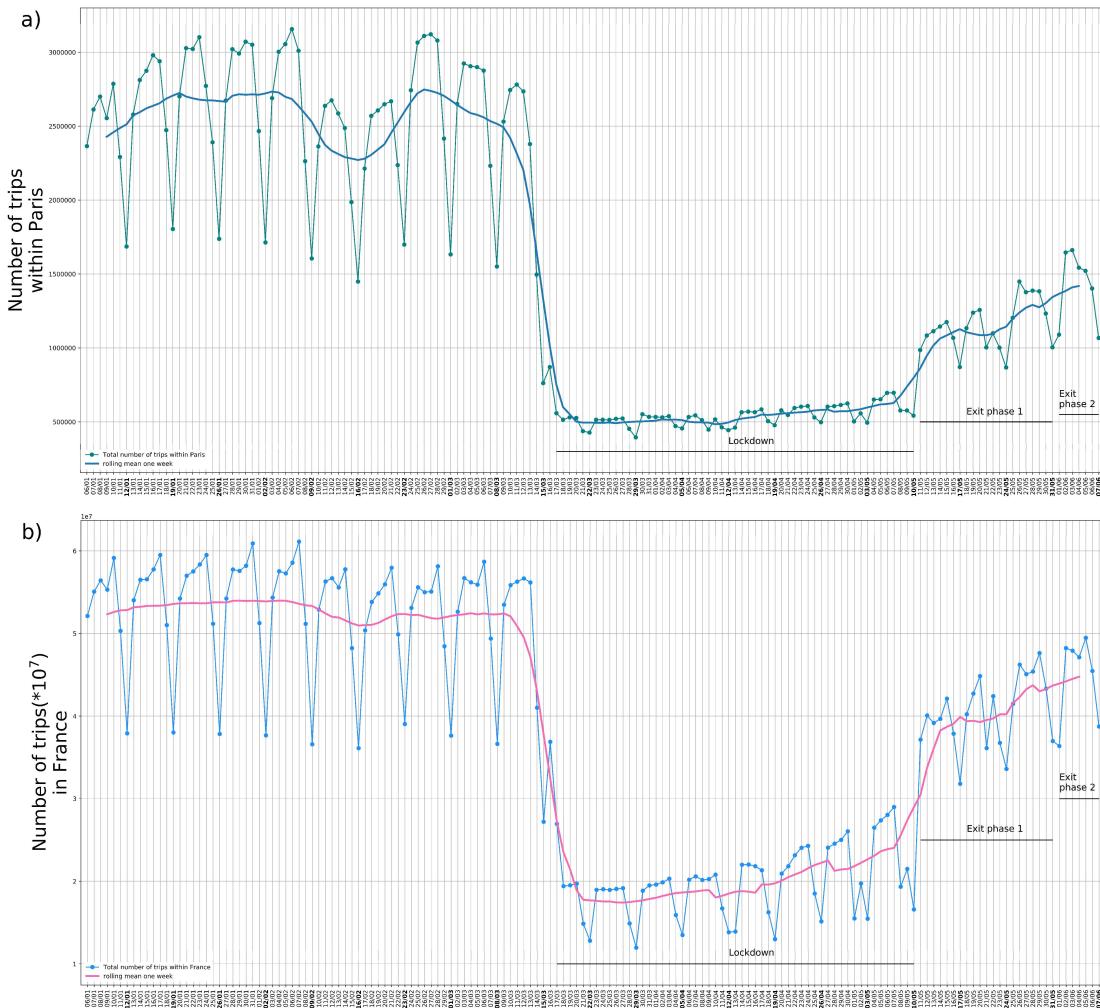
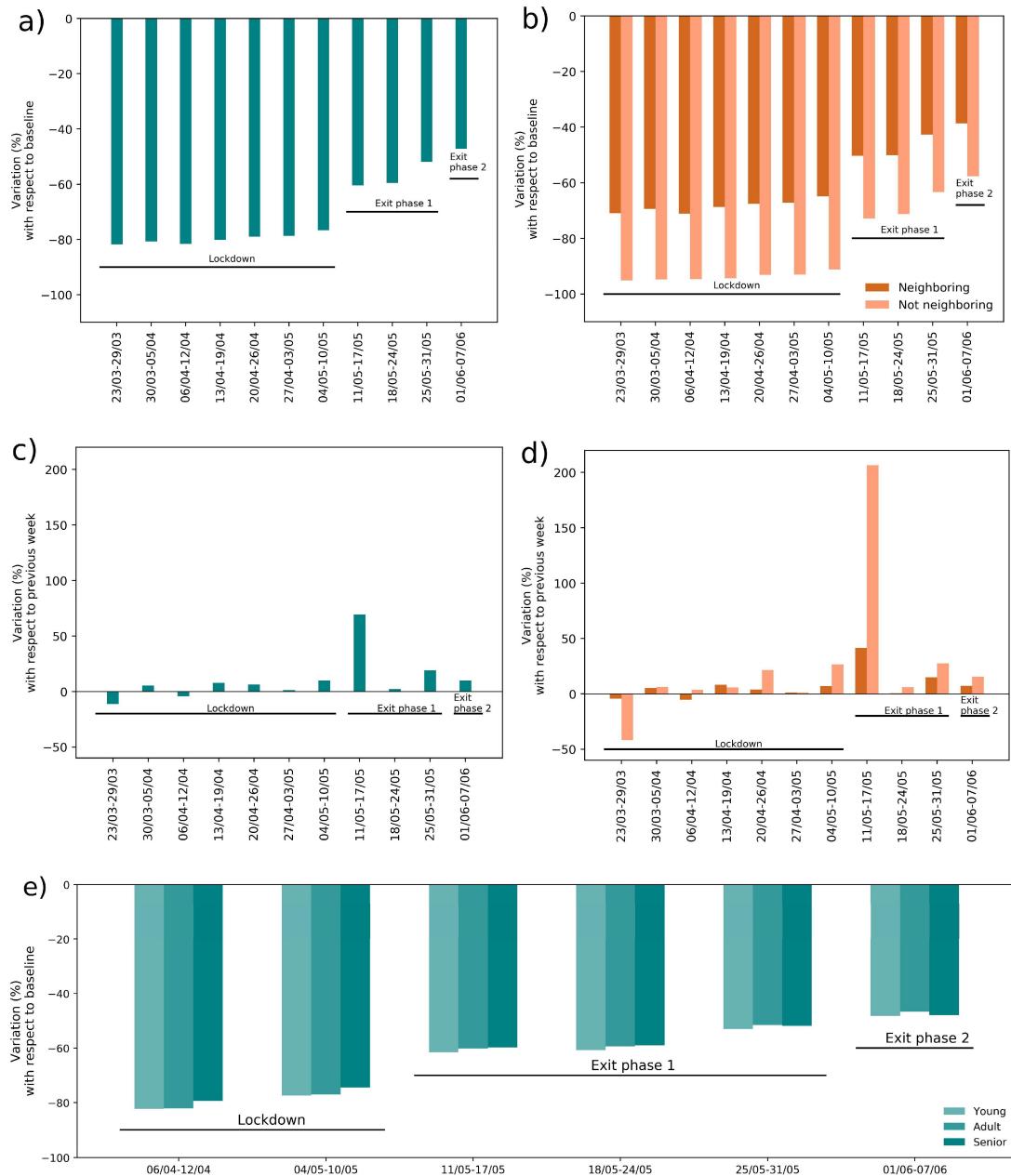


Figure 1. Number of trips within Paris and in France during the period from January 6 to June 7. Total number of trips over time is shown together with a centered moving average computed over 7 days. Lockdown, and the successive Exit phases are shown for reference.

Figure 2 focuses on lockdown and post-lockdown stages. It reports weekly variations in mobility within Paris with respect to a baseline week from the unperturbed stage (February 3-9, panels a, b), and with respect to the previous week (panels c, d). The choice of the baseline week avoids the disruption of strikes and mobility changes due to school holidays. Overall mobility reduction during lockdown ($\sim -80\%$) was much higher than what found at the level of the country ($\sim -65\%$, see also Ref. [1]) (Fig. 2a). And such reduction was even higher for non-neighboring arrondissements: traffic among non-adjacent areas all but stopped during lockdown, due to stay-at-home recommendations and the drop in demand for, and supply of, public transportation. This type of traffic was also the one with the highest relative bounce back to higher values when phasing out lockdown (Fig. 2d), with a 200% increase in the first week of Exit phase 1. In the same week, traffic among neighboring arrondissement increased by less than 50%. Figure 2e

breaks down results by age class: young (younger than 18 y.o.), adult (18-64 y.o.) and senior (65+ y.o.). No substantial difference was observed across age classes.



MOBILITY PATTERNS WITHIN PARIS

Mobility connections among arrondissements naturally identify as a network. To focus on network structure rather than raw volumes, we defined the weight of the link from arrondissement i to arrondissement j as the probability that a trip starting in i ends in j. **Figure 3** shows the network in four selected weeks: the baseline week (February 3 – February 9), one week into lockdown (April 6 – April 12), the first week post-lockdown with the beginning of Exit phase 1 (May 11 – May 17), and the first week into Exit phase 2 (June 1 – June 7). **Figure 3a-d** shows the status of these probabilities in the form of an adjacency matrix. **Figure 3e-h** shows as an example the egocentric network of the 19th arrondissement. Before lockdown, the probability of a trip starting from the 19th arrondissement and ending into a neighboring arrondissement is higher, however connections to all other arrondissements have non-negligible probabilities, around 5%. Lockdown is instead characterized by trips almost exclusively joining neighboring arrondissements (>25% probabilities compared to <2% to other arrondissements). Mobility then crystallizes almost exclusively around the connections that had the largest probabilities to occur before restrictions were put in place, the other being almost completely discarded. The first week after lockdown shows a mobility pattern that remains very similar to the lockdown phase: connections to neighboring arrondissements remain high (>20%) and longer trips are still negligible (<3%). In the first week into Exit phase 2 (June 1 – June 7) the tendency to return to the pre-lockdown pattern is present, but without a significant increase in farther distance mobility (~ 3%, about half of its value before lockdown). Not only overall traffic has not gone back to normal values yet, but mobility patterns are still perturbed with respect to baseline.

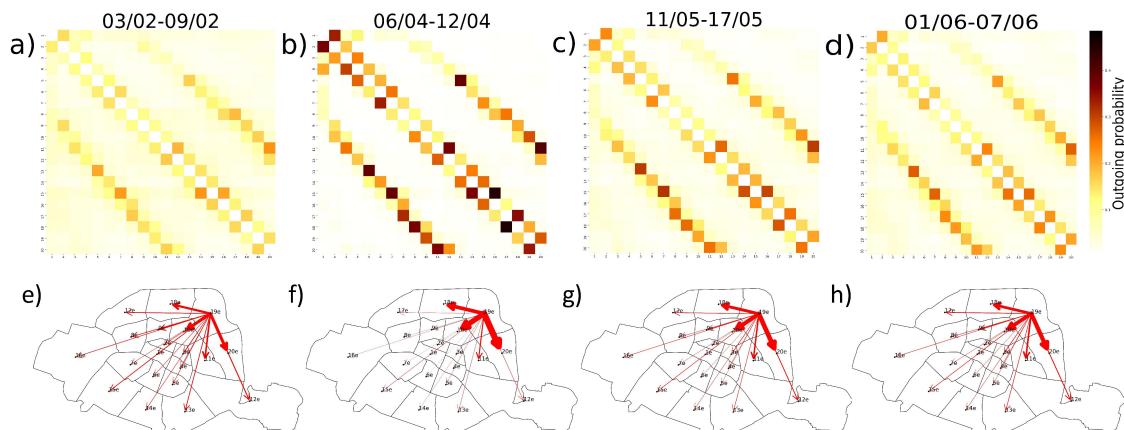


Figure 3. Outgoing probability. a) Outgoing probability before lockdown in the baseline week (February 3 – February 9). b) Into lockdown (April 6 – April 12). c) At the beginning of Exit phase 1 (May 11 – May 17). d) At the beginning of Exit phase 2 (June 1 – June 7). e) Egocentric outgoing network of the 19th arrondissement in the baseline week. f) 19th arrondissement in the week into

lockdown. g) 19th arrondissement in the first week of Exit phase 1. h) 19th arrondissement in the first week of Exit phase 2. Links are weighted with the outgoing probability of the corresponding week.

CHANGES IN MOBILITY FROM ÎLE-DE-FRANCE TO PARIS

Lockdown disrupted commuting, which constitutes a large part of traffic coming into Paris in normal times. This caused mobility to Paris from the surrounding region to be highly suppressed during lockdown, as **Figure 4** shows. Lockdown reduced incoming mobility even more than internal mobility (90% vs. 80%). Variations with respect to the previous week (**Fig. 4b**) show slight fluctuations during lockdown. For instance, the reduction in the week starting April 27 could be due to the May 1 holiday, as holidays typically lead to a reduction of trips. Exit phase 1 began with almost a 100% increase with respect to the previous week, settling at a -60% mobility compared to baseline. Again, no substantial change across age groups is visible (**Fig. 4c**).

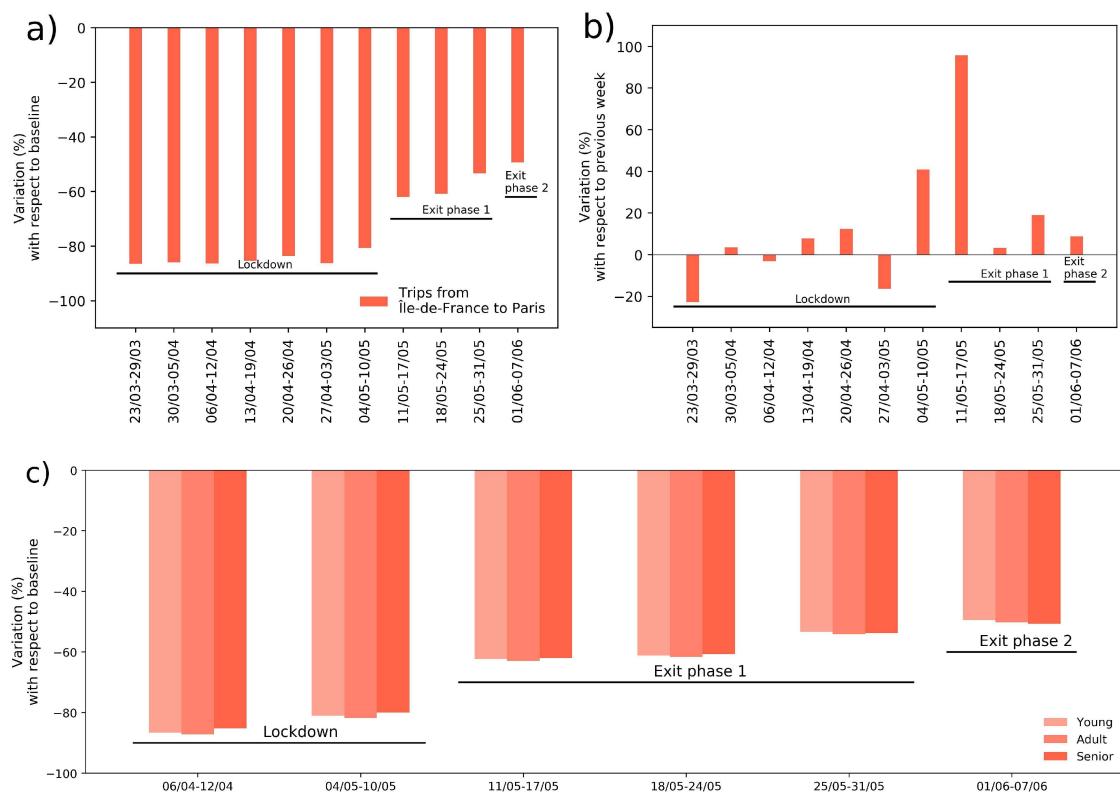


Figure 4. Variation in mobility from Île-de-France to Paris. a) Variation of the number of trips respect to the baseline (February 3 – February 9) in 7 weeks during lockdown (March 23 – May 10) in the three weeks of Exit phase 1 (May 11 – May 31) and in the first week into Exit phase 2 (June 1 – June 7). b) Variation of the total number of trips each week respect to the previous. c) Variation in mobility respect to the baseline divided by age classes (young-adult-senior) in two weeks during lockdown (April 6 – April 12 and May 4 – May 10), in the three weeks of Exit phase 1 (May 11 – May 31) and in the first week into Exit phase 2 (June 1 – June 7).

CONCLUSIONS

Lockdown had a largest impact in the city of Paris compared to the rest of the country. Mobility is increasing at a slower rate, exiting lockdown, with respect to the national average. Patterns of displacements within the city are not yet restored to pre-lockdown conditions.

REFERENCES

1. Pullano, G., Valdano E., Scarpa, N., Rubrichi, S. & Colizza, V. Population mobility reductions during COVID-19 epidemic in France under lockdown. medRxiv 2020.05.29.20097097 (2020)