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Higher risk, higher protection: COVID-19 risk among immigrants in France—results from the population-based EpiCov survey

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Background: Immigrants and ethnic/racialized minorities have been identified as being at higher risk of coronavirus disease-19 (COVID-19) infection, but few studies report on their exposures and prevention behaviours. This study aims to examine the social distribution of COVID-19 exposure (overcrowding, working outside the home, use of public transport to go to work) and prevention behaviours (use of face masks, washing hands, respect for physical distance) in France during the first wave of the epidemic. **Methods:** We used the EpiCov population-based survey from a random sample of individuals aged 15 years or more. We determined the distribution of the self-reported outcomes according to migratory status and sex, using χ^2 tests. We modelled the probability of outcomes with logistic regression. Finally, we focused the analysis on the Greater Paris area and accounted for neighbourhood characteristics. **Results:** A total of 111 824 participants were included in the study. Overall, immigrant groups from non-European countries were more exposed to COVID-19-related factors and more respectful of prevention measures. The probability of overcrowding and the use of public transport was higher for immigrants from sub-Saharan Africa [adjusted odds ratio (aOR) = 3.71 (3.19; 4.32), aOR = 6.36 (4.86; 8.32)] than for the majority population. Immigrant groups were less likely to have a non-systematic use of face masks and to breach physical distancing than the majority population [for immigrants from sub-Saharan Africa, aOR = 0.32 (0.28; 0.37) and aOR = 0.71 (0.61; 0.81), respectively]. Living in a neighbourhood with a higher share of immigrants was associated with higher exposure and better prevention behaviours. **Conclusions:** In France, immigrants had a higher exposure to COVID-19-related factors and more systematic prevention behaviours.

Introduction

Immigrants and ethnic minorities have been identified in Europe and North America as populations who are more at risk of acquiring the new coronavirus, developing severe coronavirus disease-19 (COVID-19) disease and dying of COVID-19.[1,2] As soon as August 2020, the UK Office for National Statistics published age-standardized mortality rates by ethnicity and reported that after accounting for the effect of sex, age, deprivation and region of residence, certain ethnic groups had a higher risk of death compared to people of White British ethnicity.[3] Since then, disparities according to migratory status or ethnicity have been reported on COVID-19-related exposure, clinical outcomes in cases of COVID-19 infection and COVID-19-related deaths in the UK,[4–6] Norway,[7] Belgium[8] and the USA.[9]

In France, both seroprevalence and mortality data confirm a greater COVID-19-related risk among immigrants: during the first COVID-19 wave in March/April 2020, immigrants from non-European countries had a seroprevalence of 9.4% compared to 4.1% in the majority population.[10] Furthermore, the excess of all-cause mortality during that same period was 114% for people born in sub-Saharan Africa compared to 22% among French natives.[11]

Differential exposure to the virus and differential prevention behaviour uptake are two mechanisms that can shape the risk of infection.

Regarding differential exposure, economic deprivation has been identified in previous studies as an important contributor[12,13]: immigrants and minorities more often live in overcrowded homes and can be more exposed to COVID-19 through occupational exposure in frontline jobs.[14,15] Social position is the key to understanding differential exposure, and a few studies have now shown how the social stratification of the epidemic rapidly changed in 2020: at the beginning, upper class, travelling individuals were more at risk of infection, but soon, the stratification was reversed, and lower-class individuals were more at risk due to their living conditions. This reversal was shown, for example, in Germany[16] and France.[17] Social position can be defined in different ways, but an element that could have been partly overlooked until now is the neighbourhood where individuals live and the spatial inequalities in the COVID-19 infection risk that exist. However, a recent study suggested that spatial inequalities could play an important role in the risk of infection and showed that higher commuting flows, especially by public transport, are associated with higher COVID-19 in the UK.[18]

Regarding potential differences in prevention behaviour uptake, although much research effort has been devoted to reporting on face masks and physical distancing efficacy for transmission prevention,[19] we found few studies that looks at how preventive behaviours were distributed across different social groups in the general

population. However, preventive behaviours are usually not evenly distributed across populations: women are often more inclined to adopt prevention behaviours in relation to a gendered socialization to health,[20] and upper social classes have greater social proximity to health professionals and are usually more responsive to prevention messages.[21]

Except for the data cited above on seroprevalence and mortality among immigrants, to date, there is no study in France that explores immigrants' exposure and prevention behaviours in detail. Information on migration status or ethnicity is not routinely collected in France,[22] which also explains why these data were not available until now. In France, the first wave peaked 2 weeks after the first lockdown started on 17 March, in a context of mask shortage and reduced availability of polymerase chain reaction tests. The first lockdown was very strict with the closure of schools, universities, cultural and social places, stores except for essential supply, teleworking, and limitation of outdoor circulation. It ended on 11 May 2020. At that time, the nationwide lockdown had substantially curbed transmission and the seroprevalence remained low, with about 5% of the population having developed a detectable humoural response to the virus.[23] All the barrier gestures (physical distance, washing hands, use of face masks) were then deemed highly recommended, but not compulsory.

Based on a national random population-based survey that duly collected the participants' and their parents' nationality and country of birth, this study aims to analyse the factors that can explain the higher seroprevalence among immigrants in France during the first COVID-19 epidemic wave in April/June 2020. More precisely, we wish to examine how COVID-19 exposure factors (overcrowding, working outside the home, use of public transport to go to work) and prevention behaviours (use of face masks, washing hands, respect for physical distance) were distributed according to migratory status, sex and social position.

Methods

Study design

A total of 371 000 individuals aged 15 years or older living in mainland France or three of the five French overseas territories were randomly selected from the FIDELI administrative sampling frame. FIDELI covers 96.4% of the population, and it provides postal addresses for all individuals and an e-mail address or telephone number for 83%. The stratification of the sample was fully described elsewhere.[10] The selected individuals were contacted by post, e-mail and text messages, with up to seven reminders. Self-computer-assisted web (CAWI) or computer-assisted telephone interviews were offered to a random subsample of 20% of the sample. The remaining 80% were assigned to CAWI exclusively. The language used was French. The data collection lasted from 2 May to 2 June 2020.

Study population

This analysis was conducted on all participants living in metropolitan France. We excluded persons who changed residence during the first lockdown because they represented less than 5% of the total population in the country and even less among immigrant populations, and data on the neighbourhood were not available for them. Finally, individuals with missing values on the variables of interest were also excluded from the study. We focused the analyses on immigrants from the following regions: European Union, North Africa, sub-Saharan Africa and Asia. The individuals coming from other countries were not included in the study because they constituted a very heterogeneous category. A comparison of excluded individuals with the survey participants is available in Supplementary table S1. Finally, included participants were older, of higher income and more likely to be part of the majority population. Analyses of working outside the home only and the use of public transport to go to work were performed only among persons who had worked in the last 7 days. Analyses of the use of face masks and physical distancing in the most recent 7 days were restricted to persons who went out in the most recent 7 days.

Outcomes

The three outcomes measuring COVID-19-related exposure were as follows:

- *Overcrowding:* We adopted the definition from The National Institute of Statistics and Economic Studies (Insee), i.e. a home is overcrowded if the surface is below 18 m^2 per person. We considered that people living alone were not overcrowded.
- *Working outside the home only:* people who had worked in the last 7 days and who did not telework at all.
- *Use of public transport in the most recent 7 days to go to work.*

The three outcomes measuring prevention behaviours were as follows (exact wording of questions is available in Supplementary table S2):

- *Not systematically wearing a face mask when outside in the most recent 7 days* (who never wore it or occasionally).
- *Not systematically washing hands after being outside in the most recent 7 days* (who never washed their hands or occasionally).
- *Not being able to respect physical distancing when outside in the most recent 7 days* (who said they were never able to respect it, or who could respect it occasionally).

Covariables

Individual characteristics

A first-generation immigrant is defined as a person born in a foreign country, from a foreign nationality at birth, regardless of his or her current legal status/nationality. A second-generation immigrant has at least one parent who is an immigrant. The migratory status was examined according to regions of origin in 11 categories, which are detailed in table 1.

Other covariables include sex, age, education level, occupation, household type and income level in deciles. To account for the fact

Table 1 Migratory status in 11 categories

1	Majority population	Persons born in Metropolitan France who are neither first- nor second-generation immigrants
2	Persons born in French Overseas Departments	Persons born in French Overseas Departments
3	Descendants from French Overseas Departments	Persons born in Metropolitan France whose at least one parent was born in French Overseas Department
4	Second-generation immigrant European Union	Person born in France with immigrant parent coming from the 27-country European Union
5	Second-generation immigrant from North Africa	Person born in France with immigrant parent coming from North Africa
6	Second-generation immigrant from sub-Saharan Africa	Person born in France with immigrant parent coming from sub-Saharan Africa
7	Second-generation immigrant from Asia	Person born in France with immigrant parent coming from Asia
8	Immigrant from European Union	Person born in the European Union, of non-French nationality at birth
9	Immigrant from North Africa	Person born in North Africa, of non-French nationality at birth
10	Immigrant from sub-Saharan Africa	Person born in sub-Saharan Africa, of non-French nationality at birth
11	Immigrant from Asia	Person born in Asia, of non-French nationality at birth

that people living in regions diversely affected by the epidemic could have had different practices, we included a variable region of residence in three categories: high-intensity epidemic, moderate-intensity epidemic and low-intensity epidemic. This variable is based on the work of Fouillet *et al.*,[24] who realized a spatial analysis of the first wave of the epidemic in France.

Neighbourhood characteristics

For each individual in the survey, information on the neighbourhood was provided at the IRIS (Ilots Regroupés pour l'Information Statistique), the smallest spatial statistical unit in France. We used the French Deprivation Index[25] and the proportion of first-generation immigrants in the IRIS, which is made available online by Insee.[26]

Statistical analyses

Final calibrated weights were calculated to correct for nonresponses. The sampling design was accounted for, with STATA svy procedures, to estimate percentages and crude and adjusted odds ratios (aORs) with logistic regression models and to perform statistical tests.

After presenting the study sample, we described the distribution of the outcomes according to the migratory status and sex, using χ^2 tests. We then adopted a two-step approach to model the probability of exposure (overcrowding, working outside the home, using public transport to go to work) and risk in terms of prevention behaviours (not systematically wearing face masks when out, not systematically washing hands, not being able to respect physical distancing when out): first, we modelled the probability of the risk, adjusting for individual sociodemographic characteristics. Then, in order to take the neighbourhood characteristics into account, we focused the analysis on the Greater Paris area, one of the most affected regions during the first COVID-19 wave, and repeated the analysis while accounting for the neighbourhood variables. We used this approach because variations in the neighbourhood characteristics are difficult to interpret when urban and rural areas are pooled in the same model. Because the correlation between the deprivation index and the proportion of first-generation immigrants was very strong, we showed descriptive results for both variables and included only the latter in our models.

Ethics and reglementary issues

The survey was approved by the CNIL (the French data protection authority) (ref: MLD/MFI/AR205138) and the ethics committee (Comité de Protection des Personnes Sud Méditerranee III 2020-A01191-38) on April 2020. The survey was also approved by the 'Comité du Label de la Statistique Publique'.

Results

A total of 111 824 participants were included in the study (Supplementary figure S1). Sociodemographic characteristics differed importantly according to the migratory status: first- and second-generation immigrants were generally younger, had a lower education level and more often lived in high-intensity epidemic regions compared to the majority population, with important variations according to the region of origin (table 2). First- and second-generation immigrants were more often in the lowest decile of income (as much as 28.9% among immigrants from North Africa and 26.8% among first-generation immigrants from sub-Saharan Africa compared to 6.4% in the majority population).

Exposure to COVID-19 risk

Overall, immigrants were at a higher risk of exposure: overcrowding was much more frequent in all immigrant groups, up to 41.6% of second-generation immigrants from sub-Saharan Africa, with no difference between men and women (table 3). The use of public transport was much lower during this first lockdown but had important disparities according to both migratory status (18.3% among first-generation immigrants from sub-Saharan Africa, versus 2.1% in the majority population, $P < 0.001$) and sex (in all migratory groups, women more often used public transport, although the difference was not statistically significant in all groups). The descriptive results on the distribution of different outcomes of exposure across neighbourhood characteristics followed the same pattern of social gradient with higher exposure behaviours in deprived neighbourhoods and neighbourhoods where the proportion of first-generation immigrants was higher (Supplementary table S3).

In multivariate analyses, the probability of overcrowding was still higher for first-generation immigrants from North Africa [aOR = 4.99 (4.46; 5.58)] and Asia [aOR = 4.10 (3.32; 5.07)] than for the majority population, as well as for lower-income participants [aOR = 6.02 (5.34; 6.81)] (table 4). In the study on the Greater Paris area, living in a neighbourhood with a higher proportion of first-generation immigrants was also associated with overcrowding [aOR = 2.33 (1.99; 2.72), Supplementary table S4].

Similarly, among participants who had worked in the last 7 days, the probability of using public transport to go to work was still higher [with the highest probability for first-generation immigrants from sub-Saharan Africa, aOR = 6.36 (4.86; 8.32)] than for the majority population. Additionally, women were more likely to use public transport than men [aOR = 1.28 (1.11; 1.47)]. In the study on the Greater Paris area, living in a neighbourhood with a higher proportion of first-generation immigrants was also associated with the use of public transport [aOR = 2.12 (1.60; 2.81)] (Supplementary table S4).

Although there was a higher proportion of immigrants who reported having worked outside the home only, after adjustment (notably for occupation), they were less at risk than the majority population to have worked outside only (Supplementary table S5).

Prevention behaviours

Concerning prevention behaviours, the general picture was completely different. Whereas 61.8% of the majority population reported not wearing a face mask systematically when outside, the proportion was lower in first-generation immigrant groups: only 23.5% and 33.9% in immigrants from Asia and sub-Saharan Africa, respectively ($P < 0.001$) (table 3). In total, 42.1% of the majority population reported not being able to respect physical distance, versus 31.6%% in first-generation immigrants from North Africa ($P < 0.001$). In all groups, not wearing face masks systematically was less frequent in women than in men: in the majority population, 56.3% of women versus 67.6% of men ($P < 0.001$).

First- and second-generation immigrants from the EU had a profile closer to the majority population on all of the outcomes.

The distribution of prevention behaviour outcomes across neighbourhood characteristics followed the same pattern of social gradients, with more systematic prevention practices in deprived neighbourhoods and in neighbourhoods with the highest proportion of first-generation immigrants (Supplementary table S3).

In multivariate analyses, prevention behaviours remained strongly shaped along social gradients, sex and migratory status (table 4). Compared to high-income participants, low-income participants were less at risk of not wearing masks systematically [aOR lowest decile = 0.74 (0.69; 0.79)]; the same pattern was found in not being able to respect physical distancing [aOR lowest decile = 0.83 (0.78; 0.89)]. Women were less at risk of not wearing face masks [aOR = 0.66 (0.63; 0.68)] than men. Moreover, all immigrant groups were less likely to have a non-systematic use of face masks than the majority population [aOR first-generation immigrants from sub-Saharan Africa = 0.32 (0.28; 0.37)], and immigrants were less likely to breach physical distancing [aOR = 0.71 (0.61; 0.81) for first-generation immigrants from sub-Saharan Africa]. Finally, the

Table 2 Individual and neighbourhood characteristics of participants according to migratory status, $N = 111\,824$

	Majority population ($N = 93\,071$)	Persons born in FOD[a] ($N = 666$)	FOD[a] descendants ($N = 744$)	Second generation EU ($N = 5793$)	Second generation North Africa ($N = 2850$)	Second generation Sub-Saharan Africa ($N = 704$)	Second generation Asia ($N = 471$)	First generation EU ($N = 3055$)	First generation North Africa ($N = 2448$)	First generation Sub-Saharan Africa ($N = 1264$)	First generation Asia ($N = 757$)
Individual characteristics											
Sex											
Men	48.0	52.8	44.5	47.6	46.5	47.6	49.5	42.7	51.6	47.4	44.9
Women	52.0	47.2	55.5	52.4	53.5	52.4	50.6	57.3	48.4	52.6	55.2
Age											
15–19	6.8	3.4	15.6	4.2	16.7	29.4	26.9	3.2	1.8	5.3	2.2
20–29	11.3	13.8	25.2	8.5	19.6	37.7	29.6	4.8	6.5	13.8	6.0
30–49	29.1	36.8	42.6	28.0	41.2	31.1	31.9	22.5	46.9	53.0	47.2
50–64	25.4	29.3	12.2	24.6	18.5	4.6	8.2	30.3	26.5	21.9	29.9
>64	27.4	16.6	4.5	34.7	3.9	2.2	3.4	39.3	18.3	6.0	14.7
Education level											
Primary	24.5	26.2	18.5	26.9	26.5	28.1	24.4	42.6	47.3	34.4	46.9
Secondary	42.4	47.5	43.5	45.2	41.6	38.6	34.2	32.0	29.3	31.8	23.3
Tertiary	33.2	26.4	38.1	27.9	31.9	33.3	41.4	25.4	23.4	33.8	29.8
Region of residence											
High-intensity epidemic	21.9	41.3	51.2	29.9	40.5	64.9	65.3	35.7	43.4	55.0	70.7
of which Ile-de-France	*13.0*	*37.5*	*44.4*	*19.1*	*34.1*	*59.3*	*58.9*	*26.8*	*36.6*	*51.1*	*66.1*
Moderate-intensity epidemic	27.4	15.3	14.9	26.7	25.0	12.4	11.1	21.8	21.1	14.0	10.7
Low-intensity epidemic	50.7	43.4	33.9	43.4	34.5	22.7	23.6	42.6	35.5	31.0	18.6
Activity before lockdown											
Working (employed and informal work)	52.3	62.4	66.6	48.6	56.7	45.0	50.8	46.1	51.7	64.7	61.2
Student/Apprentice	9.2	5.1	19.6	6.3	22.5	38.5	37.3	4.2	3.7	10.4	5.1
Unemployed	4.9	8.6	6.5	5.2	10.8	10.9	5.3	4.1	11.9	12.5	10.6
Retired	30.8	22.1	5.8	37.0	4.7	2.1	4.2	40.6	17.0	5.9	12.7
Inactive	2.7	1.9	1.5	2.9	5.3	3.7	2.4	5.0	15.7	6.5	10.4
Occupation											
Farmers, self –employed, entrepreneurs	8.2	1.7	2.7	8.0	3.8	1.7	4.0	9.0	6.7	3.7	8.6
Higher level professionals and managers	16.9	12.4	14.9	16.5	11.5	10.2	18.9	14.7	8.7	9.6	11.5
Lower level professionals	15.7	14.7	12.2	16.0	11.6	10.4	0.1	12.9	7.7	11.6	8.2
Skilled clerical, sales and services	5.6	7.1	8.5	5.0	7.5	6.5	7.3	4.6	5.2	8.1	9.1
Unskilled clerical, sales and services	18.9	25.5	20.6	21.6	14.8	14.5	11.1	18.6	16.7	17.2	21.9
Skilled labourers and factory workers	9.3	14.7	5.8	11.6	10.3	5.6	4.3	15.6	17.1	13.5	11.9
Unskilled labourers and factory workers	4.7	4.4	3.9	4.2	4.6	3.5	2.0	7.8	10.5	9.0	8.3
Never worked and others	16.8	13.5	25.8	14.2	32.9	44.3	39.6	15.1	26.0	21.5	19.6
Health professionals	3.7	6.1	5.7	2.8	3.0	3.3	2.6	1.7	1.4	5.8	1.1
Household type											
Live alone	18.0	16.5	13.7	20.6	12.4	9.0	7.7	17.6	11.4	13.1	10.0
Couple, no child	31.4	23.6	10.3	32.1	9.5	8.5	14.9	37.3	14.1	9.5	16.6
Couple with at least 1 child	35.9	34.5	47.7	33.7	55.3	50.3	56.0	29.7	51.6	45.4	50.0
Single parent with at least 1 child	8.3	12.7	19.4	7.9	13.7	17.1	9.2	5.8	11.0	17.2	7.3
Complex household	6.4	12.7	9.0	5.7	9.2	15.1	12.1	9.6	11.9	14.9	16.1
Income level (deciles)											
D1 (lowest)	6.4	11.8	7.4	5.9	19.7	18.8	16.9	13.0	28.9	26.8	20.6
D2–D3	16.4	23.3	25.9	17.9	31.9	41.0	27.8	21.7	36.9	34.6	31.5
D4–D5	20.4	22.0	20.4	21.5	18.8	19.5	16.0	20.9	16.1	19.5	16.5
D6–D7	22.5	20.4	22.6	22.7	14.7	9.4	12.3	18.4	9.1	10.8	14.8
D8–D9	23.2	16.7	17.8	22.4	10.5	8.9	18.2	16.6	6.3	6.3	10.3
D10 (highest)	11.0	5.9	5.9	9.6	4.4	2.4	8.9	9.5	2.7	2.0	6.4

Note: The EpiCov study, May 2020.
a: French Overseas Departments. Weighted percentages.

Table 3 COVID-19-related exposure and prevention behaviours according to migratory status and sex, $N = 111\,824$

		Overcrowding ($N = 111\,824$)	Working outside the home only (among persons who worked in last 7 days) ($N = 58\,306$)	Using public transportation (among persons who worked in last 7 days) ($N = 58\,306$)	Not wearing mask systematically in last 7 days (among who went out) ($N = 103\,350$)	Not being able to respect distance in last 7 days (among who went out) ($N = 103\,350$)
Majority population	**Total**	**7.5**	**32.6**	**2.1**	**61.8**	**42.1**
	Men	7.7	32.3	1.7	67.6	41.7
	Women	7.3	33.0	2.5	56.3	42.5
	P	*0.07*	*0.18*	*<0.001*	*<0.001*	*<0.05*
Persons born in FOD	**Total**	**21.4**	**35.1**	**7.0**	**49.7**	**41.2**
	Men	20.9	31.3	4.5	56.4	39.1
	Women	21.9	40.1	10.2	42.1	43.6
	P	*0.81*	*0.13*	*0.07*	*<0.01*	*0.35*
FOD descendants	**Total**	**22.9**	**29.7**	**9.8**	**55.5**	**53.2**
	Men	17.6	29.0	8.6	59.3	49.6
	Women	27.2	30.3	10.9	52.6	55.9
	P	*<0.05*	*0.80*	*0.47*	*0.13*	*0.17*
Second-generation EU	**Total**	**8.2**	**30.5**	**2.5**	**55.4**	**39.7**
	Men	8.9	30.1	2.0	61.7	39.1
	Women	7.6	31.0	3.0	49.5	40.3
	P	*0.16*	*0.67*	*0.12*	*<0.001*	*0.46*
Second-generation North Africa	**Total**	**32.3**	**26.8**	**4.9**	**52.0**	**47.0**
	Men	32.5	30.8	3.2	58.9	44.5
	Women	32.1	22.7	6.5	45.8	49.2
	P	*0.86*	*<0.01*	*<0.05*	*<0.001*	*<0.05*
Second-generation Sub-Saharan Africa	**Total**	**41.6**	**26.6**	**12.7**	**47.5**	**56.9**
	Men	37.8	30.8	13.2	51.6	56.8
	Women	45.1	22.1	12.1	43.6	57.1
	P	*0.10*	*0.14*	*0.82*	*0.10*	*0.94*
Second generation Asia	**Total**	**33.2**	**22.0**	**4.8**	**42.6**	**49.2**
	Men	27.7	*22.6*	3.2	45.3	44.2
	Women	38.5	*21.5*	6.4	39.7	54.5
	P	*<0.05*	*0.86*	*0.25*	*0.33*	*0.08*
First-generation EU	**Total**	**14.3**	**29.2**	**4.9**	**49.9**	**35.0**
	Men	14.5	27.2	3.5	51.9	32.8
	Women	14.2	31.0	6.2	48.2	36.7
	P	*0.84*	*0.20*	*<0.05*	*0.12*	*0.08*
First-generation North Africa	**Total**	**40.0**	**32.9**	**6.3**	**35.9**	**31.6**
	Men	39.4	30.4	5.4	40.6	31.1
	Women	40.7	37.4	7.9	29.8	32.1
	P	*0.57*	*<0.05*	*0.13*	*<0.001*	*0.66*
First-generation sub-Saharan Africa	**Total**	**40.9**	**36.2**	**18.3**	**33.9**	**38.1**
	Men	43.4	34.6	15.6	37.8	43.3
	Women	38.6	37.9	21.2	30.4	33.4
	P	*0.15*	*0.44*	*0.12*	*<0.05*	*<0.01*
First generation Asia	**Total**	36.7	*21.4*	**9.8**	**23.5**	**39.5**
	Men	38.2	18.1	10.9	23.5	40.8
	Women	35.4	24.9	8.7	23.6	38.5
	P	*0.52*	*0.17*	*0.57*	*0.96*	*0.63*
	P migratory status	<0.001	<0.001	<0.001	<0.001	<0.001

Note: The EpiCov Study, May 2020. Weighted percentages and χ^2 tests.

region of residence also mattered: participants were more likely to systematically wear the mask or to respect physical distancing if they lived in a region with a high-intensity epidemic.

The analysis of the Greater Paris area revealed that in neighbourhoods with a higher proportion of first-generation immigrants, participants were less at risk of not wearing a mask [aOR = 0.74 (0.66; 0.83), Supplementary table S4]. In contrast, they were more likely to report that they were not able to respect physical distancing [aOR = 1.13 (1.01; 1.26)].

The non-systematic handwashing was less frequent in all groups, though the immigrant groups still had marked prevention behaviours (Supplementary tables S6 and S7).

Discussion

Based on a random national population-based survey, we showed that first- and second-generation immigrants in France were more often living in overcrowded homes and using public transport during the first wave of the epidemic, even after adjustment for sociodemographic and occupational characteristics. The exposure of immigrants and minorities through overcrowding and social deprivation has been well established in other studies.[27,28] Data on how public transportation were used during pandemic are scarce but a detailed study in New York city found that in neighbourhoods with a higher share of racialized minorities, the decrease of public transport mobilities was less prominent, suggesting that minorities had a reduced ability to stop using public transportation.[29]

Our results also suggest that these populations were much aware of the risk of infection, because they were more inclined to use face mask systematically and respect physical distancing than the majority population. Few studies examined the relation between ethnicity/migratory status and prevention behaviours in Europe. A Norwegian report indicated that immigrants from lower-income

Table 4 Factors associated with exposure and prevention behaviours during the French first Covid-19 wave (April/June 2020) among EpiCov participants—Multivatiate logistic regressions

	Overcrowding			Using public transportation to go to work (among persons who worked in last 7 days)			Not wearing mask systematically in last 7 days (among who went out)			Not being able to respect distance in last 7 days (among those who went out)		
	N = 111 824			*N* = 58 306			*N* = 103 350			*N* = 103 350		
	%	aOR [CI 95%]	*P*	%	aOR [CI 95%]	*P*	%	aOR [CI 95%]	*P*	%	aOR [CI 95%]	*P*
Migratory status												
Majority population	7.5	Ref	***	2.1	Ref	***	61.8	Ref	***	42.1	Ref	***
Born in FOD*	21.4	2.47 [1.93; 3.16]		7.0	2.26 [1.39; 3.62]		49.7	0.61 [0.50; 0.74]		41.2	0.87 [0.71; 1.06]	
Parents born in FOD*	22.9	1.84 [1.47; 2.31]		9.8	3.06 [2.09; 4.40]		55.5	0.71 [0.59; 0.85]		53.2	1.14 [0.96; 1.36]	
Second generation EU	8.2	1.16 [1.03; 1.32]		2.5	1.05 [0.79; 1.38]		55.4	0.82 [0.76; 0.88]		39.7	0.96 [0.89; 1.03]	
Second generation North Africa	32.3	2.80 [2.51; 3.11]		4.9	1.71 [1.27; 2.29]		52.0	0.62 [0.57; 0.69]		47.0	1.00 [0.91; 1.10]	
Second generation sub-Saharan Africa	41.6	2.92 [2.41; 3.55]		12.7	3.40 [2.07; 5.57]		47.5	0.53 [0.43; 0.64]		56.9	1.29 [1.60; 1.56]	
Second generation Asia	33.2	2.51 [1.97; 3.20]		4.8	1.25 [0.64; 2.43]		42.6	0.41 [0.32; 0.51]		49.2	0.95 [0.75; 1.20]	
First generation EU	14.3	2.40 [2.08; 2.77]		4.9	1.95 [1.46; 2.60]		49.9	0.72 [0.66; 0.80]		35.0	0.85 [0.77; 0.94]	
First generation North Africa	40.0	4.99 [4.46; 5.58]		6.3	2.28 [1.70; 3.06]		35.9	0.37 [0.33; 0.41]		31.6	0.65 [0.58; 0.73]	
First generation sub-Saharan Africa	40.9	3.71 [3.19; 4.32]		18.3	6.36 [4.86; 8.32]		33.9	0.32 [0.28; 0.37]		38.1	0.71 [0.61; 0.81]	
First generation Asia	36.7	4.10[3.32; 5.07]		9.8	2.86 [1.83; 4.46]		23.5	0.21 [0.17; 0.26]		39.5	0.84 [0.69; 1.02]	
Sex												
Men	11.1	Ref	ns	2.5	Ref	***	64.4	Ref	***	41.0	Ref	**
Women	10.8	0.97 [0.91; 1.02]		3.5	1.28 [1.11; 1.47]		53.6	0.66 [0.63; 0.68]		42.2	1.05 [1.01. 1.08]	
Age												
15–19	21.4	1.02 [0.92; 1.12]	***	4.6	1.65 [0.74; 3.68]	ns	63.7	1.25 [1.16; 1.35]	***	48.0	1.18 [1.09; 1.27]	***
20–29	16.0	0.76 [0.71; 0.82]		3.6	1.15 [0.95; 1.39]		66.7	1.25 [1.18; 1.32]		56.0	1.36 [1.29; 1.44]	
30–49	18.7	Ref		2.9	Ref		62.0	Ref		48.2	Ref	
50–64	6.1	0.29 [0.27; 0.31]		2.9	0.98 [0.84; 1.14]		58.9	0.82 [0.79; 0.85]		37.9	0.64 [0.62; 0.67]	
>64	1.6	0.09 [0.07; 0.10]		2.9	0.82 [0.43; 1.56]		49.9	0.51 [0,48; 0,54]		28.8	0.41 [0.39; 0.43]	
Region of residence												
High intensity	17.4	1.92 [1.81; 2.04]	***	6.9	4.63 [3.91; 5.47]	***	53.1	0.76 [0.73; 0.79]	***	44.9	1.14 [1.10; 1.19]	***
Moderate intensity	9.2	1.06 [0.99; 1.13]		1.9	1.53 [1.26; 1.87]		61.4	1.01 [0.97; 1.05]		40.7	0.98 [0.95; 1.02]	
Low intensity	8.4	Ref		1.3	Ref		60.6	Ref		40.4	Ref	
Level of income (deciles)												
Decile 1 (most disadvantaged)	26.9	6.02 [5.34; 6.81]	***	5.1	1.45 [1.11; 1.91]	*	53.4	0.74 [0.69; 0.79]	***	40.5	0.83 [0.78; 0.89]	***
Decile 2–3	29.4	4.90 [4.36; 5.50]		3.7	1.14 [0.90; 1.45]		55.5	0.77 [0.72; 0.82]		40.6	0.86 [0.81; 0.91]	
Decile 4–5	10.6	2.99 [2.66; 3.36]		2.7	0.93 [0.74; 1.18]		57.6	0.79 [0.75; 0.84]		40.4	0.91 [0.86; 0.96]	
Decile 6–7	7.0	2.08 [1.85; 2.34]		2.5	0.97 [0.79; 1.19]		60.2	0.89 [0.84; 0.93]		41.4	0.95 [0.91; 1.00]	
Decile 8–9	5.1	1.53 [1.37; 1.72]		2.7	0.99 [0.82; 1.19]		61.8	0.95 [0.90; 1.00]		42.2	0.96 [0.92; 1.01]	
Decile 10	3.5	Ref		3.1	Ref		62.2	Ref		42.7	Ref	
Occupation												
Farmers, self-employed and entrepreneurs	6.4	0.70 [0.61; 0.80]	***	0.8	0.31 [0.19; 0.48]	***	59.2	0.92 [0.86; 0.99]	***	34.5	0.81 [0.76; 0.87]	***
High level prof.	7.8	Ref		3.3	Ref		63.8	Ref		43.4	Ref	
Lower level prof.	7.7	0.84 [0.76; 0.92]		2.6	0.90 [0.75; 1.09]		61.6	0.94 [0.89; 0.99]		42.9	1.00 [0.95; 1.05]	
Skilled clerical, sales and services	12.2	0.80 [0.71; 0.90]		3.7	1.10 [0.89; 1.35]		64.1	1.03 [0.97; 1.11]		51.2	1.09 [1.02; 1.16]	
Unskilled clerical, sales and services	10.1	0.99 [0.89; 1.09]		3.7	1.12 [0.92; 1.36]		53.5	0.81 [0.76; 0.85]		38.9	0.89 [0.85; 0.94]	
Skilled labourers and factory workers	11.7	0.93 [0.83; 1.04]		1.9	0.62 [0.47; 0.82]		59.6	0.85 [0.80; 0.91]		38.1	0.85 [0.80; 0.91]	
Unskilled labourers and factory workers	14.6	1.04 [0.91; 1.19]		3.7	1.19 [0.86; 1.65]		57.3	0.85 [0.77; 0.93]		37.3	0.79 [0.72; 0.86]	
Never worked and others	17.7	1.05 [0.95; 1.16]					57.0	0.73 [0.68; 0.77]		42.3	0.78 [0.73; 0.83]	
Health professionals	10.8	0.88 [0.77; 1.02]		4.3	1.49 [1.18; 1.88]		51.9	0.59 [0.55; 0.64]		54.4	1.25 [1.16; 1.35]	

*: French Overseas Departments. AdOR, adjusted odds ratio, estimated in multivariate logistic regressions further adjusted household type (except for overcrowding);

***: <0,001;

**: <0.01;

*: <0.05; analyses conducted on weighted data.

countries tended to have better prevention behaviours compared to immigrants from high-income countries.[30] A study based on the UK COVID-19 Social Study also gave detailed results on the social distribution of prevention behaviours: non-Whites were less likely to experience outdoor mixing and were more likely to wash hands during the second wave of the epidemic. The authors found no difference for the use of masks between Whites and non-Whites.[31]

Respecting physical distance does not entirely depend on individual behaviours. Instead, it relates both to a person's willingness to adopt prevention behaviours and to the type of environment they are in. However, it is striking that although immigrants tend to live in more populated areas,[17] they are still more likely to report that they are able to keep sufficient distance. Smaller quantitative and qualitative studies conducted in France among deprived first-generation immigrant populations during the first lockdown suggested a very high observance of prevention measures[32,33]: our results confirm it at a population scale.

In France, spatial segregation mechanisms have led to a certain concentration of poorer immigrants in the same neighbourhoods.[34] We were also able to show that this combination of higher risk/higher protection was also relevant at the neighbourhood level: participants living in neighbourhoods where there was a higher proportion of immigrants were more exposed to COVID-19-related factors and were more likely to wear a face mask systematically. However, participants living in these neighbourhoods were more likely not to be able to respect physical distancing. This finding can be explained in several ways: first, there could be a higher perception of the risk and of the impossibility of respecting physical distance. Additionally, immigrants were more likely to use public transport, where physical distancing is challenging. Finally, these neighbourhoods could be more densely populated.

Another salient result is the gendered pathways taken by the epidemic. We showed that women used public transport more often, whereas men used their car more often to go to work (data not shown), which reflects a highly gendered division of transport modes that is well studied by sociologists and geographers.[35] Women also appear to have a heightened perception of risk, which results in a more systematic use of face masks among both the majority population and the migrant groups, and according to the multivariate analysis, women are more likely to report difficulty in respecting physical distance. These results are in line with the results of a recent review[36] and in a large panel study in the UK.[37]

Prevention behaviours are then partly an accurate response to actual overexposure (hence disparities according to the social gradient, according to migratory status, and region of residence) and on socialization to health and prevention (hence a higher perception of risk among women compared to men).

This study is not without limitations. First, reporting prevention behaviours can reflect social desirability bias, and although face mask use was not compulsory at the time of the survey, individuals could have been inclined to overestimate their prevention behaviours. However, the prevalence of the use of face mask in the general population is exactly the same that the one found in another study conducted at the same time in France[38] and there is no hypothesis that could explain different intensities of social desirability by migratory status. Another limitation is that we could not include the persons who changed residence during the first lockdown; however, the analysis conducted by Lambert *et al.*[39] showed that the 5% who changed residence were more often high-income professionals. Because we saw that the upper classes are the ones who had less systematic use of prevention, the prevalences that we measured could be slightly overestimated. Another limitation regards the recruitment of the study: although highly representative, the survey is based on a randomized sample from administrative data. This means that immigrants who arrived very recently or are undocumented are not present in this database. However, the above-mentioned studies conducted among deprived, undocumented immigrants[32,33] suggest a very high observance of public health recommendations in these populations.

Finally, although we showed that there was an association between neighbourhood characteristics and both the level of exposure and prevention behaviours, further research is needed to understand how individual and neighbourhood characteristics intertwined to influence seroprevalence.

Our study provides the first detailed estimates of COVID-19-related exposure and prevention behaviours across gender, class and migratory status based on a nationally representative survey in France. Despite better prevention behaviours than the majority population in France, first- and second-generation immigrants were more exposed, and the seroprevalence was higher, especially in first-generation immigrants from outside Europe during the first wave in France.[10] Our results then plead for specific and sustained efforts to implement other prevention tools, such as vaccination opportunities aimed at first- and second-generation immigrants, at the individual and neighbourhood levels.

Supplementary data

Supplementary data are available at *EURPUB* online.

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Conflicts of interest: None declared.

Data availability

The EpiCov dataset is planned to be available for research purpose, from June 2021 concerning the first round, and from March 2022

concerning the second round. Anonymous aggregated data for the first round will be available online before the end of 2021. Access to de-identified data will be available only once approval has been obtained by public entities controlling access to the data. Access condition may be obtained from corresponding author on reasonable request.

Key points

- Immigrants and ethnic/racialized minorities have been identified as being at higher risk of coronavirus disease-19 (COVID-19) infection.
- Few studies report on their exposures and prevention behaviours.
- Overall, in France, immigrant groups from non-European countries were more exposed to COVID-19-related factors and more respectful of prevention measures.
- Living in a neighbourhood with a higher share of immigrants was associated with higher exposure and better prevention behaviours.

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