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The French Covid-19 vaccination policy did not solve vaccination inequities: a nationwide study on 64.5 million people

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Background: To encourage Covid-19 vaccination, France introduced during the Summer 2021 a 'Sanitary Pass', which morphed into a 'Vaccine Pass' in early 2022. While the sanitary pass led to an increase in Covid-19 vaccination rates, spatial heterogeneities in vaccination rates remained. To identify potential determinants of these heterogeneities and evaluate the French sanitary and vaccine passes' efficacies in reducing them, we used a data-driven approach on exhaustive nationwide data, gathering 141 socio-economic, political and geographic indicators. **Methods:** We considered the association between vaccination rates and each indicator at different time points: before the sanitary pass announcement (week 2021-W27), before the sanitary pass came into force (week 2021-W31) and 1 month after (week 2021-W35) and the equivalent dates for the vaccine pass (weeks 2021-W49, 2022-W03 and 2022-W07). **Results:** The indicators most associated with vaccination rates were the share of local income coming from unemployment benefits, overcrowded households rate, immigrants rate and vote for an 'anti-establishment' candidate at the 2017 Presidential election. These associations increase over time. Consequently, living in a district below the median of such indicator decreases the probability to be vaccinated by about 30% at the end of the studied period, and this probability gradually decreases by deciles of these indicators. **Conclusions:** Our analysis reveals that factors related to poverty, immigration and trust in the government are strong determinants of vaccination rate, and that vaccination inequities tended to increase after the introduction of the French sanitary and vaccination passes.

Introduction

The rapid development of effective COVID-19 vaccines brought the hope of a rapid return to normalcy, but heterogeneous vaccination rates, both among countries because of inequitable distributions of doses¹ and within countries,^{2,3} jeopardize epidemic control.

Hesitancy and hostility toward vaccination have been comparatively high in France in recent decades.⁴ Modern vaccine hesitancy in France started with claims of a link between the hepatitis B vaccine and multiple sclerosis⁵; it strongly increased following the 2009–10 vaccination campaign against pandemic flu, the contested management of which in France was a tipping point that led to higher vaccine hesitancy and hostility.^{5,6}

The trend was confirmed with the COVID-19 pandemic^{7,8}: just before Covid-19 vaccines became available, intentions to get vaccinated were comparatively very low in France compared to other countries (44% of the respondents⁹ in the Fall 2020; about 40% of respondents¹⁰ in December 2020). Acceptance of the COVID-19 vaccine however gradually grew during 2021.^{10,11}

Spatial heterogeneities in vaccination rates have already been documented in France for previous vaccines. Vaccination coverage

for the hepatitis B vaccine and for the Measles–Mumps–Rubella vaccine has been lower in the South of France, and especially in the South-East of the country.⁶ Distance to the central political power in Paris, as well as a sense of belonging to a local community with a strong cultural identity, has been put forward as potential explanations for this geographic gradient in vaccination rates.⁶

Attitudes toward vaccination are also known to be influenced by social and territorial inequalities. Surveys conducted in 2020 in France showed that respondents with lower education,^{12,13} lower income levels or less trust in authorities^{7,8} were more likely to be hostile to COVID-19 vaccines.

By mid-July 2021, France was facing an epidemic wave due to the Delta variant. To speed up vaccination, President Macron announced on 12 July 2021 the implementation of a domestic 'sanitary pass' (le passe sanitaire), which came fully into force on 9 August 2021. Presenting as a QR code, a long-term sanitary pass was obtained after full vaccination (two doses, or only one dose in the case of a documented previous Covid-19 infection), and a short-term version could be obtained with a negative Covid-19 test. The 'sanitary pass' was required in most cultural venues, for both indoor and outdoor dining and in health structures. This announcement led to an unprecedented

demand for vaccination.¹⁴ Vaccination rates climbed from about 64% of the population over 20 years old by 11 July 2021 (52% of all ages) to 82% on 5 September 2021 (69% of all ages). Because it targeted pay-for social activities, however, the 'sanitary pass' was feared to have a limited impact on vaccination inequities.

By mid-December 2021, at the height of the winter Delta wave, and while the Omicron wave was looming, the French Prime Minister announced that the sanitary pass would become a vaccine pass, i.e. that a negative Covid-19 test would not provide a temporary QR code any longer for adults—making vaccination implicitly mandatory in France. The vaccine pass came into force on 24 January 2022.¹⁵

This study aims to obtain further insights on the socio-economic, political and geographic factor associated with vaccination rates, and to evaluate the effect of the French domestic sanitary pass, by using nationwide, exhaustive datasets.

Methods

Our study follows recommendations provided by the REporting of studies Conducted using Observational Routinely collected health Data.

Study design

This is a retrospective cohort study including the whole French population.

Data

The French state health insurance service (Assurance Maladie) provides public datasets of vaccination rates in France. These datasets are based on aggregated individual data on beneficiaries of the national health insurance service who received health care in the past year. These exhaustive datasets were updated weekly, and are provided at the district scale nationally ['Établissement public de coopération intercommunale' (EPCI), an administrative level gathering multiple towns or cities] and at the suburban scale for the Paris, Lyon and Marseille metropolitan areas. For this study, we focused on mainland France, because vaccination rates are much lower in overseas localities, and because determinants of vaccination rates are likely to differ in overseas localities compared to mainland ones.⁸

The vaccination data are available by age group: 00–19, 20–39, 40–54, 55–64, 65–74, 75 and over. Population sizes for each locality and each age group are also provided.

We paired these vaccination data with three other datasets gathering socio-economic, political orientation and geographic variables.

Socio-economic data are provided by the French national statistics institute (INSEE), and are available at the same administrative levels as the vaccination data. We selected the most recent dataset available (year 2018). The different variables available in the dataset are classified by INSEE according to eight categories (activity, education, employment, family, housing, immigration, income and population).

Latitude, longitude and surface data were extracted from open geographic datasets. We calculated from these measures four additional geographic indicators: distance to Paris, relative position along a South-East–North–West gradient, relative position along a South–West–North–East gradient and local population density.

Political orientation data consisted of the results of the 2017 Presidential election in France, which we aggregated to reconstitute the same administrative levels as the vaccination dataset. This political dataset contains the proportions of votes for each of the 11 candidates of the first round, 2 candidates of the second round (Macron and Le Pen) and proportion of abstention at each round.

These three datasets comprised 312 indicators. We then removed those indicators with over 5% missing data, or with over 0.9 correlation with other indicators of the dataset, which left us with 141 indicators: 123 socio-economic indicators (activity: $n = 10$; education:

$n = 16$; employment: $n = 25$; family: $n = 20$; housing: $n = 30$; immigration: $n = 1$; income: $n = 13$; and population: $n = 8$); 6 geographic indicators; and 12 elections indicators (Supplementary table S1).

Patient and public involvement

Because this study concerns nationwide data, i.e. data on the whole French population, the public was not involved in the design of the study.

Statistical analysis

Vaccination was accessible to all adults in France after 27 May 2021. It opened to teenagers (12- to 17-year olds) on 15 June 2021, and to children (5- to 11-year olds) on 22 December 2021. Because of this differential accessibility of vaccines, and because vaccine pass rules also differed for non-adults, we excluded the 00–19 age class from our analysis, and focused on vaccination rates among 20+ year-old individuals (hereafter 'adults').

For each indicator in our dataset, at each of the six chosen dates (weeks 2021-W27, 2021-W31, 2021-W35, 2021-W49, 2022-W03 and 2022-W07), we considered the association between living in a district above the median of a that indicator and individual first-dose vaccination rates among adults. Odds ratios (ORs) were computed from the output of a logistic regression. To be able to compare predictors irrespective of the direction of the effect, we considered the maximum of (OR, 1/OR). Note that vaccination data are at the individual level, and indicator data at the district level.

The analysis is done at the individual level, with indicators characterizing the geographic districts in which individuals live. For each date, we determined a significance threshold by computing ORs on 1000 random permutations of a predictor, and identifying the value of the 99% percentile of the maximum of (OR, 1/OR) of these permuted data.

For representative indicators among the most statistically significantly associated ones, we estimated standardized vaccination rates among adults over time, for each decile of each indicator (treated as a factor). These estimations were obtained from a logistic model taking age class into account; adult vaccination rates were standardized using an age distribution matching that of mainland France.

All analysis code is available at <https://doi.org/10.5281/zenodo.7057659>; analyses were done in R version 4.0.4 (15 February 2021).

Results

The vaccination dataset for mainland France encompasses 1555 districts (1228 EPCIs and 327 districts at the suburban scale in Paris, Lyon and Marseille) for about 64.5 million individuals (median district size 22 310 inhabitants, interquartile range 11 012–43 038).

We investigated the associations between each of the 141 indicators characterizing districts of residence, and the fact of having received at least one Covid-19 vaccine dose, on the whole population of mainland France. Two indicators were among the top five most associated ones at all-time points (figure 1 and Supplementary table S1): the share of local income coming from unemployment benefits (strongest association on 23 January 2022, OR = 0.72) and vote for the 'anti-establishment' political party represented by the candidate Asselineau (OR = 0.71 on 20 February 2022). The three other most associated indicators remained the same in the later dates that we considered, and were the proportion of immigrants in the district (OR = 0.71 on 20 February 2022), the district's relative position along a North–West–South–East gradient (OR = 0.74 on 12 December 2021) and the proportion of overcrowded households (OR = 0.74 on 23 January 2022).

To better visualize the effects (or lack thereof) of the sanitary and vaccine passes on vaccination rates over time, we computed age-

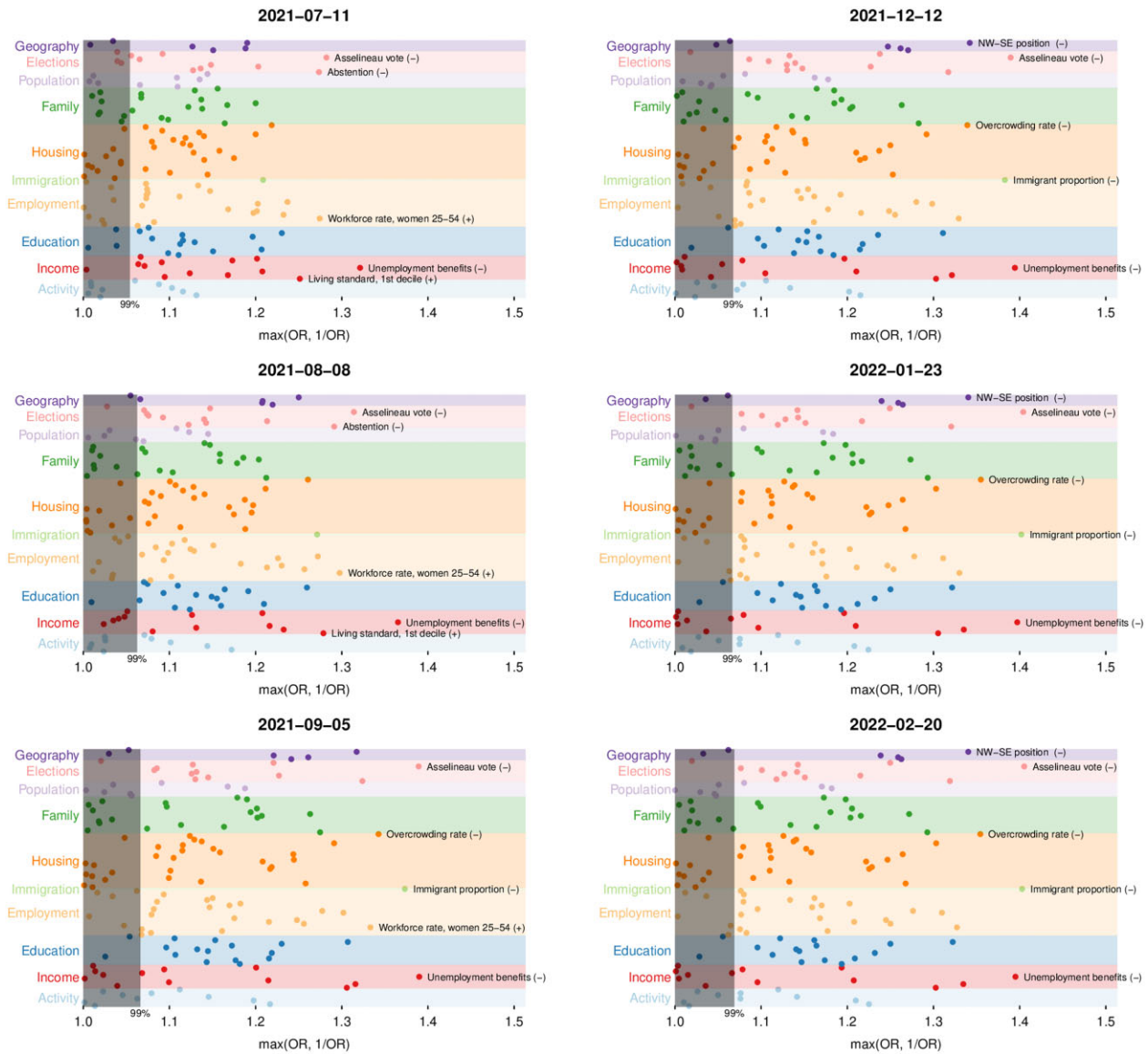


Figure 1 Manhattan plots of the ORs for each of the indicator of our dataset, by date. Left column: around the sanitary pass implementation; right column: around the vaccine pass implementation. The top ORs are labeled at each time point; the symbol next to the name indicates the direction of the effect. The gray rectangle corresponds to the 99% percentile of ORs in the permuted data; points falling in the gray rectangle are considered as non-significant

adjusted vaccination rates over time, by decile of three of the most associated indicators, treated as factors (figure 2).

The sanitary pass, implemented in the Summer 2021, led to an overall increase in vaccination rates; on the other hand, the vaccine pass, implemented in the end of 2021, did not affect the evolution of vaccination rates. Heterogeneities in vaccination rates persisted after both types of pass; vaccination rates gradually decrease by decile of each indicator, confirming the association of these indicators with vaccination rates without threshold effect. Of note, for the Unemployment and Asselineau vote indicators, the difference between the ninth and 10th deciles appears to be much larger than between the other consecutive deciles.

Finally, historically under-vaccinated areas in France stand out as being less vaccinated against Covid-19, in particular the South-East region (figure 3).

Discussion

Our results, based on exhaustive national datasets, indicate that the French sanitary pass, and the later vaccine pass, did not solve Covid-19 vaccination heterogeneities, but instead crystallized them.

Indicators most associated with vaccination rates were associated to poverty, immigration, anti-establishment vote (or abstention) and a North-West—South-East contrast. For instance, the odds for an adult to still be unvaccinated by the end of February 2021 are about 1.4 times higher when living in the districts with higher than median value share of income coming from unemployment benefits than when living in the districts with lower than median value.

The indicators associated to vaccination rates can be interpreted in the light of the dimensions of vaccine hesitancy.¹⁵ A first reason for vaccine hesitancy is complacency: not fully perceiving the benefit of vaccination or the risks of severe disease. While in this case, a sanitary or vaccine pass may convince complacent individuals to get vaccinated, it is less efficient if the associated constrain is low. As the French domestic pass was associated with pay-for activities (restaurants and tourism), its persuading effect could be limited among poorer populations. This may explain the association of lower vaccination rate with poverty in the data that we analyzed: vaccination rates decrease as the share of local income coming from unemployment benefits or the proportion of overcrowded households increase.

A second reason for vaccine hesitancy is confidence, i.e. trust in the vaccine, in the health care system, and more generally in the

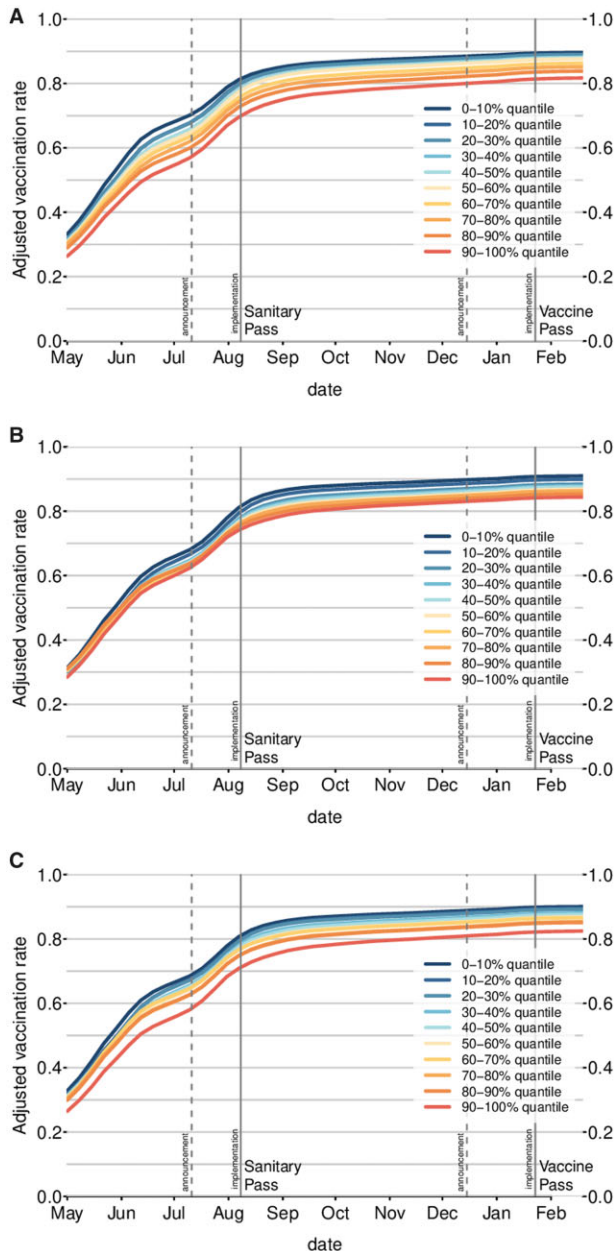


Figure 2 Age-adjusted vaccination rates among adults, over time, by decile of each indicator [(A) unemployment rate; (B) immigrant rate; and (C) Asselineau vote rate]. The vertical lines indicate the dates of announcements and implementations of the sanitary and vaccine passes

government.^{7,15} A survey conducted in July 2021 in France confirmed that trust in the government and trust in scientists were associated to higher odds to be vaccinated.¹⁶ Votes for Mr Asselineau—which represented a minority of cast votes in 2017 in France (<1% overall)—can be interpreted as a marker of mistrust in the government (or more generally, against the establishment): this candidate for instance proposed that France exits the European Union, leave the Euro zone and reinstall the Franc currency; he was a proponent of hydroxychloroquin and ivermectin during the Covid-19 pandemic, and publicly expressed doubts about the safety of available Covid-19 vaccines.¹⁷ The association of higher proportion of votes for Mr Asselineau with lower vaccination rates can be seen as a marker of a lack of confidence for the government. Noteworthy, among political indicators, the second strongest association is with abstention rates (higher abstention rates being

associated to lower vaccination rates), again in favor of higher distrust for institutions.¹⁸ Likewise, the lower vaccination rates in the South-East of France can be interpreted as mistrust of the central government in Paris.

Finally, a third reason for vaccine hesitancy is convenience, i.e. the availability and accessibility of the vaccines.¹⁵ During the first half of 2021, vaccination rate in France was mostly constrained by dose availability. Vaccination slots were to be booked online, and there was no general system for sending individual invitations to get vaccinated. It is therefore still possible that, in spite of some local outreach efforts, vaccine accessibility remained an issue, which may explain at least part of the association of lower vaccination rates with poverty as poor digital literacy is more prevalent among deprived populations. These accessibility issues may also explain the association we find between lower vaccination rates and living in a district with a high proportion of immigrants, which may for instance reveal language barriers. These associations of lower vaccination rates with more poverty and with higher proportions of immigrants in the district of residence are compatible with the results of a survey conducted in July 2021 in France¹⁶ on close to 81 000 participants, which indicated that unvaccinated respondents were more likely to have lower income and more likely to belong to ethnic minorities than vaccinated respondents.

Relative position of the district of residency along a North-West–South-East gradient is also associated with vaccination probability, the South-East being less vaccinated. This geographic feature, already documented for other kinds of vaccination,⁶ has been shown to be associated with a local climate of mistrust for the central Parisian power. General Practitioners based in the South-East, and to a lesser extent those in the South-West, have been shown to have a more negative opinion of vaccination than their colleagues practicing in the northern part of France.¹⁹ Finally, in and around the Marseille metropolis, the image of a rebellious territory was reinforced since the first months of the epidemic in France through the hypermediatized Pr Didier Raoult. Based in Marseille, he was a promoter of a controversial treatment against Covid-19 based on hydroxychloroquine and azithromycin,²⁰ and later held ambiguous positions regarding Covid-19 vaccination.

The design of our study offers several advantages. First, we used a data-driven approach, i.e. we did not focus on indicators that we *a priori* thought to be associated with vaccination rate. The indicators that we identified as the most associated with vaccination rates were not biased toward our previous knowledge or surveys about vaccine hesitancy. Secondly, the data that we used are real-world data on effective vaccination, and not vaccination intentions. Intentions to be vaccinated and realized vaccination may not always match, especially with the introduction of measures like the French sanitary and vaccine passes. For instance, according to a survey conducted in the Fall 2021, the introduction of the sanitary pass led to an increase in the share of individuals reporting being ‘angry they had to be vaccinated’.¹⁵ From an immediate public health perspective, such as the limitation of the number of severe cases, realized vaccination rates are a more useful metric. Finally, the vaccination data, we used are based on records of the national health insurance service: they cover 64.5 million individuals living in mainland France, and vaccination rates are not self-reported, which strongly limits reporting bias.

Still, the design of our study also presents limitations. While our vaccination data are at the individual level, the socio-economic, political and geographic indicators are at the district level, and must therefore be interpreted as such: for instance, we cannot not show that receiving unemployment benefits is associated with lower vaccination probability, but we find an association with lower vaccination probability and the fact of living in a district where a large share of income comes from unemployment benefits. In addition, although the different indicators are analyzed independently in our study, their combinations may affect vaccination rates. For instance,

Adult vaccination rates on 2022-02-20

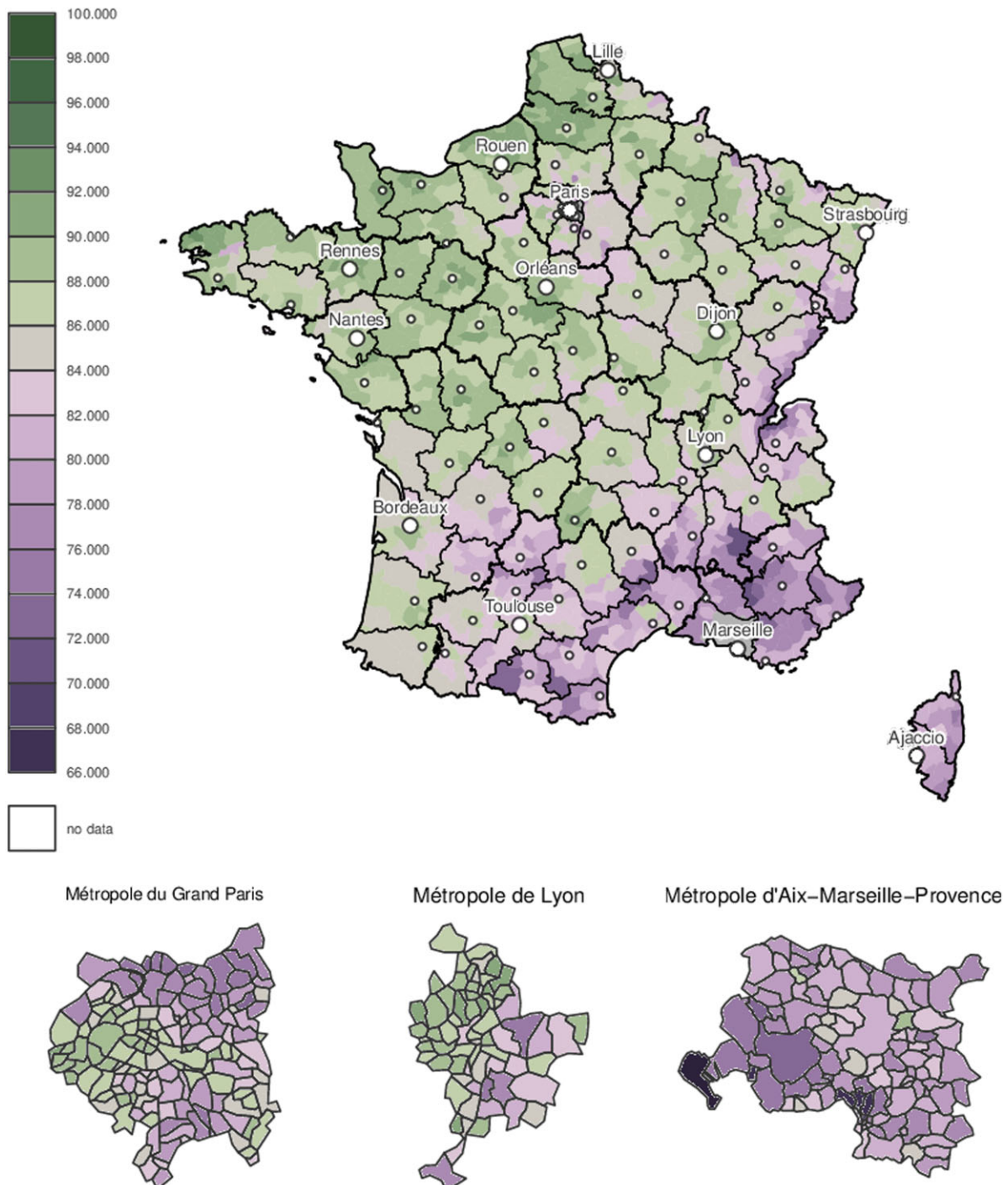


Figure 3 Adult vaccination rates by district of mainland France

the effect of mistrust in the government on vaccination refusal was shown to be even stronger among individuals from lower social classes than from higher social classes.¹⁶ Finally, our data do not inform directly on the reasons for non-vaccination—e.g. whether it is hesitancy, refusal, or accessibility issues, which is why our approach is complementary to qualitative surveys.

To conclude, by emphasizing a differentiated use of COVID-19 vaccination according to a socio-economic gradient, our study confirms the strong impact of social inequalities on COVID-19. Previous research found that the most deprived areas have been disproportionately infected and hospitalized during the pandemic.^{21,22} We further show that poorer districts are also the least vaccinated and,

hence, the most still at risk, despite the widely celebrated domestic sanitary pass. There is an urgent need to define new vaccination policies that truly address social inequities.

Supplementary data

Supplementary data are available at *EURPUB* online.

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Conflicts of interest: None declared.

Research ethics approval

Only open access aggregated data are analyzed for this study, therefore no ethical approval was required.

Data sources

- Assurance Maladie: <https://datavaccin-covid.ameli.fr/explore/dataset/donnees-devaccination-par-epci/> <https://datavaccin-covid.ameli.fr/explore/dataset/donnees-de-vaccination-parcommune/information/>.
- INSEE: <https://www.insee.fr/fr/statistiques/5359146#consulter>.
- 2017 Presidential election: <https://www.data.gouv.fr/fr/datasets/election-presidentielle-des-23-avril-et-7-mai-2017-resultats-definitifs-du-1er-tour-par-communes/#resource-d282e53a-d273-425d-95bb-8a0d7632c79a-header>.

Key points

- In France, living in a district below the median of indicators related to poverty, immigration and trust in the government strongly reduces the probability to be vaccinated.
- This reduction increases over time: before the sanitary pass announcement, this reduction was of about 20% and 6 months later, it reaches about 30%.
- This reduction is gradual along the deciles of these indicators.

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