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Title: Social Inequalities and Dynamics of the early COVID-19 Epidemic. Evidence from France.

Authors

Nathalie Bajos, PhD[1], Emilie Counil*, PhD[2], Jeanna-Eve Franck*, PhD[1], Florence Jusot[3], Ariane Pailhé, PhD[2], Alexis Spire, PhD[1], Claude Martin, PhD[4], Nathalie Lydié, PhD[5], Rémy Slama[6], PhD, Laurence Meyer, PhD[7], Josiane Warszawski, PhD[7]; for the EpiCoV study group**

Affiliations

[1] IRIS, Inserm/EHESS/CNRS, Aubervilliers, France.

[2] Ined, Aubervilliers, France.

[3] Université Paris Dauphine, Paris, France.

[4] ARENES UMR 6051, CNRS, EHESP, Rennes, France.

[5] Santé publique France, Saint-Maurice, France.

[6] University Grenoble Alpes, Inserm, CNRS, Institute for Advanced Biosciences, Grenoble, France.

[7] CESP UMR 1018, Université Paris-Saclay, APHP, le Kremlin-Bicêtre, France.

***These authors contributed equally to this work**

****The EpiCoV study group**

EpiCoV study group: Nathalie Bajos (co-principal investigator), Josiane Warszawski (co-principal investigator), Guillaume Bagein, Muriel Barlet, François Beck, Emilie Counil, Florence Jusot, Aude Leduc, Nathalie Lydie, Claude Martin, Laurence Meyer, Ariane Pailhé, Nicolas Paliod, Delphine Rahib, Philippe Raynaud, Alexandra Rouquette, Patrick Sicard, Rémy Slama, Alexis Spire.

Correspondence to

Dr Nathalie Bajos, Institut de Recherche Interdisciplinaire sur les enjeux Sociaux - Sciences sociales, politique, santé, IRIS (UMR 8156 CNRS - EHESS - U997 Inserm) 5 cours des humanités, 93322 Aubervilliers cedex, France.
Tel: +33 (0)6 66 32 30 00. nathalie.bajos@inserm.fr

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ABSTRACT

Objective Although social inequalities in COVID-19 mortality by race, gender and socioeconomic status are well documented, less is known about social disparities in infection rates and their shift over time. We aim to study the evolution of social disparities in infection at the early stage of the epidemic in France with regard to the policies implemented.

Design Random population-based prospective cohort.

Setting From May to June 2020 in France.

Participants Adults included in the EpiCoV cohort (n=77,588).

Main outcome measures Self-reported anosmia and/or ageusia in three categories: no symptom, during the first epidemic peak (in March 2020) or thereafter (during lockdown).

Results In all, 2,045 participants (1.53%) reported anosmia/ageusia. The social distribution of exposure factors (density of place of residence, overcrowded housing and working outside the home) was described. Multinomial regressions were used to identify changes in social variables (gender, class and race) associated with symptoms of anosmia/ageusia. Women were more likely to report symptoms during the peak and after. Racialized minorities accumulated more exposure risk factors than the mainstream population and were at higher risk of anosmia/ageusia during the peak and after. By contrast, senior executive professionals were the least exposed to the virus with the lower rate of working outside the home during lockdown. They were more affected than lower social classes at the peak of the epidemic, but this effect disappeared after the peak.

Conclusion The shift in the social profile of the epidemic was related to a shift in exposure factors under the implementation of a stringent stay-at-home order. Our study shows the importance to consider in a dynamic way the gender, socioeconomic and race direct and indirect effects of the COVID-19 pandemic, notably to implement policies that do not widen health inequalities.

Keywords: COVID-19; Social inequalities; Gender; Social class; Race

ARTICLE SUMMARY

Strengths and limitations of the study

- EpiCoV is a large random socio-epidemiological prospective cohort including both detailed social characteristics, exposure risk factors and date of first COVID-19-Like symptom(s), enabling us to study the dynamic of the pandemic social profile.
- We focused on the most specific symptoms of SARS-CoV2 infection - anosmia/ageusia - which makes our analyses more robust.
- Our outcome is based on reported symptoms rather than on biologically confirmed cases due to the lack of tests at the time of the survey.
- Highly vulnerable populations, such as homeless people, are not represented in our sample.

INTRODUCTION

The COVID-19 pandemic that has been hitting the world since the beginning of the year 2020 has reinforced and strengthened social inequalities in health[1-3]. This evidence mostly comes from mortality-based studies[4 5]. Few studies are based on the incidence of COVID-19[6], while the disease has an infection case-fatality ratio below 1%[7]. Most of these analyses are from the USA and the UK, which have strong specificities in terms of healthcare systems and social and ethnic inequalities. They are based on ecological studies, not allowing to consider socioeconomic inequalities at the individual level and to adjust for potential confounders[4]. In addition, the literature very little addressed the dynamics of social inequalities as the epidemic evolves and prevention measures are implemented, measures that may themselves have differential efficiency across social and ethnic groups and between sexes. Notable exceptions are Wright et al[8] (in the United Kingdom) and Jefferies et al[9] (in New-Zealand), who found trends towards lower risk of suspected COVID-19 and lower testing rates of SARS-CoV-2 among people of lower socioeconomic status during the early weeks of the epidemic and a higher risk and higher testing rates subsequently.

Few studies showed that the prevention policies put in place, in particular the mobility restrictions and the strong incentive to work remotely, were more beneficial to the most privileged classes in terms of disease incidence[10 11]. This suggests that the social distribution of exposure factors may had changed over time, as has been previously found for other influenza pandemics[12 13].

Our objective was to study the dynamics of gender, race and social class-related inequalities in COVID-19 disease incidence at the early stage of the epidemic in France. We adopted an intersectional approach[14] that simultaneously takes into account these three social factors[15].

We first compared the occurrence of reported anosmia and/or ageusia - a specific proxy of disease incidence - by socio-demographic characteristics between the first peak of the epidemic, around March 19th, until the beginning of June 2020, when the incidence decreased following the first lockdown[16]. Then we studied how the distribution of three important risk factors of COVID-19 exposure and infection, *i.e.* population density, overcrowded housing and working outside the home[17], varied across socio-demographic groups. Finally, we studied how the association of social characteristics with anosmia/ageusia evolved during and after the epidemic peak while adjusting for exposure risk factors and health variables.

PARTICIPANTS AND METHODS

Study design and participants

The EpiCoV (Epidémiologie et Conditions de Vie) cohort was set-up in April 2020, with the general aim of understanding the main epidemiological, social and behavioral features of the COVID-19 epidemic in France. The data collection period ran from May 2nd to June 2nd, 2020. In France, strict lockdown expanded from March the 17th to May the 10th and the first epidemic peak was recorded around March 19th[16].

A stratified random sample of 350,000 people aged 15 and over was drawn from the tax database of the National Institute of Statistics and Economic Studies (INSEE), which covers 96% of the population living in France, but excludes people living in institutional settings. People belonging to the lowest decile of income were over-represented. A total of 134,391 (38.4%) participated in the survey. Individuals were invited to answer the questionnaire online, or by phone if they did not have Internet access.

We used reweighting and marginal calibrations in the survey and sampling design to correct for non-participation bias. We focused on people living in metropolitan France, aged 18-64

years, in order to take into account working arrangements and type of occupation in the analysis (n=98,787).

Ethical statement

The survey was approved by the CNIL (French independent administrative authority responsible for data protection) on April 25th 2020 (ref: MLD/MFI/AR205138) and by the "Comité de protection des personnes" (French equivalent of the Research Ethics Committee) on April 24th. The survey also obtained an agreement from the "Comité du Label de la statistique publique", proving its adequacy to statistical quality standards.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Outcome

Participants were invited to report COVID-19-Like symptoms (such as cough, fever, dyspnea, anosmia and/or ageusia), if they were unusual and if they were present at or occurred since the beginning of the lockdown. They also reported when the first symptom appeared. The main health outcome studied here was reporting symptoms of anosmia and/or ageusia, the most specific symptoms of SARS-CoV2 infection[18 19 17]. Among those who did not report anosmia/ageusia, the analysis was restricted to people without reported cough, fever or dyspnea in order to exclude possible COVID-19 cases (n=14,080). Individuals whose symptoms started before lockdown were also not considered in the analysis to avoid overrepresentation of long-lasting forms of COVID-19 (n=844).

A distinction was made between those people whose first symptoms began more than one month before their response to the survey, likely to have occurred *during* the epidemic peak, and those whose first symptoms began less than one month before, likely to have occurred

after the peak, during the epidemic decline phase (during and early after lockdown). Our outcome was in three categories: no reported anosmia/ageusia (nor cough, fever or dyspnea), anosmia/ageusia starting during the epidemic peak, anosmia/ageusia starting after the epidemic peak.

Socio-demographic variables

We considered the following six variables: age, sex, ethno-racial status (based on migration history), social class (based on current or most recent occupation combined with education), standard of living (based on decile of income per household consumption unit) and formal education (defined according to the hierarchical grid of diplomas in France). The ethno-racial status distinguished mainstream population, *i.e.* persons residing in metropolitan France who are neither immigrants nor native to French Overseas Departments (DOM, *i.e.* Martinique, Guadeloupe, Reunion Island), nor descendants of immigrant(s) or of DOM native[20]. For the minority population, a distinction was made according to the first (immigrants) and second (descendants of immigrants) generations of immigration, and the country of origin. The term racialized refers to people from the Maghreb, Turkey, Asia and Africa.

Exposure risk factors

We considered three main risk factors of exposure to COVID-19: high density of the place of residence (*i.e.* at least 1,500 inhabitants per km^2 and a minimum of 50,000 inhabitants), overcrowded housing (*i.e*. at least two persons living in housing with less than $18m^2$ per person) and having worked outside the home during lockdown (at least partly). Additional explanatory variables included self-reported essential occupations and household size. To account for regional variations in incidence, we distinguished between the least affected and the three most affected regions at the time of the survey.

Health variables

Health variables included smoking habits, self-reported history of chronic diseases and body mass index.

Statistical analyses

We first studied the association between the three social variables of interest (gender, race, social class) and anosmia/ageusia, distinguishing between the two periods, and then with the exposure risk factors (density, overcrowding and working outside) using Chi2-test. To study how the social characteristics associated with anosmia/ageusia evolved during and after the epidemic peak, we further developed a step by step multinomial analysis adjusted for *(i)* age and social variables (M0), *(ii)* then adding the three main exposure variables and regions (M1), *(iii)* and finally adding health variables (M2).

Observations with missing values on anosmia/ageusia or main social and exposure variables were excluded from our analysis (n=6275, 7.5%). In all, 77,588 individuals were included in our analyses. All analyses were weighted using a Heckman model to take into account the effect of the response mode on the reporting of COVID-19-Like symptoms[21]. Analyses were performed with the SAS software 9.4. A P-value <0.05 was considered statistically significant.

RESULTS

Gendered differences

Women were more likely to have been affected by anosmia/ageusia: 1.84% of women versus 1.22% of men (p<0.01) (Table 1). Sex was not strongly associated with most risk factors of anosmia/ageusia, with the exception of working outside home (44.7% in men *versus* 40.6% in women, p<0.001) (Table 2). The significant association of anosmia/ageusia with gender only weakly attenuated over time, with the crude odds ratio (OR) decreasing from 1.57 (95% CI: 1.40-1.76) to 1.40 (1.14-1.71) (Table 3). While adjusting for other social characteristics (M0),

exposure risk factors (M1) and health variables (M2) did not strongly attenuate the association, inclusion of essential occupations did (Supplementary table 1).

Ethno-racial status

If we now consider ethno-racial affiliation, we find that all minority groups, to varying degrees (from 1.79% to 2.67%, Table 1), reported anosmia more often than the majority population (1.35%, p<0.001).

Ethno-racial affiliation was strongly associated with exposure risk factors, with the exception of working outside home. For example, 72.6% of the racialized first-generation immigrants reported living in a high-density place of residence (compared to 31.8% for the mainstream population, p<0.001) and 41.4% in an overcrowded housing (compared to 8.7% for the mainstream population, p<0.001, Table 2).

Over-risk of reporting anosmia/ageusia was recorded among racialized minorities both during and after the epidemic peak (crude models), although non-significant after the peak for non-racialized second-generation immigrants and racialized first-generation immigrants (Table 3). Adjusting for the exposure risk factors that significantly attenuated the observed associations, both during and after the peak (M1). After further adjusting for health variables, only racialized second-generation immigrants (respectively 1.48 (1.19-1.83) and 1.42 (1.00-2.01) during and after the peak), DOM or descendants of DOM native (1.50 (1.07-2.12) during the peak) and non-racialized first-generation immigrants (1.77 (1.04-3.04) after the peak) remained at higher risk of reporting anosmia/ageusia compared to the mainstream population (M2).

Social class

There were marked differences between occupational classes. The top categories appeared to be most affected by anosmia/ageusia: 1.89% for middle executive professionals, 1.81% for

senior executive professionals and 1.83% for skilled employees, against 0.99% for skilled and 1.11% for low-skilled manual workers (Table 1).

These social groups are differently exposed to risk factors. Although senior executive professionals are more likely to live in high-density areas than low-skilled manual workers (53.5% compared to 27.4%), they are less likely to live in an overcrowded accommodation (10.3% compared to 17.5%) and have more often been able to telework during the lockdown (39.2% have worked outside the home compared to 56.9% for low-skilled manual workers, Table 2).

Marked evolutions are observed over time. In crude models, while the lower social categories and self-employed were significantly less affected than senior executive professionals during the peak, this most privileged social category did not appear to be more at risk of anosmia/ageusia than the others after the peak (Table 3). Only middle executive professionals were at increased risk after the peak, and only simultaneous adjustment on exposure risk factors, health variables, essential occupations and regions lowered this association towards the null (Supplementary Table 1).

Table 1. Socio-demographic characteristics associated with anosmia/ageusia

	Anosmia/ageusia[i] n=2,052 (1.53%)	*P-value**	*Anosmia/ageusia during peak n=1,521 (1.12%)*	*Anosmia/ageusia after peak n=531 (0.41%)*
Age		**<0.001**		
18-24	253 (1.27)		168 (0.86)	85 (0.41)
25-34	431 (1.92)		322 (1.43)	109 (0.48)
35-44	510 (1.83)		379 (1.33)	131 (0.50)
45-54	521 (1.57)		407 (1.22)	114 (0.35)
55-64	337 (1.07)		245 (0.76)	92 (0.31)
Sex		**<0.001**		
Men	773 (1.22)		570 (0.88)	203 (0.34)
Women	1,279 (1.84)		951 (1.37)	328 (0.47)
Ethno-racial status		**<0.001**		
Mainstream population	1,454 (1.35)		1,075 (0.98)	379 (0.36)
Non-racialized first-generation immigrants	94 (2.20)		69 (1.48)	25 (0.72)
Non-racialized second-generation immigrants	108 (1.79)		80 (1.37)	28 (0.42)
Racialized first-generation immigrants	164 (1.86)		127 (1.43)	37 (0.43)
Racialized second generation immigrants	170 (2.62)		125 (1.95)	45 (0.67)
DOM or descendants of DOM native-	62 (2.67)		45 (1.95)	17 (0.72)
Social class		**<0.001**		
Self-employed and entrepreneurs	92 (1.39)		63 (0.91)	29 (0.48)
Senior executive professionals	454 (1.81)		365 (1.45)	89 (0.37)
Middle executive professionals	434 (1.89)		313 (1.35)	121 (0.54)
Skilled employees	203 (1.83)		160 (1.44)	43 (0.39)
Low-skilled employees	356 (1.56)		254 (1.10)	102 (0.45)
Skilled manual workers	125 (0.99)		87 (0.68)	38 (0.31)
Low-skilled manual workers	62 (1.11)		38 (0.76)	24 (0.34)
Never worked and others	326 (1.28)		241 (0.93)	85 (0.35)
Standard of living (in deciles)		**0.003**		
D1	209 (1.41)		140 (0.92)	69 (0.49)
D2-D3	316 (1.33)		221 (0.94)	95 (0.39)
D4-D5	349 (1.49)		255 (1.10)	94 (0.39)
D6-D7	389 (1.47)		295 (1.10)	94 (0.37)
D8-D9	519 (1.77)		388 (1.32)	131 (0.45)
D10	247 (1.74)		209 (1.46)	38 (0.28)
Formal education		**<0.001**		
No diploma	123 (1.43)		82 (0.89)	41 (0.54)
Primary education	74 (1.03)		53 (0.77)	21 (0.25)
Vocational secondary	335 (1.17)		229 (0.80)	106 (0.36)
High school	467 (1.48)		330 (1.03)	137 (0.44)
High school +2 to 4 years	663 (1.82)		502 (1.38)	161 (0.44)
High school +5 or more years	390 (1.95)		325 (1.62)	65 (0.33)
Working arrangement during lockdown		**<0.001**		
Not working and others	669 (1.33)		484 (0.96)	185 (0.38)
Remote working only	376 (1.79)		308 (1.46)	68 (0.33)
Working outside the home partly or only	1,007 (1.62)		729 (1.16)	278 (0.45)
High density of the place of residence		**<0.001**		
No	1,078 (1.21)		778 (0.85)	300 (0.36)
Yes	974 (2.04)		743 (1.56)	231 (0.49)
Overcrowded housing		**<0.001**		
No	1,719 (1.44)		1,280 (1.07)	439 (0.37)

Yes	333 (2.12)		241 (1.47)	92 (0.64)
Number of persons living in the house		**<0.001**		
1	232 (1.34)		175 (1.01)	57 (0.33)
2	472 (1.28)		348 (0.94)	124 (0.35)
3-4	979 (1.61)		720 (1.17)	259 (0.44)
5 or more	369 (1.95)		278 (1.46)	91 (0.49)
Essential occupation		**<0.001**		
No	1,193 (1.39)		908 (1.05)	285 (0.34)
Healthcare workers	205 (2.94)		131 (1.78)	74 (1.16)
Others	654 (1.61)		482 (1.18)	172 (0.43)
Region		**<0.001**		
Least affected regions	866 (1.04)		622 (0.73)	244 (0.31)
Grand Est	305 (2.15)		242 (1.72)	63 (0.43)
Hauts-de-France	215 (1.50)		147 (1.03)	68 (0.47)
Ile-de-France	666 (2.85)		510 (2.16)	156 (0.68)

Significant Chi-2 tests are indicated in bold.

i: symptoms were recorded if they occured between the 17th of March, 2020 and the date of survey (from 2nd of May to 2nd of June, 2020).

*Chi-2 test for anosmia/ageusia during the whole period (yes, no).

Table 2. Socio-demographic characteristics associated with COVID-19 risk factors

	High density of the place of residence *n=27,104 (38.6%)*	Overcrowded housing *n=8,430 (13.2%)*	Worked outside the home during lockdown *n=37,129 (47.7%)*
Age (years)			
18-24	3,506 (38.5)	1,225 (13.9)	2,794 (27.5)
25-34	5,504 (47.2)	2,051 (18.1)	6,366 (50.1)
35-44	6,128 (39.8)	2,786 (19.8)	9,239 (56.0)
45-54	6,298 (35.7)	1,748 (11.6)	11,374 (59.0)
55-64	5,668 (33.5)	620 (4.5)	7,356 (39.1)
Sex			
Men	12,404 (38.1)	3,880 (13.1)	18,148 (50.6)
Women	14,700 (39.0)	4,550 (13.4)	18,981 (44.7)
Ethno-racial status			
Mainstream population	18,772 (31.8)	4,823 (8.7)	30,625 (49.0)
Non-racialized first-generation immigrants	1,128 (51.0)	432 (21.3)	1,100 (47.0)
Non-racialized second-generation immigrants	1,391 (40.1)	360 (11.0)	1,815 (48.1)
Racialized first-generation immigrants	2,894 (72.6)	1,655 (41.4)	1,744 (41.4)
Racialized second generation immigrants	2,297 (68.0)	954 (29.2)	1,303 (37.4)
DOM or descendants of DOM native	622 (56.6)	206 (20.5)	542 (48.5)
Social class			
Self-employed and entrepreneurs	1,133 (32.0)	390 (11.7)	2,671 (68.1)
Senior executive professionals	7,959 (53.5)	1,373 (10.3)	6,448 (39.2)
Middle executive professionals	4,633 (36.4)	1,235 (10.2)	8,142 (57.9)
Skilled employees	2,494 (41.2)	708 (12.2)	3,543 (52.0)
Low-skilled employees	3,885 (36.1)	1,498 (13.7)	7,562 (58.1)
Skilled manual workers	1,589 (28.7)	862 (15.0)	4,466 (66.1)
Low-skilled manual workers	743 (27.4)	515 (17.5)	1,843 (56.9)
Never worked and others	4,668 (38.9)	1,849 (16.7)	2,454 (16.6)
Standard of living (in deciles)			
D1	3,068 (46.9)	1,794 (28.2)	2,796 (34.7)
D2-D3	4,082 (40.4)	2,317 (22.1)	5,405 (45.5)
D4-D5	3,761 (33.1)	1,506 (12.8)	7,065 (53.4)
D6-D7	4,512 (31.9)	1,262 (8.5)	8,595 (54.6)
D8-D9	6,586 (37.7)	1,100 (6.3)	8,973 (47.7)
D10	4,773 (49.8)	385 (4.3)	4,032 (40.1)
Formal education			
No diploma	1,790 (42.9)	1,065 (24.7)	2,052 (42.3)
Primary education	1,093 (34.8)	455 (13.5)	1,375 (39.4)
Vocational secondary	3,670 (27.0)	1,613 (12.1)	8,848 (56.9)
High school	5,356 (34.4)	2,036 (13.2)	8,810 (48.9)
High school +2 to 4 years	8,007 (39.0)	1,991 (10.5)	11,252 (49.0)
High school +5 or more years	7,188 (61.1)	1,270 (11.7)	4,792 (36.5)
Region			
Least affected regions	11,829 (26.8)	4,186 (10.3)	24,673 (51.0)
Grand Est	1,829 (26.4)	551 (9.1)	3,814 (49.3)
Hauts de France	2,294 (34.2)	858 (12.3)	3,631 (44.5)
Ile-de-France	11,152 (83.4)	2,835 (24.8)	5,011 (37.8)

All socio-demographic variables were significantly associated with each three COVID-19 exposure risk factors (P-value <0.001, Chi-2 tests), except sex with high density (P-value=0.051) and overcrowded housing (P-value=0.30).

Table 3. Factors associated with anosmia/ageusia during or after the first epidemic peak (as compared to no reported anosmia/ageusia starting after lockdown). Multinomial logistic regressions.

	M0				M1		M2	
	Crude model		+ Social variables		+ Exposure variables[a]		+ Health variables	
	During peak OR (95% CI)	*After peak OR (95% CI)*	*During peak OR (95% CI)*	*After peak OR (95% CI)*	*During peak OR (95% CI)*	*After peak OR (95% CI)*	*During peak OR (95% CI)*	*After peak OR (95% CI)*
Age								
18-24	1	1	1	1	1	1	1	1
25-34	**1.68 (1.36-2.07)**	1.18 (0.87-1.60)	**1.44 (1.15-1.80)**	1.03 (0.77-1.47)	**1.45 (1.16-1.82)**	1.04 (0.73-1.48)	**1.43 (1.14-1.80)**	0.93 (0.66-1.32)
35-44	**1.56 (1.27-1.91)**	1.22 (0.91-1.65)	**1.36 (1.09-1.68)**	1.07 (0.76-1.51)	**1.41 (1.13-1.76)**	1.08 (0.76-1.52)	**1.37 (1.10-1.72)**	0.90 (0.64-1.27)
45-54	**1.43 (1.17-1.74)**	0.86 (0.63-1.18)	**1.30 (1.05-1.61)**	**0.77 (0.54-1.09)**	**1.37 (1.10-1.70)**	0.80 (0.55-1.14)	**1.31 (1.05-1.63)**	**0.63 (0.44-0.90)**
55-64	0.89 (0.71-1.11)	0.76 (0.54-1.06)	0.84 (0.66-1.06)	**0.67 (0.44-1.02)**	0.91 (0.72-1.14)	0.73 (0.47-1.12)	0.84 (0.66-1.07)	**0.54 (0.36-0.82)**
Sex								
Men	1	1	1	1	1	1	1	1
Women	**1.57 (1.40-1.76)**	**1.40 (1.14-1.71)**	**1.52 (1.34-1.71)**	**1.37 (1.10-1.70)**	**1.52 (1.35-1.72)**	**1.38 (1.11-1.71)**	**1.51 (1.34-1.70)**	**1.42 (1.14-1.77)**
Ethno-racial status								
Mainstream population	1	1	1	1	1	1	1	1
Non-racialized first-generation immigrants	**1.52 (1.16-2.00)**	**2.00 (1.14-3.53)**	**1.55 (1.18-2.04)**	**2.08 (1.18-3.65)**	1.25 (0.95-1.65)	**1.71 (1.00-2.94)**	1.26 (0.95-1.66)	**1.77 (1.04-3.04)**
Non-racialized second-generation immigrants	**1.40 (1.07-1.82)**	1.16 (0.77-1.76)	**1.41 (1.09-1.84)**	1.17 (0.77-1.77)	1.26 (0.97-1.64)	1.08 (0.71-1.63)	1.26 (0.96-1.64)	1.07 (0.71-1.62)
Racialized first-generation immigrants	**1.46 (1.18-1.80)**	1.20 (0.82-1.75)	**1.52 (1.23-1.88)**	1.24 (0.84-1.83)	1.08 (0.87-1.35)	0.89 (0.60-1.33)	1.12 (0.89-1.40)	0.95 (0.64-1.42)
Racialized second generation immigrants	**2.01 (1.63-2.48)**	**1.87 (1.34-2.63)**	**1.97 (1.59-2.43)**	**1.79 (1.27-2.51)**	**1.46 (1.18-1.81)**	1.39 (0.98-1.98)	**1.48 (1.19-1.83)**	**1.42 (1.00-2.01)**
DOM or descendants of DOM native	**2.01 (1.43-2.81)**	**2.02 (1.21-3.36)**	**1.96 (1.40-2.75)**	**1.93 (1.16-3.24)**	**1.50 (1.07-2.11)**	1.56 (0.93-2.60)	**1.50 (1.07-2.12)**	1.50 (0.89-2.52)
Social class								
Self-employed and entrepreneurs	**0.62 (0.47-0.83)**	1.30 (0.77-2.19)	**0.66 (0.49-0.88)**	1.35 (0.81-2.27)	0.77 (0.57-1.04)	1.30 (0.77-2.18)	0.79 (0.58-1.07)	1.25 (0.74-2.11)
Senior executive professionals	1	1	1	1	1	1	1	1
Middle executive professionals	0.93 (0.79-1.10)	**1.47 (1.09-1.98)**	0.92 (0.78-1.08)	**1.44 (1.07-1.95)**	1.04 (0.88-1.24)	**1.43 (1.05-1.94)**	1.05 (0.88-1.24)	**1.36 (1.00-1.85)**
Skilled employees	0.99 (0.81-1.21)	1.07 (0.73-1.58)	0.83 (0.67-1.02)	0.91 (0.62-1.35)	0.95 (0.77-1.17)	0.93 (0.62-1.39)	0.95 (0.77-1.17)	0.91 (0.61-1.35)

Low-skilled employees	**0.76 (0.64-0.91)**	1.23 (0.90-1.68)	**0.70 (0.59-0.84)**	1.17 (0.85-1.61)	**0.80 (0.66-0.97)**	1.09 (0.77-1.53)	**0.81 (0.67-0.99)**	1.00 (0.71-1.41)
Skilled manual workers	**0.47 (0.35-0.62)**	0.83 (0.55-1.24)	**0.51 (0.39-0.67)**	0.89 (0.59-1.33)	**0.61 (0.46-0.82)**	0.85 (0.55-1.30)	**0.63 (0.47-0.83)**	0.79 (0.51-1.21)
Low-skilled manual workers	**0.52 (0.35-0.79)**	0.93 (0.57-1.54)	**0.52 (0.34-0.78)**	0.91 (0.55-1.51)	0.65 (0.43-1.00)	0.90 (0.53-1.51)	0.67 (0.44-1.02)	0.82 (0.49-1.39)
Never worked and others	**0.64 (0.54-0.77)**	0.94 (0.67-1.33)	**0.64 (0.53-0.78)**	0.85 (0.57.1.29)	0.81 (0.64-1.01)	0.85 (0.54-1.33)	0.81 (0.64-1.01)	0.80 (0.51-1.25)
High density of the place of residence								
No	1	1			1	1	1	1
Yes	**1.83 (1.64-2.05)**	**1.38 (1.14-1.68)**			1.21 (1.06-1.38)	0.96 (0.77-1.21)	**1.21 (1.06-1.38)**	0.95 (0.76-1.20)
Overcrowded housing								
No	1	1			1	1	1	1
Yes	**1.38 (1.19-1.62)**	**1.74 (1.32-2.31)**			1.03 (0.87-1.21)	**1.41 (1.05-1.89)**	1.04 (0.88-1.22)	**1.41 (1.05-1.89)**
Working arrangement during lockdown								
Remote working only	1	1			1	1	1	1
Not working and others	**0.65 (0.56-0.76)**	1.13 (0.84-1.53)			1.00 (0.82-1.21)	**1.41 (1.00-1.99)**	0.99 (0.82-1.21)	1.34 (0.95-1.88)
Working outside the home partly or only	**0.80 (0.69-0.92)**	**1.36 (1.03-1.81)**			**1.18 (1.01-1.38)**	**1.65 (1.22-2.21)**	**1.19 (1.02-1.40)**	**1.64 (1.21-2.20)**

Significant associations are indicated in bold.
a: including regions (data not shown).

DISCUSSION

Main study results

Our results are based on data documenting exposure factors and symptoms during the first epidemic wave. By distinguishing infections which probably occurred at the time of the epidemic peak (just before or in the very first days after the start of lockdown), from those which occurred later (during and early after the lockdown, as the epidemic declined), a change in the social profile of the affected people emerged. This allowed us to unmask social characteristics and exposure risk factors that increased the risk of infection during and/or after the first epidemic peak, which would have been masked by an analysis over the whole period. Our results point that women and ethno-racial minorities were at higher risk of anosmia/ageusia during the peak and after. While senior executive professionals were more affected than lower social classes at the peak of the epidemic, this effect disappeared after.

We show that important exposure factors likely to increase contact with the virus, *i.e.* the density of the place of residence, living in overcrowded housing, and having worked outside the home during lockdown[4 17] have not been evenly distributed across social groups, and also that some social groups do cumulate these risk factors. Hence, racialized minorities, the least educated, and those with the lowest financial resources are particularly affected by living in densely populated communities and overcrowded housing. These data reflect the well-documented effects of socio-spatial segregation policies[20]. Furthermore, among those who continued to work during lockdown, working class groups have been more likely to work outside the home than senior managers who were able to work remotely, to a large extent.

Interpretation of findings

The persistent increased risk of anosmia/ageusia among women compared to men are likely to reflect occupational specificities, beyond the categories used here. Indeed, women are

over-represented in the nursing and care assistant occupations as well as in cleaning activities[22]. In addition, they take care of children and the elderly[23 24],which may increase their social contacts. This greater exposure of women raises questions as they are shown to be less likely to die from COVID-19 than men, which may partly reflect their lower rates of comorbidities[5].

With regard to ethno-racial status, the persistent higher risk of reporting anosmia/ageusia among racialized people was not linked to a lower propensity to wear a mask[11]. It may instead be indicative of social contacts in neighborhoods where the circulation of the virus was and remained higher over time, as suggested by our results, since their increased risk was substantially attenuated after adjusting for density of place of residence and overcrowded housing. Understanding determinants of infection among those minorities throughout the epidemic is all the more so important as a higher likelihood of dying from COVID-19 was reported in many countries, including France[5 9 25].

Whereas senior executive professionals were more affected than lower social classes at the peak of the epidemic, this effect disappeared afterwards. Only middle executive professionals were at higher risk during the epidemic decline, which was likely due to the presence of health professionals, particularly nurses, in this group, as this association totally disappeared when further adjusted for essential occupations. The increased risk among essential occupations was particularly sharp for health professionals, due to the continuous care provided to patients with a high viral load[16]. It is important to note that the other so-called essential occupations were overexposed after the peak of the epidemic, this group includes those in regular contact with the public such as cashiers, bus drivers, etc. Such results call for an in-depth and longitudinal analysis of occupational disparities in COVID-19 exposure based on the combination of type of job (e.g. healthcare, high-contact jobs, etc.), working arrangement

(remote, on-site, layoff), as well as implementation of preventive measures at the worksite. Indeed, the higher risk of infection of people who worked outside the home during lockdown was particularly marked after the peak of the epidemic, *i.e.* during a period of epidemic decline when contact with the virus was proportionally more marked among on-site workers as compared to people who stayed at home.

It should also be noted that the density of the place of residence was no longer related to the reporting of anosmia/ageusia occurring after the peak of the epidemic probably because the virus circulates less in the neighborhood, thanks to the lockdown. On the contrary, overcrowding was significantly associated after the peak only, probably due to the higher risk of COVID-19 transmission linked to unavoidable close proximity and/or large number of people in the household. Background rates and circulation patterns of SARS-CoV-2 should be considered while looking at the social and spatial dynamics of the epidemic[26], as they influence the relative importance of community and workplace transmission[27].

Study limitations

Our analysis has nevertheless some limitations. First, as any national population-based survey, the study fails to capture highly vulnerable groups such as undocumented migrants and homeless people, who are particularly affected by the pandemic[28].

Additionally, due to a shortage of tests at the national level in the early stage of the epidemic, our analyses are based on reported symptoms of anosmia/ageusia rather than on biologically confirmed cases. This excludes infected people reporting other symptoms, and of course asymptomatic individuals who represent one out of six of the infected population according to a recent meta-analysis[29].

Although anosmia/ageusia reporting may be socially differentiated, especially due to differences in recognition of symptoms, it is reasonable to assume that such a bias did not

vary during the month of the survey. One might also think that women are more likely to report anosmia/ageusia since they have a heightened sense of smell compared to men, as shown by sociological studies[30]. Nevertheless, the ratio of women to men reporting such symptoms is only slightly larger than that recorded for seroprevalence in a sub-sample of the same cohort[31] as found in other European countries[32].

We chose to focus on anosmia/ageusia only, which are the most specific symptoms of COVID-19[18 19], so that our analyses would be more robust[33]. Indicative of internal validity, our results are consistent with epidemiological surveillance data by region[34] as well as with data on increased risk of infection in people with chronic conditions[16 35], and instead a protective effect of smoking[36].

Finally, while it was not possible to build clear-cut periods of "likely infection" based on the timing of symptoms reported by the participants, the broad distinction made between people for whom symptoms started during the epidemic peak *versus* after it, allowed us to compare an early stage of the epidemic with the phase of decline in the incidence corresponding to the first lockdown in France.

Conclusion

To our knowledge, EpiCoV is one of the first socio-epidemiological surveys conducted among a very large random sample of a national population that simultaneously considers living conditions and health data and allows for an intersectional analysis of social inequalities by gender, ethno-racial status and social class. Our results show the importance of closely monitoring social changes over time to implement prevention policies that do not contribute to increasing the already significant social inequalities in health. In all, the associations reported during the epidemic peak – lower exposures among low-skilled jobs than senior executives, over-exposure among all ethno-racial minorities compared to the majority

population, with a strong influence of overcrowding and population density – are likely to reflect the social profile and associated risk factors that prevailed just before the implementation of stay-at-home measures and national lockdown. By contrast, those observed after the peak point to a shift in the social profile of the epidemic related to a shift in exposure factors under the implementation of stringent collective prevention measures. They notably stress the importance of working outside the home, all the more so in essential occupations, particularly, though not exclusively, for healthcare workers[37]. The persistent excess risk among women and some ethno-racial minorities call for further research.

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Competing interest

None

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Authors and contributors

Dr. Bajos had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Bajos, Counil, Franck

Data acquisition: IPSOS.

Data analysis and interpretation: Bajos, Counil, Franck, Meyer, Warszawski

Drafting of the manuscript: Bajos, Counil, Franck

Critical revision of the manuscript for important intellectual content: All authors.

Statistical analysis: Franck, Khun

Obtained funding: Slama

Administrative, technical, or material support: Durlemand, Lydié, Rahib

Study supervision: Bajos and Warszawski

Data availability statement

Data are available from the corresponding author on reasonable request.

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Supplementary Table 1

Factors associated with anosmia/ageusia during or after the epidemic peak (as compared to no reported anosmia/ageusia starting after lockdown). Multinomial logistic regressions.

	Crude model		Full adjusted model	
	During peak OR (95% CI)	*After peak OR (95% CI)*	*During peak OR (95% CI)*	*After peak OR (95% CI)*
Age				
18-24	1	1	1	1
25-34	**1.68 (1.36-2.07)**	1.18 (0.87-1.60)	**1.51 (1.20-1.91)**	0.93 (0.65-1.33)
35-44	**1.56 (1.27-1.91)**	1.22 (0.91-1.65)	**1.39 (1.11-1.74)**	0.90 (0.64-1.27)
45-54	**1.43 (1.17-1.74)**	0.86 (0.63-1.18)	**1.34 (1.07-1.67)**	**0.64 (0.44-0.91)**
55-64	0.89 (0.71-1.11)	0.76 (0.54-1.06)	0.92 (0.72-1.18)	**0.59 (0.38-0.91)**
Sex				
Men	1	1	1	1
Women	**1.57 (1.40-1.76)**	**1.40 (1.14-1.71)**	**1.48 (1.31-1.68)**	**1.27 (1.02-1.59)**
Ethno-racial status				
Mainstream population	1	1	1	1
Non-racialized first-generation immigrants	**1.52 (1.16-2.00)**	**2.00 (1.14-3.53)**	1.27 (0.97-1.68)	**1.85 (1.09-3.17)**
Non-racialized second-generation immigrants	**1.40 (1.07-1.82)**	1.16 (0.77-1.76)	1.26 (0.97-1.64)	1.08 (0.72-1.64)
Racialized first-generation immigrants	**1.46 (1.18-1.80)**	1.20 (0.82-1.75)	1.09 (0.87-1.36)	0.96 (0.65-1.43)
Racialized second generation immigrants	**2.01 (1.63-2.48)**	**1.87 (1.34-2.63)**	**1.44 (1.16-1.79)**	**1.42 (1.00-2.01)**
DOM or descendants of DOM native	**2.01 (1.43-2.81)**	**2.02 (1.21-3.36)**	**1.50 (1.06-2.11)**	1.44 (0.85-2.42)
Social class				
Self-employed and entrepreneurs	**0.62 (0.47-0.83)**	1.30 (0.77-2.19)	0.80 (0.59-1.09)	1.44 (0.84-2.45)
Senior executive professionals	1	1	1	1
Middle executive professionals	0.93 (0.79-1.10)	**1.47 (1.09-1.98)**	1.02 (0.86-1.21)	1.18 (0.86-1.61)
Skilled employees	0.99 (0.81-1.21)	1.07 (0.73-1.58)	0.96 (0.78-1.19)	0.93 (0.62-1.39)
Low-skilled employees	**0.76 (0.64-0.91)**	1.23 (0.90-1.68)	0.82 (0.67-1.00)	1.05 (0.74-1.49)
Skilled manual workers	**0.47 (0.35-0.62)**	0.83 (0.55-1.24)	**0.64 (0.48-0.85)**	0.84 (0.54-1.31)
Low-skilled manual workers	**0.52 (0.35-0.79)**	0.93 (0.57-1.54)	0.68 (0.44-1.04)	0.92 (0.54-1.56)
Never worked and others	**0.64 (0.54-0.77)**	0.94 (0.67-1.33)	0.81 (0.65-1.02)	0.89 (0.56-1.41)
High density of the place of residence				
No	1	1	1	1
Yes	**1.83 (1.64-2.05)**	**1.38 (1.14-1.68)**	**1.24 (1.08-1.41)**	0.97 (0.77-1.23)
Overcrowded housing				
No	1	1	1	1
Yes	**1.38 (1.19-1.62)**	**1.74 (1.32-2.31)**	0.92 (0.77-1.10)	**1.35 (0.96-1.90)**
Working arrangement during lockdown				
Remote working only	1	1	1	1
Not working and others	**0.65 (0.56-0.76)**	1.13 (0.84-1.53)	0.99 (0.81-1.22)	1.38 (0.96-1.99)
Working outside the home partly or only	**0.80 (0.69-0.92)**	**1.36 (1.03-1.81)**	1.14 (0.96-1.34)	1.25 (0.92-1.70)
Smoking				
Daily	1	1	1	1
Occasionally	**1.63 (1.25-2.13)**	1.13 (0.74-1.73)	**1.50 (1.14-1.96)**	1.10 (0.72-1.70)
No longer	**1.40 (1.18-1.67)**	0.90 (0.69-1.17)	**1.39 (1.16-1.66)**	0.91 (0.69-1.19)

No	**1.28 (1.09-1.51)**	0.82 (0.64-1.06)	1.11 (0.94-1.32)	**0.74 (0.57-0.95)**
Chronic disease				
No	1	1	1	1
Kidney disease	1.00 (0.46-2.17)	**3.19 (1.11-9.15)**	1.21 (0.55-2.63)	**3.95 (1.36-11.5)**
Other disease	1.09 (0.96-1.23)	**1.52 (1.23-1.88)**	**1.19 (1.04-1.36)**	**1.68 (1.37-2.07)**
Body mass index				
Normal	1	1	1	1
Underweight	0.96 (0.72-1.28)	0.98 (0.60-1.59)	1.00 (0.75-1.34)	0.94 (0.57-1.53)
Overweight	0.86 (0.75-0.98)	1.08 (0.86-1.34)	0.90 (0.79-1.03)	1.11 (0.88-1.40)
Obese	1.06 (0.89-1.25)	**1.44 (1.09-1.91)**	1.06 (0.89-1.27)	**1.38 (1.04-1.84)**
Number of persons living in the house				
1	1	1	1	1
2	0.92 (0.75-1.14)	1.05 (0.73-1.52)	0.99 (0.80-1.22)	1.07 (0.74-1.56)
3 or 4	1.15 (0.95-1.39)	1.35 (0.96-1.91)	1.14 (0.93-1.39)	1.26 (0.88-1.79)
5 or more	**1.45 (1.17-1.80)**	1.50 (1.01-2.21)	**1.42 (1.12-1.81)**	1.20 (0.77-1.87)
Essential occupations				
No	1	1	1	1
Healthcare workers	**1.72 (1.41-2.10)**	**3.49 (2.59-4.70)**	**1.32 (1.05-1.66)**	**3.46 (2.43-4.93)**
Others	1.13 (1.00-1.28)	**1.26 (1.02-1.57)**	1.05 (0.90-1.22)	**1.35 (1.04-1.74)**
Region				
Least affected regions	1	1	1	1
Grand Est	**2.37 (2.01-2.79)**	**1.43 (1.05-1.95)**	**2.40 (2.03-2.84)**	**1.44 (1.06-1.96)**
Hauts de France	**1.41 (1.14-1.73)**	**1.55 (1.15-2.10)**	**1.43 (1.16-1.76)**	**1.53 (1.13-2.08)**
Ile-de-France	**3.01 (2.64-3.43)**	**2.26 (1.79-2.84)**	**2.47 (2.13-2.86)**	**2.21 (1.71-2.84)**

Significant associations are indicated in bold.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up (*b*) For matched studies, give matching criteria and number of exposed and unexposed	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	NA
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding (*b*) Describe any methods used to examine subgroups and interactions (*c*) Explain how missing data were addressed (*d*) If applicable, explain how loss to follow-up was addressed (*e*) Describe any sensitivity analyses	8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	8-10
Outcome data	15*	Report numbers of outcome events or summary measures over time	8-10

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	8-16
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-16
Discussion			
Key results	18	Summarise key results with reference to study objectives	17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	20
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	21

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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Title: Social Inequalities and Dynamics of the early COVID-19 Epidemic: a prospective cohort study in France

Authors

Nathalie Bajos, PhD[1], Emilie Counil*, PhD[2], Jeanna-Eve Franck*, PhD[1], Florence Jusot[3], Ariane Pailhé, PhD[2], Alexis Spire, PhD[1], Claude Martin, PhD[4], Nathalie Lydié, PhD[5], Rémy Slama[6], PhD, Laurence Meyer, PhD[7], Josiane Warszawski, PhD[7]; for the EpiCoV study group**

Affiliations

[1] IRIS, Inserm/EHESS/CNRS, Aubervilliers, France.

[2] Ined, Aubervilliers, France.

[3] Université Paris Dauphine, Paris, France.

[4] ARENES UMR 6051, CNRS, EHESP, Rennes, France.

[5] Santé publique France, Saint-Maurice, France.

[6] University Grenoble Alpes, Inserm, CNRS, Institute for Advanced Biosciences, Grenoble, France.

[7] CESP UMR 1018, Université Paris-Saclay, APHP, le Kremlin-Bicêtre, France.

***These authors contributed equally to this work**

****The EpiCoV study group**

EpiCoV study group: Nathalie Bajos (co-principal investigator), Josiane Warszawski (co-principal investigator), Guillaume Bagein, Muriel Barlet, François Beck, Emilie Counil, Florence Jusot, Aude Leduc, Nathalie Lydie, Claude Martin, Laurence Meyer, Ariane Pailhé, Nicolas Paliod, Delphine Rahib, Philippe Raynaud, Alexandra Rouquette, Patrick Sicard, Rémy Slama, Alexis Spire.

Correspondence to

Dr Nathalie Bajos, Institut de Recherche Interdisciplinaire sur les enjeux Sociaux - Sciences sociales, politique, santé, IRIS (UMR 8156 CNRS - EHESS - U997 Inserm) 5 cours des humanités, 93322 Aubervilliers cedex, France.
Tel: +33 (0)6 66 32 30 00. nathalie.bajos@inserm.fr

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ABSTRACT

Objective Although social inequalities in COVID-19 mortality by race, gender and socioeconomic status are well documented, less is known about social disparities in infection rates and their shift over time. We aim to study the evolution of social disparities in infection at the early stage of the epidemic in France with regard to the policies implemented.

Design Random population-based prospective cohort.

Setting From May to June 2020 in France.

Participants Adults included in the EpiCoV cohort (n=77,588).

Main outcome measures Self-reported anosmia and/or ageusia in three categories: no symptom, during the first epidemic peak (in March 2020) or thereafter (during lockdown).

Results In all, 2,045 participants (1.53%) reported anosmia/ageusia. The social distribution of exposure factors (density of place of residence, overcrowded housing and working outside the home) was described. Multinomial regressions were used to identify changes in social variables (gender, class and race) associated with symptoms of anosmia/ageusia. Women were more likely to report symptoms during the peak and after. Racialized minorities accumulated more exposure risk factors than the mainstream population and were at higher risk of anosmia/ageusia during the peak and after. By contrast, senior executive professionals were the least exposed to the virus with the lower rate of working outside the home during lockdown. They were more affected than lower social classes at the peak of the epidemic, but this effect disappeared after the peak.

Conclusion The shift in the social profile of the epidemic was related to a shift in exposure factors under the implementation of a stringent stay-at-home order. Our study shows the importance to consider in a dynamic way the gender, socioeconomic and race direct and indirect effects of the COVID-19 pandemic, notably to implement policies that do not widen health inequalities.

Keywords: COVID-19; Social inequalities; Gender; Social class; Race

ARTICLE SUMMARY

Strengths and limitations of the study

- EpiCoV is a large random socio-epidemiological prospective cohort including both detailed social characteristics, exposure risk factors and date of first COVID-19-Like symptom(s), enabling us to study the dynamic of the pandemic social profile.
- We focused on the most specific symptoms of SARS-CoV2 infection - anosmia/ageusia - which makes our analyses more robust.
- Our outcome is based on reported symptoms rather than on biologically confirmed cases due to the lack of tests at the time of the survey.
- Highly vulnerable populations, such as homeless people, are not represented in our sample.

INTRODUCTION

The COVID-19 pandemic that has been hitting the world since the beginning of the year 2020 has reinforced and strengthened social inequalities in health[1-3]. This evidence mostly comes from mortality-based studies[4 5]. Few studies are based on the incidence of COVID-19[6], while the disease has an infection case-fatality ratio below 1%[7]. Most of these analyses are from the USA and the UK, which have strong specificities in terms of healthcare systems and social and ethnic inequalities. They are based on ecological studies, not allowing to consider socioeconomic inequalities at the individual level and to adjust for potential confounders[4]. In addition, the literature very little addressed the dynamics of social inequalities as the epidemic evolves and prevention measures are implemented, measures that may themselves have differential efficiency across social and ethnic groups and between sexes. Notable exceptions are Wright et al[8] (in the United Kingdom) and Jefferies et al[9] (in New-Zealand), who found trends towards lower risk of suspected COVID-19 and lower testing rates of SARS-CoV-2 among people of lower socioeconomic status during the early weeks of the epidemic and a higher risk and higher testing rates subsequently.

Few studies showed that the prevention policies put in place, in particular the mobility restrictions and the strong incentive to work remotely, were more beneficial to the most privileged classes in terms of disease incidence[10 11]. This suggests that the social distribution of exposure factors may have changed over time, as has been previously found for other influenza pandemics[12 13].

Our objective was to study the dynamics of gender, race and social class-related inequalities in COVID-19 disease incidence at the early stage of the epidemic in France. We adopted an intersectional approach[14] that simultaneously takes into account these three social factors[15].

We first compared the occurrence of reported anosmia and/or ageusia - a specific proxy of disease incidence - by socio-demographic characteristics between the first peak of the epidemic, around March 19th, until the beginning of June 2020, when the incidence decreased following the first lockdown[16]. Then we studied how the distribution of three important risk factors of COVID-19 exposure and infection, *i.e.* population density, overcrowded housing and working outside the home[17], varied across socio-demographic groups. Finally, we studied how the association of social characteristics with anosmia/ageusia evolved during and after the epidemic peak while adjusting for exposure risk factors and health variables.

PARTICIPANTS AND METHODS

Study design and participants

The EpiCoV (Epidémiologie et Conditions de Vie) cohort was set-up in April 2020, with the general aim of understanding the main epidemiological, social and behavioral features of the COVID-19 epidemic in France. The data collection period ran from May 2nd to June 2nd, 2020. In France, strict lockdown expanded from March the 17th to May the 10th and the first epidemic peak was recorded around March 19th[16].

A stratified random sample of 350,000 people aged 15 and over was drawn from the tax database of the National Institute of Statistics and Economic Studies (INSEE), which covers 96% of the population living in France, but excludes people living in institutional settings. People belonging to the lowest decile of income were over-represented. A total of 134,391 (38.4%) participated in the survey. Individuals were invited to answer the questionnaire online, or by phone if they did not have Internet access.

We used reweighting and marginal calibrations in the survey and sampling design to correct for non-participation bias. We focused on people living in metropolitan France, aged 18-64

years, in order to take into account working arrangements and type of occupation in the analysis (n=98,787).

Ethical statement

The survey was approved by the CNIL (French independent administrative authority responsible for data protection) on April 25th 2020 (ref: MLD/MFI/AR205138) and by the "Comité de protection des personnes" (French equivalent of the Research Ethics Committee) on April 24th. The survey also obtained an agreement from the "Comité du Label de la statistique publique", proving its adequacy to statistical quality standards.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Outcome

Participants were invited to report COVID-19-Like symptoms (such as cough, fever, dyspnea, anosmia and/or ageusia), if they were unusual and if they were present at or occurred since the beginning of the lockdown. They also reported when the first symptom appeared. The main health outcome studied here was reporting symptoms of anosmia and/or ageusia, the most specific symptoms of SARS-CoV2 infection[18 19 17]. Among those who did not report anosmia/ageusia, the analysis was restricted to people without reported cough, fever or dyspnea in order to exclude possible COVID-19 cases (n=14,080). Individuals whose symptoms started before lockdown were also not considered in the analysis to avoid overrepresentation of long-lasting forms of COVID-19 (n=844).

A distinction was made between those people whose first symptoms began more than one month before their response to the survey, likely to have occurred *during* the epidemic peak, and those whose first symptoms began less than one month before, likely to have occurred

after the peak, during the epidemic decline phase (during and early after lockdown). Our outcome was in three categories: no reported anosmia/ageusia (nor cough, fever or dyspnea), anosmia/ageusia starting during the epidemic peak, anosmia/ageusia starting after the epidemic peak.

Socio-demographic variables

We considered the following six variables: age, sex, ethno-racial status (based on migration history), social class (based on current or most recent occupation combined with education), standard of living (based on decile of income per household consumption unit) and formal education (defined according to the hierarchical grid of diplomas in France). The ethno-racial status distinguished mainstream population, *i.e.* persons residing in metropolitan France who are neither immigrants nor native to French Overseas Departments (DOM, *i.e.* Martinique, Guadeloupe, Reunion Island), nor descendants of immigrant(s) or of DOM native[20]. For the minority population, a distinction was made according to the first (immigrants) and second (descendants of immigrants) generations of immigration, and the country of origin. The term racialized refers to people from the Maghreb, Turkey, Asia and Africa.

Exposure risk factors

We considered three main risk factors of exposure to COVID-19: having worked outside the home during lockdown (at least partly), high density of the place of residence (*i.e.* at least 1,500 inhabitants per km^2 and a minimum of 50,000 inhabitants) and overcrowded housing (*i.e*. at least two persons living in housing with less than $18m^2$ per person) both assessed using the official national definitions. Additional explanatory variables included self-reported essential occupations and household size. To account for regional variations in incidence, we distinguished between the least affected and the three most affected regions at the time of the survey.

Health variables

Health variables included smoking habits, self-reported history of chronic diseases and body mass index.

Statistical analyses

We first studied the association between the three social variables of interest (gender, race, social class) and anosmia/ageusia, distinguishing between the two periods, and then with the exposure risk factors (density, overcrowding and working outside) using Chi2-test. To study how the social characteristics associated with anosmia/ageusia evolved during and after the epidemic peak, we further developed a step by step multinomial analysis adjusted for *(i)* age and social variables (M0), *(ii)* then adding the three main exposure variables and regions (M1), *(iii)* and finally adding health variables (M2).

Observations with missing values on anosmia/ageusia or main social and exposure variables were excluded from our analysis (n=6275, 7.5%). In all, 77,588 individuals were included in our analyses. All analyses were weighted using a Heckman model to take into account the effect of the response mode on the reporting of COVID-19-Like symptoms[21]. Analyses were performed with the SAS software 9.4. A P-value <0.05 was considered statistically significant.

RESULTS

Gendered differences

Women were more likely to have been affected by anosmia/ageusia: 1.84% of women versus 1.22% of men (p<0.01) (Table 1). Sex was not strongly associated with most risk factors of anosmia/ageusia, with the exception of working outside home (44.7% in men *versus* 40.6% in women, p<0.001) (Table 2). The significant association of anosmia/ageusia with gender only weakly attenuated over time, with the crude odds ratio (OR) decreasing from 1.57 (95% CI:

1.40-1.76) to 1.40 (1.14-1.71) (Table 3). While adjusting for other social characteristics (M0), exposure risk factors (M1) and health variables (M2) did not strongly attenuate the association, inclusion of essential occupations did (Supplementary table 1).

Ethno-racial status

If we now consider ethno-racial affiliation, we find that all minority groups, to varying degrees (from 1.79% to 2.67%, Table 1), reported anosmia more often than the majority population (1.35%, p<0.001).

Ethno-racial affiliation was strongly associated with exposure risk factors, with the exception of working outside home. For example, 72.6% of the racialized first-generation immigrants reported living in a high-density place of residence (compared to 31.8% for the mainstream population, p<0.001) and 41.4% in an overcrowded housing (compared to 8.7% for the mainstream population, p<0.001, Table 2).

Over-risk of reporting anosmia/ageusia was recorded among racialized minorities both during and after the epidemic peak (crude models), although non-significant after the peak for non-racialized second-generation immigrants and racialized first-generation immigrants (Table 3). Adjusting for the exposure risk factors that significantly attenuated the observed associations, both during and after the peak (M1). After further adjusting for health variables, only racialized second-generation immigrants (respectively 1.48 (1.19-1.83) and 1.42 (1.00-2.01) during and after the peak), DOM or descendants of DOM native (1.50 (1.07-2.12) during the peak) and non-racialized first-generation immigrants (1.77 (1.04-3.04) after the peak) remained at higher risk of reporting anosmia/ageusia compared to the mainstream population (M2).

Social class

There were marked differences between occupational classes. The top categories appeared to be most affected by anosmia/ageusia: 1.89% for middle executive professionals, 1.81% for

senior executive professionals and 1.83% for skilled employees, against 0.99% for skilled and 1.11% for low-skilled manual workers (Table 1).

These social groups are differently exposed to risk factors. Although senior executive professionals are more likely to live in high-density areas than low-skilled manual workers (53.5% compared to 27.4%), they are less likely to live in an overcrowded accommodation (10.3% compared to 17.5%) and have more often been able to telework during the lockdown (39.2% have worked outside the home compared to 56.9% for low-skilled manual workers, Table 2).

Marked evolutions are observed over time. In crude models, while the lower social categories and self-employed were significantly less affected than senior executive professionals during the peak, this most privileged social category did not appear to be more at risk of anosmia/ageusia than the others after the peak (Table 3). Only middle executive professionals were at increased risk after the peak, and only simultaneous adjustment on exposure risk factors, health variables, essential occupations and regions lowered this association towards the null (Supplementary Table 1).

Table 1. Socio-demographic characteristics associated with anosmia/ageusia

	Anosmia/ageusia[i] n=2,052 (1.53%)	*P-value**	*Anosmia/ageusia during peak n=1,521 (1.12%)*	*Anosmia/ageusia after peak n=531 (0.41%)*
Age		**<0.001**		
18-24	253 (1.27)		168 (0.86)	85 (0.41)
25-34	431 (1.92)		322 (1.43)	109 (0.48)
35-44	510 (1.83)		379 (1.33)	131 (0.50)
45-54	521 (1.57)		407 (1.22)	114 (0.35)
55-64	337 (1.07)		245 (0.76)	92 (0.31)
Sex		**<0.001**		
Men	773 (1.22)		570 (0.88)	203 (0.34)
Women	1,279 (1.84)		951 (1.37)	328 (0.47)
Ethno-racial status		**<0.001**		
Mainstream population	1,454 (1.35)		1,075 (0.98)	379 (0.36)
Non-racialized first-generation immigrants	94 (2.20)		69 (1.48)	25 (0.72)
Non-racialized second-generation immigrants	108 (1.79)		80 (1.37)	28 (0.42)
Racialized first-generation immigrants	164 (1.86)		127 (1.43)	37 (0.43)
Racialized second generation immigrants	170 (2.62)		125 (1.95)	45 (0.67)
DOM or descendants of DOM native-	62 (2.67)		45 (1.95)	17 (0.72)
Social class		**<0.001**		
Self-employed and entrepreneurs	92 (1.39)		63 (0.91)	29 (0.48)
Senior executive professionals	454 (1.81)		365 (1.45)	89 (0.37)
Middle executive professionals	434 (1.89)		313 (1.35)	121 (0.54)
Skilled employees	203 (1.83)		160 (1.44)	43 (0.39)
Low-skilled employees	356 (1.56)		254 (1.10)	102 (0.45)
Skilled manual workers	125 (0.99)		87 (0.68)	38 (0.31)
Low-skilled manual workers	62 (1.11)		38 (0.76)	24 (0.34)
Never worked and others	326 (1.28)		241 (0.93)	85 (0.35)
Standard of living (in deciles)		**0.003**		
D1	209 (1.41)		140 (0.92)	69 (0.49)
D2-D3	316 (1.33)		221 (0.94)	95 (0.39)
D4-D5	349 (1.49)		255 (1.10)	94 (0.39)
D6-D7	389 (1.47)		295 (1.10)	94 (0.37)
D8-D9	519 (1.77)		388 (1.32)	131 (0.45)
D10	247 (1.74)		209 (1.46)	38 (0.28)
Formal education		**<0.001**		
No diploma	123 (1.43)		82 (0.89)	41 (0.54)
Primary education	74 (1.03)		53 (0.77)	21 (0.25)
Vocational secondary	335 (1.17)		229 (0.80)	106 (0.36)
High school	467 (1.48)		330 (1.03)	137 (0.44)
High school +2 to 4 years	663 (1.82)		502 (1.38)	161 (0.44)
High school +5 or more years	390 (1.95)		325 (1.62)	65 (0.33)
Working arrangement during lockdown		**<0.001**		
Not working and others	669 (1.33)		484 (0.96)	185 (0.38)
Remote working only	376 (1.79)		308 (1.46)	68 (0.33)
Working outside the home partly or only	1,007 (1.62)		729 (1.16)	278 (0.45)
High density of the place of residence		**<0.001**		
No	1,078 (1.21)		778 (0.85)	300 (0.36)
Yes	974 (2.04)		743 (1.56)	231 (0.49)
Overcrowded housing		**<0.001**		
No	1,719 (1.44)		1,280 (1.07)	439 (0.37)

Yes	333 (2.12)		241 (1.47)	92 (0.64)
Number of persons living in the house		**<0.001**		
1	232 (1.34)		175 (1.01)	57 (0.33)
2	472 (1.28)		348 (0.94)	124 (0.35)
3-4	979 (1.61)		720 (1.17)	259 (0.44)
5 or more	369 (1.95)		278 (1.46)	91 (0.49)
Essential occupation		**<0.001**		
No	1,193 (1.39)		908 (1.05)	285 (0.34)
Healthcare workers	205 (2.94)		131 (1.78)	74 (1.16)
Others	654 (1.61)		482 (1.18)	172 (0.43)
Region		**<0.001**		
Least affected regions	866 (1.04)		622 (0.73)	244 (0.31)
Grand Est	305 (2.15)		242 (1.72)	63 (0.43)
Hauts-de-France	215 (1.50)		147 (1.03)	68 (0.47)
Ile-de-France	666 (2.85)		510 (2.16)	156 (0.68)

Significant Chi-2 tests are indicated in bold.

i: symptoms were recorded if they occured between the 17th of March, 2020 and the date of survey (from 2nd of May to 2nd of June, 2020).

*Chi-2 test for anosmia/ageusia during the whole period (yes, no).

Table 2. Socio-demographic characteristics associated with COVID-19 risk factors

	High density of the place of residence *n=27,104 (38.6%)*	Overcrowded housing *n=8,430 (13.2%)*	Worked outside the home during lockdown *n=37,129 (47.7%)*
Age (years)			
18-24	3,506 (38.5)	1,225 (13.9)	2,794 (27.5)
25-34	5,504 (47.2)	2,051 (18.1)	6,366 (50.1)
35-44	6,128 (39.8)	2,786 (19.8)	9,239 (56.0)
45-54	6,298 (35.7)	1,748 (11.6)	11,374 (59.0)
55-64	5,668 (33.5)	620 (4.5)	7,356 (39.1)
Sex			
Men	12,404 (38.1)	3,880 (13.1)	18,148 (50.6)
Women	14,700 (39.0)	4,550 (13.4)	18,981 (44.7)
Ethno-racial status			
Mainstream population	18,772 (31.8)	4,823 (8.7)	30,625 (49.0)
Non-racialized first-generation immigrants	1,128 (51.0)	432 (21.3)	1,100 (47.0)
Non-racialized second-generation immigrants	1,391 (40.1)	360 (11.0)	1,815 (48.1)
Racialized first-generation immigrants	2,894 (72.6)	1,655 (41.4)	1,744 (41.4)
Racialized second generation immigrants	2,297 (68.0)	954 (29.2)	1,303 (37.4)
DOM or descendants of DOM native	622 (56.6)	206 (20.5)	542 (48.5)
Social class			
Self-employed and entrepreneurs	1,133 (32.0)	390 (11.7)	2,671 (68.1)
Senior executive professionals	7,959 (53.5)	1,373 (10.3)	6,448 (39.2)
Middle executive professionals	4,633 (36.4)	1,235 (10.2)	8,142 (57.9)
Skilled employees	2,494 (41.2)	708 (12.2)	3,543 (52.0)
Low-skilled employees	3,885 (36.1)	1,498 (13.7)	7,562 (58.1)
Skilled manual workers	1,589 (28.7)	862 (15.0)	4,466 (66.1)
Low-skilled manual workers	743 (27.4)	515 (17.5)	1,843 (56.9)
Never worked and others	4,668 (38.9)	1,849 (16.7)	2,454 (16.6)
Standard of living (in deciles)			
D1	3,068 (46.9)	1,794 (28.2)	2,796 (34.7)
D2-D3	4,082 (40.4)	2,317 (22.1)	5,405 (45.5)
D4-D5	3,761 (33.1)	1,506 (12.8)	7,065 (53.4)
D6-D7	4,512 (31.9)	1,262 (8.5)	8,595 (54.6)
D8-D9	6,586 (37.7)	1,100 (6.3)	8,973 (47.7)
D10	4,773 (49.8)	385 (4.3)	4,032 (40.1)
Formal education			
No diploma	1,790 (42.9)	1,065 (24.7)	2,052 (42.3)
Primary education	1,093 (34.8)	455 (13.5)	1,375 (39.4)
Vocational secondary	3,670 (27.0)	1,613 (12.1)	8,848 (56.9)
High school	5,356 (34.4)	2,036 (13.2)	8,810 (48.9)
High school +2 to 4 years	8,007 (39.0)	1,991 (10.5)	11,252 (49.0)
High school +5 or more years	7,188 (61.1)	1,270 (11.7)	4,792 (36.5)
Region			
Least affected regions	11,829 (26.8)	4,186 (10.3)	24,673 (51.0)
Grand Est	1,829 (26.4)	551 (9.1)	3,814 (49.3)
Hauts de France	2,294 (34.2)	858 (12.3)	3,631 (44.5)
Ile-de-France	11,152 (83.4)	2,835 (24.8)	5,011 (37.8)

All socio-demographic variables were significantly associated with each three COVID-19 exposure risk factors (P-value <0.001, Chi-2 tests), except sex with high density (P-value=0.051) and overcrowded housing (P-value=0.30).

Table 3. Factors associated with anosmia/ageusia during or after the first epidemic peak (as compared to no reported anosmia/ageusia starting after lockdown). Multinomial logistic regressions.

	M0				M1		M2	
	Crude model		+ Social variables		+ Exposure variables[a]		+ Health variables	
	During peak OR (95% CI)	*After peak OR (95% CI)*	*During peak OR (95% CI)*	*After peak OR (95% CI)*	*During peak OR (95% CI)*	*After peak OR (95% CI)*	*During peak OR (95% CI)*	*After peak OR (95% CI)*
Age								
18-24	1	1	1	1	1	1	1	1
25-34	**1.68 (1.36-2.07)**	1.18 (0.87-1.60)	**1.44 (1.15-1.80)**	1.03 (0.77-1.47)	**1.45 (1.16-1.82)**	1.04 (0.73-1.48)	**1.43 (1.14-1.80)**	0.93 (0.66-1.32)
35-44	**1.56 (1.27-1.91)**	1.22 (0.91-1.65)	**1.36 (1.09-1.68)**	1.07 (0.76-1.51)	**1.41 (1.13-1.76)**	1.08 (0.76-1.52)	**1.37 (1.10-1.72)**	0.90 (0.64-1.27)
45-54	**1.43 (1.17-1.74)**	0.86 (0.63-1.18)	**1.30 (1.05-1.61)**	**0.77 (0.54-1.09)**	**1.37 (1.10-1.70)**	0.80 (0.55-1.14)	**1.31 (1.05-1.63)**	**0.63 (0.44-0.90)**
55-64	0.89 (0.71-1.11)	0.76 (0.54-1.06)	0.84 (0.66-1.06)	**0.67 (0.44-1.02)**	0.91 (0.72-1.14)	0.73 (0.47-1.12)	0.84 (0.66-1.07)	**0.54 (0.36-0.82)**
Sex								
Men	1	1	1	1	1	1	1	1
Women	**1.57 (1.40-1.76)**	**1.40 (1.14-1.71)**	**1.52 (1.34-1.71)**	**1.37 (1.10-1.70)**	**1.52 (1.35-1.72)**	**1.38 (1.11-1.71)**	**1.51 (1.34-1.70)**	**1.42 (1.14-1.77)**
Ethno-racial status								
Mainstream population	1	1	1	1	1	1	1	1
Non-racialized first-generation immigrants	**1.52 (1.16-2.00)**	**2.00 (1.14-3.53)**	**1.55 (1.18-2.04)**	**2.08 (1.18-3.65)**	1.25 (0.95-1.65)	**1.71 (1.00-2.94)**	1.26 (0.95-1.66)	**1.77 (1.04-3.04)**
Non-racialized second-generation immigrants	**1.40 (1.07-1.82)**	1.16 (0.77-1.76)	**1.41 (1.09-1.84)**	1.17 (0.77-1.77)	1.26 (0.97-1.64)	1.08 (0.71-1.63)	1.26 (0.96-1.64)	1.07 (0.71-1.62)
Racialized first-generation immigrants	**1.46 (1.18-1.80)**	1.20 (0.82-1.75)	**1.52 (1.23-1.88)**	1.24 (0.84-1.83)	1.08 (0.87-1.35)	0.89 (0.60-1.33)	1.12 (0.89-1.40)	0.95 (0.64-1.42)
Racialized second generation immigrants	**2.01 (1.63-2.48)**	**1.87 (1.34-2.63)**	**1.97 (1.59-2.43)**	**1.79 (1.27-2.51)**	**1.46 (1.18-1.81)**	1.39 (0.98-1.98)	**1.48 (1.19-1.83)**	**1.42 (1.00-2.01)**
DOM or descendants of DOM native	**2.01 (1.43-2.81)**	**2.02 (1.21-3.36)**	**1.96 (1.40-2.75)**	**1.93 (1.16-3.24)**	**1.50 (1.07-2.11)**	1.56 (0.93-2.60)	**1.50 (1.07-2.12)**	1.50 (0.89-2.52)
Social class								
Self-employed and entrepreneurs	**0.62 (0.47-0.83)**	1.30 (0.77-2.19)	**0.66 (0.49-0.88)**	1.35 (0.81-2.27)	0.77 (0.57-1.04)	1.30 (0.77-2.18)	0.79 (0.58-1.07)	1.25 (0.74-2.11)
Senior executive professionals	1	1	1	1	1	1	1	1
Middle executive professionals	0.93 (0.79-1.10)	**1.47 (1.09-1.98)**	0.92 (0.78-1.08)	**1.44 (1.07-1.95)**	1.04 (0.88-1.24)	**1.43 (1.05-1.94)**	1.05 (0.88-1.24)	**1.36 (1.00-1.85)**
Skilled employees	0.99 (0.81-1.21)	1.07 (0.73-1.58)	0.83 (0.67-1.02)	0.91 (0.62-1.35)	0.95 (0.77-1.17)	0.93 (0.62-1.39)	0.95 (0.77-1.17)	0.91 (0.61-1.35)

Low-skilled employees	**0.76 (0.64-0.91)**	1.23 (0.90-1.68)	**0.70 (0.59-0.84)**	1.17 (0.85-1.61)	**0.80 (0.66-0.97)**	1.09 (0.77-1.53)	**0.81 (0.67-0.99)**	1.00 (0.71-1.41)
Skilled manual workers	**0.47 (0.35-0.62)**	0.83 (0.55-1.24)	**0.51 (0.39-0.67)**	0.89 (0.59-1.33)	**0.61 (0.46-0.82)**	0.85 (0.55-1.30)	**0.63 (0.47-0.83)**	0.79 (0.51-1.21)
Low-skilled manual workers	**0.52 (0.35-0.79)**	0.93 (0.57-1.54)	**0.52 (0.34-0.78)**	0.91 (0.55-1.51)	0.65 (0.43-1.00)	0.90 (0.53-1.51)	0.67 (0.44-1.02)	0.82 (0.49-1.39)
Never worked and others	**0.64 (0.54-0.77)**	0.94 (0.67-1.33)	**0.64 (0.53-0.78)**	0.85 (0.57.1.29)	0.81 (0.64-1.01)	0.85 (0.54-1.33)	0.81 (0.64-1.01)	0.80 (0.51-1.25)
High density of the place of residence								
No	1	1			1	1	1	1
Yes	**1.83 (1.64-2.05)**	**1.38 (1.14-1.68)**			1.21 (1.06-1.38)	0.96 (0.77-1.21)	**1.21 (1.06-1.38)**	0.95 (0.76-1.20)
Overcrowded housing								
No	1	1			1	1	1	1
Yes	**1.38 (1.19-1.62)**	**1.74 (1.32-2.31)**			1.03 (0.87-1.21)	**1.41 (1.05-1.89)**	1.04 (0.88-1.22)	**1.41 (1.05-1.89)**
Working arrangement during lockdown								
Remote working only	1	1			1	1	1	1
Not working and others	**0.65 (0.56-0.76)**	1.13 (0.84-1.53)			1.00 (0.82-1.21)	**1.41 (1.00-1.99)**	0.99 (0.82-1.21)	1.34 (0.95-1.88)
Working outside the home partly or only	**0.80 (0.69-0.92)**	**1.36 (1.03-1.81)**			**1.18 (1.01-1.38)**	**1.65 (1.22-2.21)**	**1.19 (1.02-1.40)**	**1.64 (1.21-2.20)**

Significant associations are indicated in bold.
a: including regions (data not shown).

DISCUSSION

Main study results

Our results are based on data documenting exposure factors and symptoms during the first epidemic wave. By distinguishing infections which probably occurred at the time of the epidemic peak (just before or in the very first days after the start of lockdown), from those which occurred later (during and early after the lockdown, as the epidemic declined), a change in the social profile of the affected people emerged. This allowed us to unmask social characteristics and exposure risk factors that increased the risk of infection during and/or after the first epidemic peak, which would have been masked by an analysis over the whole period. Our results point that women and ethno-racial minorities were at higher risk of anosmia/ageusia during the peak and after. While senior executive professionals were more affected than lower social classes at the peak of the epidemic, this effect disappeared after.

We show that important exposure factors likely to increase contact with the virus, *i.e.* the density of the place of residence, living in overcrowded housing, and having worked outside the home during lockdown[4 17] have not been evenly distributed across social groups, and also that some social groups do cumulate these risk factors. Hence, racialized minorities, the least educated, and those with the lowest financial resources are particularly affected by living in densely populated communities and overcrowded housing. These data reflect the well-documented effects of socio-spatial segregation policies[20]. Furthermore, among those who continued to work during lockdown, working class groups have been more likely to work outside the home than senior managers who were able to work remotely, to a large extent.

Interpretation of findings

The persistent increased risk of anosmia/ageusia among women compared to men are likely to reflect occupational specificities, beyond the categories used here. Indeed, women are

over-represented in the nursing and care assistant occupations as well as in cleaning activities[22]. In addition, they take care of children and the elderly[23 24], which may increase their social contacts. This greater exposure of women raises questions as they are shown to be less likely to die from COVID-19 than men, which may partly reflect their lower rates of comorbidities[5].

With regard to ethno-racial status, the persistent higher risk of reporting anosmia/ageusia among racialized people was not linked to a lower propensity to wear a mask[11]. It may instead be indicative of social contacts in neighborhoods where the circulation of the virus was and remained higher over time, as suggested by our results, since their increased risk was substantially attenuated after adjusting for density of place of residence and overcrowded housing. Understanding determinants of infection among those minorities throughout the epidemic is all the more so important as a higher likelihood of dying from COVID-19 was reported in many countries, including France[5 9 25].

Whereas senior executive professionals were more affected than lower social classes at the peak of the epidemic, this effect disappeared afterwards. Only middle executive professionals were at higher risk during the epidemic decline, which was likely due to the presence of health professionals, particularly nurses, in this group, as this association totally disappeared when further adjusted for essential occupations. The increased risk among essential occupations was particularly sharp for health professionals, due to the continuous care provided to patients with a high viral load[16]. It is important to note that the other so-called essential occupations were overexposed after the peak of the epidemic, this group includes those in regular contact with the public such as cashiers, bus drivers, etc. Such results call for an in-depth and longitudinal analysis of occupational disparities in COVID-19 exposure based on the combination of type of job (e.g. healthcare, high-contact jobs, etc.), working arrangement

(remote, on-site, layoff), as well as implementation of preventive measures at the worksite. Indeed, the higher risk of infection of people who worked outside the home during lockdown was particularly marked after the peak of the epidemic, *i.e.* during a period of epidemic decline when contact with the virus was proportionally more marked among on-site workers as compared to people who stayed at home.

It should also be noted that the density of the place of residence was no longer related to the reporting of anosmia/ageusia occurring after the peak of the epidemic probably because the virus circulates less in the neighborhood, thanks to the lockdown. On the contrary, overcrowding was significantly associated after the peak only, probably due to the higher risk of COVID-19 transmission linked to unavoidable close proximity and/or large number of people in the household. Background rates and circulation patterns of SARS-CoV-2 should be considered while looking at the social and spatial dynamics of the epidemic[26], as they influence the relative importance of community and workplace transmission[27].

Study limitations

Our analysis has nevertheless some limitations. First, as any national population-based survey, the study fails to capture highly vulnerable groups such as undocumented migrants and homeless people, who are particularly affected by the pandemic[28].

Additionally, due to a shortage of tests at the national level in the early stage of the epidemic, our analyses are based on reported symptoms of anosmia/ageusia rather than on biologically confirmed cases. This excludes infected people reporting other symptoms, and of course asymptomatic individuals who represent one out of six of the infected population according to a recent meta-analysis[29].

Although anosmia/ageusia reporting may be socially differentiated, especially due to differences in recognition of symptoms, it is reasonable to assume that such a bias did not

vary during the month of the survey. One might also think that women are more likely to report anosmia/ageusia since they have a heightened sense of smell compared to men, as shown by sociological studies[30]. Nevertheless, the ratio of women to men reporting such symptoms is only slightly larger than that recorded for seroprevalence in a sub-sample of the same cohort[31] as found in other European countries[32].

We chose to focus on anosmia/ageusia only, which are the most specific symptoms of COVID-19[18 19], so that our analyses would be more robust[33]. Indicative of internal validity, our results are consistent with epidemiological surveillance data by region[34] as well as with data on increased risk of infection in people with chronic conditions[16 35], and instead a protective effect of smoking[36].

Finally, while it was not possible to build clear-cut periods of "likely infection" based on the timing of symptoms reported by the participants, the broad distinction made between people for whom symptoms started during the epidemic peak *versus* after it, allowed us to compare an early stage of the epidemic with the phase of decline in the incidence corresponding to the first lockdown in France.

Conclusion

To our knowledge, EpiCoV is one of the first socio-epidemiological surveys conducted among a very large random sample of a national population that simultaneously considers living conditions and health data and allows for an intersectional analysis of social inequalities by gender, ethno-racial status and social class. Our results show the importance of closely monitoring social changes over time to implement prevention policies that do not contribute to increasing the already significant social inequalities in health. In all, the associations reported during the epidemic peak – lower exposures among low-skilled jobs than senior executives, over-exposure among all ethno-racial minorities compared to the majority

population, with a strong influence of overcrowding and population density – are likely to reflect the social profile and associated risk factors that prevailed just before the implementation of stay-at-home measures and national lockdown. By contrast, those observed after the peak point to a shift in the social profile of the epidemic related to a shift in exposure factors under the implementation of stringent collective prevention measures. They notably stress the importance of working outside the home, all the more so in essential occupations, particularly, though not exclusively, for healthcare workers[37]. The persistent excess risk among women and some ethno-racial minorities call for further research.

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Competing interest

None

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Authors and contributors

NB had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. IPSOS collected data. NB, EC and JF provided the study concept and design. JF made the statistical analysis and NB, EC, JF, LM and JW interpreted the results. RS obtained funding. NL contributed as administrative support. NB and JW supervised the study. NB, EC and JF drafted the first manuscript and NB, EC, JF, FJ, AP, AS, CM, NL, RS, LM and JW contributed to the final manuscript.

Data availability statement

Data are available from the corresponding author on reasonable request.

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Supplementary Table 1

Factors associated with anosmia/ageusia during or after the epidemic peak (as compared to no reported anosmia/ageusia starting after lockdown). Multinomial logistic regressions.

	Crude model		Full adjusted model	
	During peak OR (95% CI)	*After peak OR (95% CI)*	*During peak OR (95% CI)*	*After peak OR (95% CI)*
Age				
18-24	1	1	1	1
25-34	**1.68 (1.36-2.07)**	1.18 (0.87-1.60)	**1.51 (1.20-1.91)**	0.93 (0.65-1.33)
35-44	**1.56 (1.27-1.91)**	1.22 (0.91-1.65)	**1.39 (1.11-1.74)**	0.90 (0.64-1.27)
45-54	**1.43 (1.17-1.74)**	0.86 (0.63-1.18)	**1.34 (1.07-1.67)**	**0.64 (0.44-0.91)**
55-64	0.89 (0.71-1.11)	0.76 (0.54-1.06)	0.92 (0.72-1.18)	**0.59 (0.38-0.91)**
Sex				
Men	1	1	1	1
Women	**1.57 (1.40-1.76)**	**1.40 (1.14-1.71)**	**1.48 (1.31-1.68)**	**1.27 (1.02-1.59)**
Ethno-racial status				
Mainstream population	1	1	1	1
Non-racialized first-generation immigrants	**1.52 (1.16-2.00)**	**2.00 (1.14-3.53)**	1.27 (0.97-1.68)	**1.85 (1.09-3.17)**
Non-racialized second-generation immigrants	**1.40 (1.07-1.82)**	1.16 (0.77-1.76)	1.26 (0.97-1.64)	1.08 (0.72-1.64)
Racialized first-generation immigrants	**1.46 (1.18-1.80)**	1.20 (0.82-1.75)	1.09 (0.87-1.36)	0.96 (0.65-1.43)
Racialized second generation immigrants	**2.01 (1.63-2.48)**	**1.87 (1.34-2.63)**	**1.44 (1.16-1.79)**	**1.42 (1.00-2.01)**
DOM or descendants of DOM native	**2.01 (1.43-2.81)**	**2.02 (1.21-3.36)**	**1.50 (1.06-2.11)**	1.44 (0.85-2.42)
Social class				
Self-employed and entrepreneurs	**0.62 (0.47-0.83)**	1.30 (0.77-2.19)	0.80 (0.59-1.09)	1.44 (0.84-2.45)
Senior executive professionals	1	1	1	1
Middle executive professionals	0.93 (0.79-1.10)	**1.47 (1.09-1.98)**	1.02 (0.86-1.21)	1.18 (0.86-1.61)
Skilled employees	0.99 (0.81-1.21)	1.07 (0.73-1.58)	0.96 (0.78-1.19)	0.93 (0.62-1.39)
Low-skilled employees	**0.76 (0.64-0.91)**	1.23 (0.90-1.68)	0.82 (0.67-1.00)	1.05 (0.74-1.49)
Skilled manual workers	**0.47 (0.35-0.62)**	0.83 (0.55-1.24)	**0.64 (0.48-0.85)**	0.84 (0.54-1.31)
Low-skilled manual workers	**0.52 (0.35-0.79)**	0.93 (0.57-1.54)	0.68 (0.44-1.04)	0.92 (0.54-1.56)
Never worked and others	**0.64 (0.54-0.77)**	0.94 (0.67-1.33)	0.81 (0.65-1.02)	0.89 (0.56-1.41)
High density of the place of residence				
No	1	1	1	1
Yes	**1.83 (1.64-2.05)**	**1.38 (1.14-1.68)**	**1.24 (1.08-1.41)**	0.97 (0.77-1.23)
Overcrowded housing				
No	1	1	1	1
Yes	**1.38 (1.19-1.62)**	**1.74 (1.32-2.31)**	0.92 (0.77-1.10)	**1.35 (0.96-1.90)**
Working arrangement during lockdown				
Remote working only	1	1	1	1
Not working and others	**0.65 (0.56-0.76)**	1.13 (0.84-1.53)	0.99 (0.81-1.22)	1.38 (0.96-1.99)
Working outside the home partly or only	**0.80 (0.69-0.92)**	**1.36 (1.03-1.81)**	1.14 (0.96-1.34)	1.25 (0.92-1.70)
Smoking				
Daily	1	1	1	1
Occasionally	**1.63 (1.25-2.13)**	1.13 (0.74-1.73)	**1.50 (1.14-1.96)**	1.10 (0.72-1.70)
No longer	**1.40 (1.18-1.67)**	0.90 (0.69-1.17)	**1.39 (1.16-1.66)**	0.91 (0.69-1.19)

No	**1.28 (1.09-1.51)**	0.82 (0.64-1.06)	1.11 (0.94-1.32)	**0.74 (0.57-0.95)**
Chronic disease				
No	1	1	1	1
Kidney disease	1.00 (0.46-2.17)	**3.19 (1.11-9.15)**	1.21 (0.55-2.63)	**3.95 (1.36-11.5)**
Other disease	1.09 (0.96-1.23)	**1.52 (1.23-1.88)**	**1.19 (1.04-1.36)**	**1.68 (1.37-2.07)**
Body mass index				
Normal	1	1	1	1
Underweight	0.96 (0.72-1.28)	0.98 (0.60-1.59)	1.00 (0.75-1.34)	0.94 (0.57-1.53)
Overweight	0.86 (0.75-0.98)	1.08 (0.86-1.34)	0.90 (0.79-1.03)	1.11 (0.88-1.40)
Obese	1.06 (0.89-1.25)	**1.44 (1.09-1.91)**	1.06 (0.89-1.27)	**1.38 (1.04-1.84)**
Number of persons living in the house				
1	1	1	1	1
2	0.92 (0.75-1.14)	1.05 (0.73-1.52)	0.99 (0.80-1.22)	1.07 (0.74-1.56)
3 or 4	1.15 (0.95-1.39)	1.35 (0.96-1.91)	1.14 (0.93-1.39)	1.26 (0.88-1.79)
5 or more	**1.45 (1.17-1.80)**	1.50 (1.01-2.21)	**1.42 (1.12-1.81)**	1.20 (0.77-1.87)
Essential occupations				
No	1	1	1	1
Healthcare workers	**1.72 (1.41-2.10)**	**3.49 (2.59-4.70)**	**1.32 (1.05-1.66)**	**3.46 (2.43-4.93)**
Others	1.13 (1.00-1.28)	**1.26 (1.02-1.57)**	1.05 (0.90-1.22)	**1.35 (1.04-1.74)**
Region				
Least affected regions	1	1	1	1
Grand Est	**2.37 (2.01-2.79)**	**1.43 (1.05-1.95)**	**2.40 (2.03-2.84)**	**1.44 (1.06-1.96)**
Hauts de France	**1.41 (1.14-1.73)**	**1.55 (1.15-2.10)**	**1.43 (1.16-1.76)**	**1.53 (1.13-2.08)**
Ile-de-France	**3.01 (2.64-3.43)**	**2.26 (1.79-2.84)**	**2.47 (2.13-2.86)**	**2.21 (1.71-2.84)**

Significant associations are indicated in bold.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up (*b*) For matched studies, give matching criteria and number of exposed and unexposed	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	NA
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding (*b*) Describe any methods used to examine subgroups and interactions (*c*) Explain how missing data were addressed (*d*) If applicable, explain how loss to follow-up was addressed (*e*) Describe any sensitivity analyses	8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	8-10
Outcome data	15*	Report numbers of outcome events or summary measures over time	8-10

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	8-16
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-16
Discussion			
Key results	18	Summarise key results with reference to study objectives	17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	20
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	21

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.