


Reciprocal association between voting and the epidemic spread of COVID-19: observational and dynamic modeling study

Jean-David Zeitoun^{1,2}, Matthieu Faron^{3,4,5}, Sylvain Manternach⁶, Jérôme Fourquet⁷, Marc Lavielle^{8,9}, Jérémie H. Lefèvre ^{10,11}

1 Centre d'Epidémiologie Clinique, Hôtel Dieu Hospital, Assistance Publique-Hôpitaux de Paris, Paris, France

2 Department of Gastroenterology and Nutrition, Hôpital Saint-Antoine, Assistance Publique-Hôpitaux de Paris, Paris, France

3 Department of Surgical Oncology, Gustave Roussy Cancer Campus Grand Paris, Villejuif, France

4 Department of Biostatistics and Epidemiology, Gustave Roussy Cancer Campus Grand Paris, Villejuif, France

5 INSERM U1018 CESP, Oncostat Team, Université Paris-Sud, Université Paris-Saclay, Villejuif, France

6 Paris

7 IFOP, Paris, France

8 Inria, Rocquencourt, France

9 Institut Polytechnique de Paris, CMAP, Ecole Polytechnique, CNRS, Paris, France

10 Department of Digestive Surgery, Sorbonne Université, AP-HP, Hôpital Saint Antoine, Paris, France

11 Equipe "Instabilité des Microsatellites et Cancers", Equipe labellisée par la Ligue Nationale contre le Cancer, INSERM, UMRS 938 – Centre de Recherche Saint-Antoine, Paris, France

Correspondence : Jean-David Zeitoun, Centre d'Epidémiologie Clinique, Hôtel Dieu Hospital, Assistance Publique-Hôpitaux de Paris, Paris, France, Tel: +33 (0)1.42.34.89.87, e-mail: jdzeitoun@yahoo.fr
Marc Lavielle and Jérémie H. Lefèvre contributed equally to this work.

Background: Whether voting is a risk factor for epidemic spread is unknown. Reciprocally, whether an epidemic can deter citizens from voting has not been often studied. We aimed to investigate such relationships for France during the coronavirus disease 19 (COVID-19) epidemic. **Methods:** We performed an observational study and dynamic modelling using a sigmoidal mixed effects model. All hospitals with COVID-19 patients were included (18 March 2020–17 April 2020). Abstention rate of a concomitant national election was collected. **Results:** Mean abstention rate in 2020 among departments was $52.5\% \pm 6.4\%$ and had increased by a mean of 18.8% as compared with the 2014 election. There was a high degree of similarity of abstention between the two elections among the departments ($P < 0.001$). Among departments with a high outbreak intensity, those with a higher participation were not affected by significantly higher COVID-19 admissions after the elections. The sigmoidal model fitted the data from the different departments with a high degree of consistency. The covariate analysis showed that a significant association between participation and number of admitted patients was observed for both elections (2020: $\beta = -5.36$, $P < 1e^{-9}$ and 2014: $\beta = -3.15$, $P < 1e^{-6}$) contradicting a direct specific causation of the 2020 election. Participation was not associated with the position of the inflexion point suggesting no effect in the speed of spread. **Conclusions:** Our results suggest that the surrounding intensity of the COVID-19 epidemic in France did not have any local impact on participation to a national election. The level of participation had no impact on the spread of the pandemic.

Introduction

The first wave of the outbreak of coronavirus disease 19 (COVID-19), the viral pneumonia related to severe acute respiratory syndrome coronavirus 2, has led the French government to impose a mandatory national containment.¹ It was officially advertised by the French President on 12 March 2020, yet containment was scheduled to be fully effective as of 17 March 2020. The first round of the municipal elections for mayor designation in all French cities was to be held on 15 March 2020, i.e. between the announcement and the implementation of the containment, while the phase III of the epidemic has been declared on 14 March 2020.

Most governments worldwide have faced difficulties in determining what events implying human gatherings could be maintained and which ones should be cancelled or postponed. Data were either nonexistent or lacked external validity to adequately inform decision makers. Even more than 1 year after the inception of the pandemic, there is an ongoing debate over the effectiveness of lockdown measures, what should be their precise content, not to mention their

negative social impact.^{2,3} The case of elections is even less well documented and atypical. Indeed, elections are not perse a human gathering event. They effectively involve a substantial part of a countries population, yet they are not supposed to actually aggregate as much people as artistic or sporting events usually do. The decision of the French government to maintain the 2020 elections for mayor designation has been a matter of national controversy.⁴ Containment had already been decided and defined as a protective public health measure, and many stakeholders claimed that barrier gestures and other countermeasures would not be properly applied along the event in every voting office. The elections took place, yet national participation was historically low as compared with prior occurrences of the same types of elections. Anecdotal reports in the lay press suggested that some city officials were affected by COVID-19 or even died from it within days or weeks following the elections.⁵ However, we still do not know what may have been the actual mutual influences between the epidemic and those elections. Whether the people participation was influenced by the surrounding intensity of epidemic has not been analyzed. On the other hand, whether the holding of those elections has been a worsening factor

increasing the spread of the epidemic is unknown. The same questions have raised up after an election in the USA occurring in Wisconsin, Berry AC, submitted for publication.⁶ However, the local scope of this election is not representative of the potential impact of a nationwide election.

We sought to answer these two questions by examining the pattern of COVID-19 spread before and in the wake of the elections, and by studying its possible association with the level of voting participation.

Methods

We retrieved demographic characteristics regarding the 95 French departments, which were our geographic unit of analysis: number of inhabitants and surface. In France, areas between departments vary widely, ranging from 176 to 9976 km² (mean value = 5880 km²), and the median value of population per department is 529 468 (inter quartile range = 277 632–867 480). We also collected data regarding the epidemic around the time of the elections and after the elections: number of deaths, number of hospitalized patients. All those data were found in governmental data sources, namely the National Institute for Statistics and Economic Studies (*Institut National de la Statistique et des Etudes Economiques*) and Public Health France (*Santé Publique France*). Finally, we constructed a specific dataset about participation at the first round of the elections in each French department both in 2014 and 2020. The former date corresponds to the prior version of the same type of election and was deemed necessary not only to measure recent participation but also to compare it in each department with its own predicate. This was made through exhaustive data gathered by IFOP, an international polling institute, city by city, which were then summed to obtain participation rate at the department level.

Observational analysis

The departments were categorized depending on a composite criterion based on an evaluation of the intensity of the outbreak just before the election, i.e. from 24 January 2020 through 18 March 2020. This latter date was chosen since it was the closest date for which public data were exhaustively available and since it was

assumed that data at this time would also be highly reflective of what was perceived by people at the time of the elections. Three subgroups were created: so-called high-intensity departments (more than 70 proven cases and/or more than 25 admitted patients), medium-intensity departments (30–70 proven cases and/or 10–25 admitted patients) and low-intensity departments (<30 proven cases and < 10 admitted patients).

Statistical analysis and modeling

A sigmoidal mixed effects model was used to describe the cumulative number of admissions for 100 000 habitants: $f = Nmax \times [\exp(k \times t) - 1] / [\exp(k \times t) + \exp(k \times \tau)]$. Such model has three parameters: the final level $Nmax$, the rate of increase k and the midpoint of increase τ . Random effects on the three parameters of the model made it possible to take into account the variability of the number of admissions between departments. Log-normal distributions were used for the three parameters. A covariate analysis then made it possible to analyze how part of the interdepartmental variability of the model parameters could be explained by the participation rates in the 2014 and 2020 elections. Monolix 2019R2 was used to implement and fit the model to the data.

Research ethics approval

This study used administrative and anonymized data that do not permit any reidentification, as well as public data. Use of such data complies with the European General Data Protection Regulation and does not require any approval from an ethics committee according to the French law.

Results

During the pre-election period, only 278 deaths had been reported in France making this criterion irrelevant for a proper classification of the departments. Generation of the three subgroups of departments was based upon the 2954 admitted patients and 4114 cases that were recorded in the pre-election period (table 1). The more intense was the outbreak, the more populated and denser were the departments (table 1).

Table 1 COVID-19 epidemic, demographic data in the pre-electoral period and participation to the vote

Variables	All departments (n = 95)	High intensity (n = 34, 35.8%)	Medium intensity (n = 23, 24.2%)	Low intensity (n = 39, 41%)
Pre-electoral period				
Total number of deaths (min–max)	278 (0–74)	262 (0–74)	10 (0–3)	6 (0–1)
Total proven cases (min–max)	4114 (0–688)	2944 (22–688)	798 (10–58)	372 (0–29)
Total admitted patients (min–max)	2954 (0–371)	2603 (0–371)	255 (4–23)	96 (0–9)
Demographic characteristics				
Median population (IQR)	532 886 (278 360–906 554)	826 741 (547 824–1 423 607)	653 660 (326 875–1 173 526)	287 382 (203 368–398 146)
Median superficies km ² (IQR)	5938 (5088–6775)	5233 (3387–6193)	6260 (5909–6837)	6002 (5196–6848)
Population density (hab/km ²) (IQR)	82.63 (50.78–166.65)	188.79 (97.72–425.33)	96.54 (66.69–161.73)	48.19 (32.58–67.27)
Median number of cities (IQR)	327 (246–493)	353 (173–600)	343 (274–478)	298 (244–421)
Electoral data 2020				
Median registered individuals (IQR)	374 337 (205 176–694 583)	561 657 (389 752–798 869)	454 440 (288 921–718 362)	211 686 (151 615–309 141)
Ratio registered/population (IQR)	72.38% (68.39–76.84)	67.45% (62.26–71.20)	72.52% (69.19–75.55)	75.98% (72.41–78.03)
Median number of votes (IQR)	175 311 (99 270–272 243)	258 117 (175 350–370 765)	226 356 (136 119–331 587)	103 872 (84 976–159 378)
Median abstention rate (IQR)	53.7% (48.2–57.0)	57.7% (53.4–60.3)	54.1% (50.6–56.6)	48.2% (43.8–53.4)
Electoral data 2014				
Median registered individuals (IQR)	373 418 (211 241–684 236)	560 799 (398 295–812 226)	456 858 (272 354–781 811)	220 278 (164 054–302 588)
Median number of votes (IQR)	243 271 (144 477–383 526)	367 042 (247 695–506 980)	308 834 (187 453–503 552)	146 113 (110 797–203 806)
Median abstention rate (IQR)	33.6% (29.8–37.6)	38.9% (34.1–41.8)	33.9% (28.9–36.6)	30.3% (26.7–33.3)
Trends between 2014 and 2020 elections				
Mean increase in abstention	18.83 ± 2.56	19.07 ± 2.59%*	19.70 ± 2.04%*	18.11 ± 2.66%*
17th April status				
Total number of deaths (min–max)	11 450 (0–1132)	9510 (37–1132)	1155 (5–145)	785 (0–74)
Total admitted patients (min–max)	30 940 (5–3083)	24 493 (70–3083)	3948 (29–474)	2499 (5–261)

*: $P < 0.0001$.

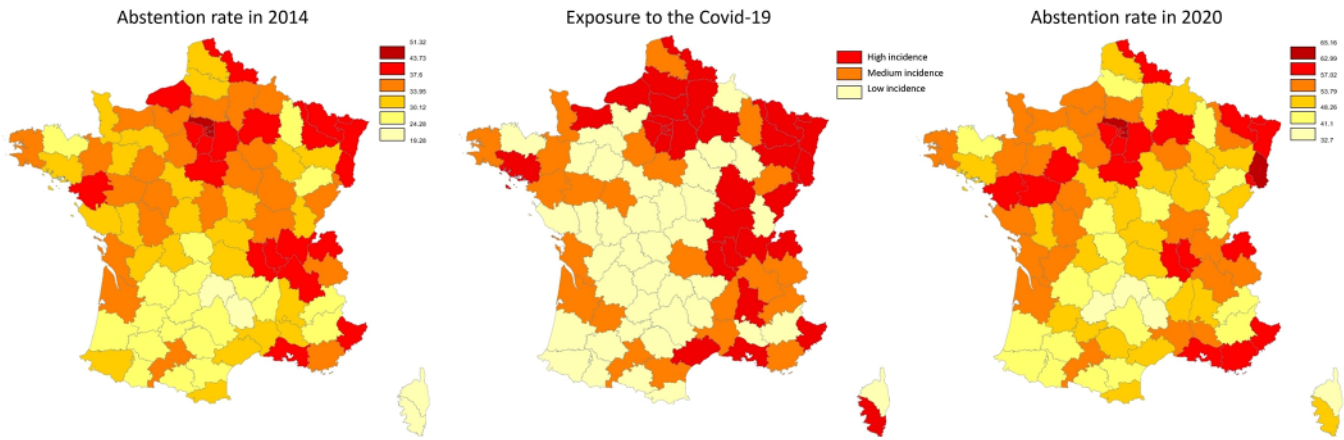


Figure 1 Map of abstention rate among the 95 departments in France after 2014 and 2020 municipal elections and localization of departments among the three groups in COVID-19 incidence before 2020 election

Abstention rate in 2020 had a normal distribution among the 95 French departments with a mean of $52.5\% \pm 6.4\%$. Abstention increased by a mean of 18.8% as compared with the 2014 election. There was a significant difference in the variation of abstention between the three subgroups of departments (table 1). Figure 1 represents the abstention rate in the French departments after the 2014 and 2020 elections, as well as the localization of the departments among the three groups. There was a high degree of similarity between 2014 and 2020 with respect to the patterns of departments as compared with others, i.e. regardless of the absolute level of voting, ‘higher participants’ were approximately the same departments at both elections and ‘lower participants’ also. Also, we found a linear correlation among the departments between the abstention rate in 2014 and 2020 ($P < 0.001$).

The observed curves of admissions following the election in each subgroup of departments are presented in figure 2, with the upper half of departments in terms of participation in red lines and the lower half in blue. Among the departments with a high outbreak intensity, those with a higher participation were not affected by a significantly higher number of admissions for COVID-19 after the elections. Indeed, the departments with a lower participation (i.e. a high abstention) were the ones with more admitted cases. The same divergence was observed in the low intensity departments yet with a smaller difference.

Modeling

Figure 3 showed that the sigmoidal model fitted the data from the different departments with a high degree of consistency. The covariate analysis showed that the 2020 participation explained a very significant part of the variability in the final level N_{max} ($\beta = -5.36$, $P < 1e^{-9}$). However, a similar level of significance was obtained with the 2014 participation ($\beta = -3.15$, $P < 1e^{-6}$), suggesting that the association was most likely due to a confounding variable and not a direct causation specific of the 2020 election.

The difference of participation between the two elections (2020 – 2014) in the covariate model increased slightly the hospitalization rate, but this observed effect was not statistically significant ($\beta = 0.096$, $P = 0.35$).

The relationships between the participation rates and the other two parameters of the model k and τ were not statistically

significant, suggesting that participation had no effect on the speed of spread.

Discussion

Our study is the first national evaluation to date of the reciprocal association between the intensity of the COVID-19 epidemic in France and the level of voting to municipal elections. We did not find any solid evidence suggesting that the level of intensity of the epidemic had a local impact on voting participation. Neither had we found any positive statistical association between the level of participation and the subsequent spread of the epidemic in terms of hospitalizations.

Our study has several strengths. First, it is a nationwide analysis gathering exhaustive data regarding all studied variables and outcomes. Patient outcome data, although aggregated at the department level, are thought to be trustworthy since reporting of hospitalizations, as well as in-hospital deaths from COVID-19 were mandatory. Those data were made publicly available and updated on a daily basis by *Santé Publique France*, a public agency depending upon the French Ministry of Health. Data regarding participation to the vote were all collected and structured in an exhaustive manner by IFOP, a polling institute of reference. Then, we chose to retain hospital admissions as an outcome of the possible impact of people participation since it is a clinically relevant endpoint, and since it would allow an earlier assessment as compared with deaths. Also, we used strong and sophisticated methods, such as maximum likelihood estimation, covariate model building and model validation, for nonlinear mixed effects models.

Our findings may have implications. The fact that people participation was initially found to be commensurate to the local intensity of the epidemic could have suggested that when prevalent and aggressive, the outbreak deterred citizens to go voting. Importantly, the level of abstention at the national scale was historically low, and more than 30 000 mayors were re-elected after this first round, out of approximately 35 000 cities in the whole territory.⁷ However, subsequent accounting for 2014 data showed that there was actually no significant association between the differences in participation between both elections and the local intensity of the outbreak. This in fact suggests that the outbreak may have had a national effect on participation yet independently of local intensity. We also found that on the other hand, while there had been great concern that

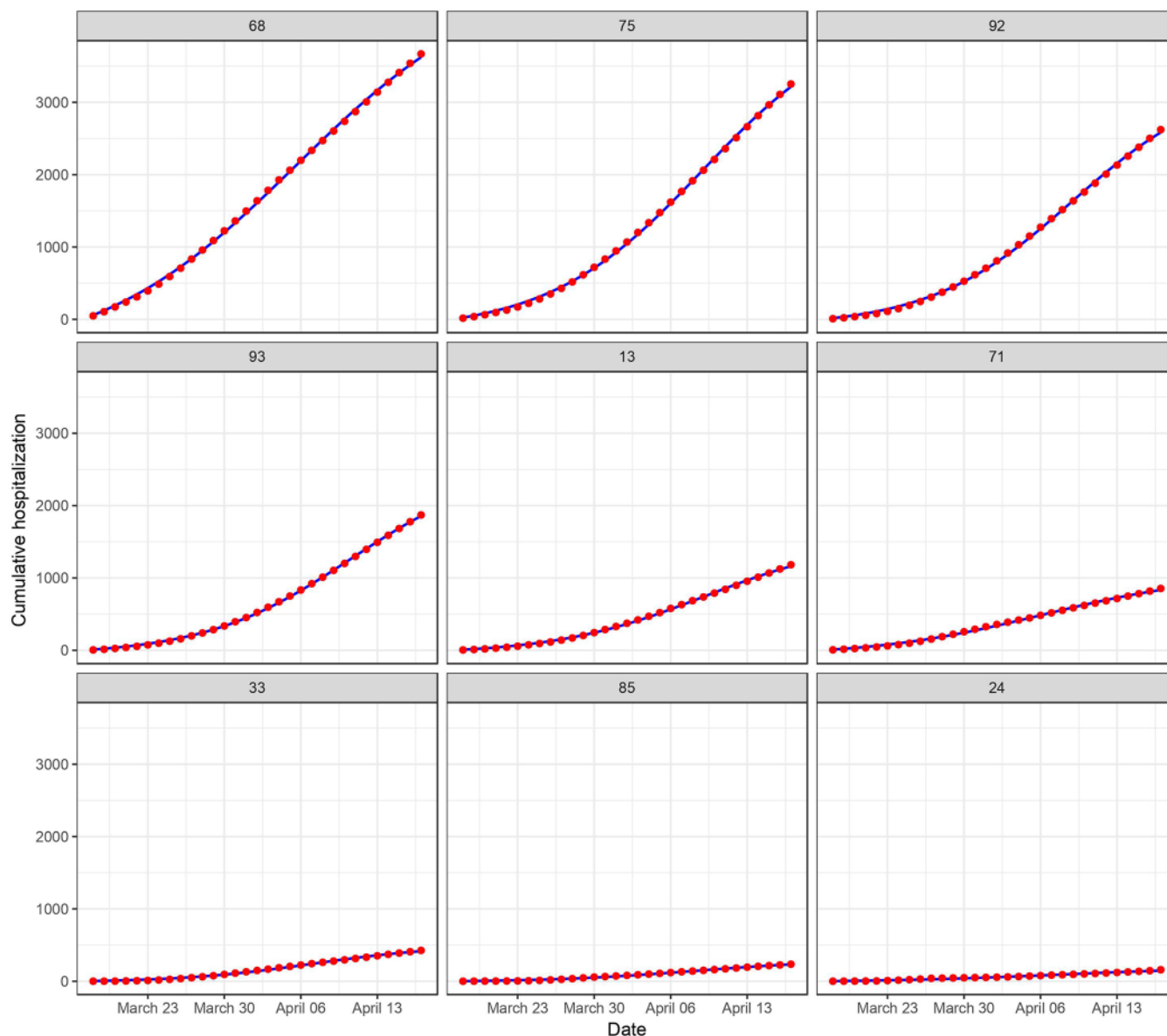


Figure 2 Observed versus predicted cumulative hospitalization number in nine French departments. The red points indicate the observed value, the blue line is the model prediction. The upper panel represent three departments among the high incidence group, the medium panel represent three departments among the medium incidence group and the lower panel represent three departments among the low incidence group

the holding of the elections might trigger an acceleration of the epidemic spread, there was no positive association between the level of participation and subsequent numbers of admitted patients for COVID-19. Even though it has been reported in the lay press that some so-called assessors (city officials or citizen volunteers participating to the counting of the ballots and to the organization in general) were affected by COVID-19 soon after the holding of the elections, we could not identify any significant effect of the level of participation on following local evolution.

Our report has a main limitation, namely its ecological design. We could not access individual data. We cannot exclude the possibility that our results might be confounded by factors that were not measured and cannot establish (or exclude) definitive causality.

Indeed, it is still possible that in some departments, the intensity of the outbreak decreased the level of voting as compared with others. Random surveys from voters and (or) non-voters could have helped to support or to eliminate this hypothesis. Conversely, we cannot exclude that in some cases, voting was a source of transmission. Individual data from voters or at least aggregated data from a lower scale (e.g. municipal) would have allowed to assess this, yet those data do not exist to our knowledge.

In conclusion, we did not find any local effect of the intensity of the COVID-19 epidemic in France on participation to a national election for mayor designation. While there had been a concern that participation could accelerate virus transmission, we did not measure any statistical association between

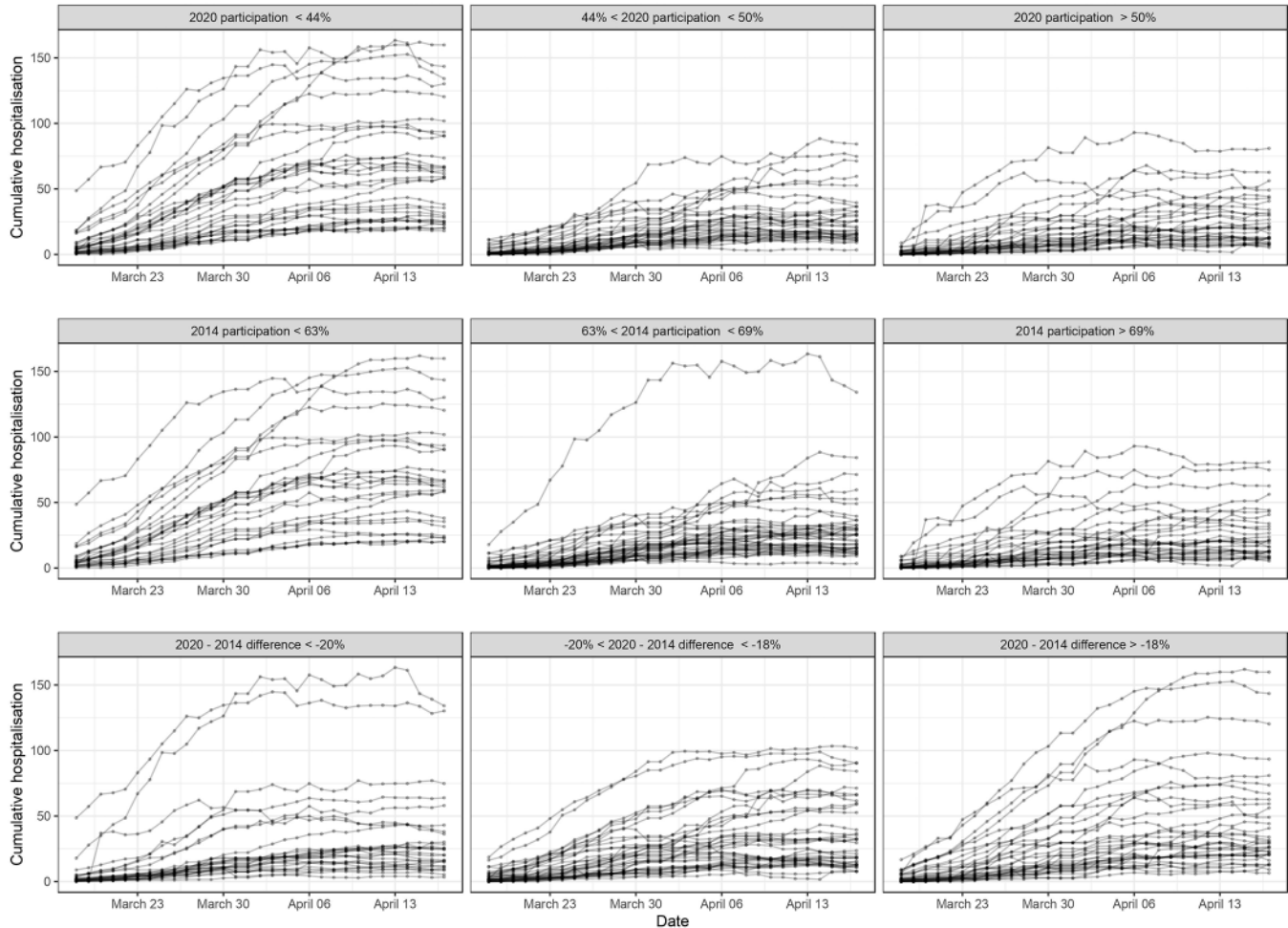


Figure 3 Cumulative hospitalizations over time in tertile of 2020 participation (upper panel), 2014 participation (middle panel) and 2020–14 differences (lower panel). Each line is a French department with the point representing the observed value

participation at a local level and subsequent evolution of the epidemic. Our results do not support the election as an interfering factor for outbreak outcome.

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Supplementary data

Supplementary data are available at *EURPUB* online.

Conflicts of interest: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. No conflict of interest related to the current work was reported. Outside the submitted work, Dr Zeitoun reports being an advisor for several consulting firms in link with pharmaceutical industry (Oliver Wyman, Roland Berger). He also reports speaking fees from a manufacturers' professional association, consulting fees from Ferring, Pierre Fabre, AbbVie, Astra Zeneca, Biogen, Boehringer Ingelheim, Takeda, Novartis, Fujifilm and Johnson & Johnson. He is a personal investor in approximately 30 digital companies, medical device companies or biotech companies, and as a limited partner in several investment funds. He reports being a founding partner of Inato, a company involved in clinical research and whose customers are pharmaceutical companies. Dr Lefèvre reports fees from Ethicon, Takeda and MD Start, invitation to a medical congress by Biomup. He is a consultant for Safeheal. Marc Lavielle is a consultant for Simulation Plus, a software company.

Key points

- While national elections for mayor designation in France (15 March 2020) were maintained despite upcoming containment against the COVID-19 epidemic, whether the participation may have worsened the subsequent trajectory of the outbreak has not been evaluated.
- No worsening of the epidemic was measured in French departments in which people voting rate was higher.
- There was no statistical relationship between the intensity of the outbreak at the local level and change in participation as compared with the prior version of the election.

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