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Cumulative incidence of Covid-19 deaths in France: a tentative analysis at département level

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On both sides of the Atlantic, in the Anglo-Saxon countries, the issue of excessive mortality due to Covid-19 among members of minorities has emerged as a central issue of social justice. In the turmoil caused by the eruption of the pandemic, arguments have been put forward fervently in the United-States, with more circumspection in the United-Kingdom where, nevertheless, medical authorities consider the identification of groups at high risk for SARS-Cov2 to be a health priority. Very quickly in the United States, the perceived disproportion of deaths among minority groups has been associated with the lack of health care facilities accessible and the unequal treatment of the poor, especially minorities – an argument that could not be made as such in the United Kingdom. Neither in France, nor in Germany, nor in Italy or Spain has this debate surfaced with such intensity. Outside the Anglo-Saxon countries, where "race/ethnicity" is generally recorded, it is neither legitimate nor easy to address this issue. However, in France data files for the period up to the end of containment, mentioning the place of birth of people, allow to make comparisons on the determinants of Covid-19 severity integrating ethnicity.

In the US, at the county level, Li & al. (2020) analyzed the effects of Black race and environmental temperature on the *mortality* of COVID-19, adjusting for variables that span social and health domain, notably variables associated with respiratory illness. These adjustments do not cancel out the statistical effect of the percentage of Blacks (and temperature). This leads Li & al. (2020) to write "that many of the mechanisms proposed to explain the higher risks of covid-19, such as socio-economic background and access to care, are insufficient to explain the full extent of this ethnic disparity in health ". For UK, the Epi-cell of Public Health England (2020) mentions that they were "not able to include the effect of comorbidities or obesity...[which] are important factors because they are associated with the risk of death and are more commonly seen in some Black and Asian minority groups"; adding however that "other evidence has shown that when these are included, the difference in risk of death among hospitalized patients is greatly reduced." In other words, at aggregated level, the social and health contexts matter but do not fully account of ethnic disparities in the risk of deaths. Conversely, at the individual level, several studies show that for the risk of death, once underlying pathologies are taken into account, ethnicity is no longer associated in the United States (Souleyman & al. 2020, Gu & al. 2020), or only slightly so in the United Kingdom where South Asians are more affected (Harisson & al. 2020).

For the risk of *contamination* by the SARS-Cov2, many studies at the individual level indicate that minorities are more at risk. For instance, in UK, using a large sample of people followed in the UK-Biobank, and controlling urbanization, education, occupation, unemployment, and deprivation levels Niedzwiedz & al. (2020) show that all these aspects of social disadvantage in addition to obesity, smoking and drinking reduce strongly the influence of ethnicity but this influence remains significant for Black Caribbean; Raisi-Estrabagh & al. (2020) find similar results with another sample from the UK Biobank. While in the US, Gu & al (2020) built two

control groups matched and unmatched and compare to a cohort of tested patients from the University of Michigan Medicine Health System, they find an important gap between non-Hispanic Blacks and non-Hispanic Whites. In other words, as far as the contamination process is concerned, if social disadvantage and collective aspects of health play an important role it remains an unexplained part coded by ethnicity.

The present study at the *département* level in France is part of an attempt to compare the determinants of susceptibility and severity of the SARS-Cov2 epidemic at the local level in European countries and the US¹.

Data available and framework of the analysis of French Covid crisis during the spring 2020

Two outcomes of interest, with distinct social and moral tones, are raised by the coronavirus pandemic. The differential in susceptibility, measured by the percentage of people contaminated in various social groups, and the differences in contaminations severity which can be measured by hospitalizations and death rates in these groups.

Outcomes

The contamination numbers are not very reliable because of the high proportion of asymptomatic or mildly symptomatic cases and the low level of testing². To put the French situation in perspective we could have nevertheless considered French data on hospitalizations for the spring 2020, in complement to deaths rates, to address the question which has dominated the papers published on the socio-political impact of the Covid-19 in the US and the UK, if a measure of ethnicity was accessible. However, in France ethnicity is not documented in public data, with a partial exception for death certificates. Hence, our attempt to compare took advantage of a narrow window, using the death tallies from another source.

In several European countries, difficulties arise because of the way nursing-home deaths have been taken in account. In France and UK during the first months of the epidemic, the deaths occurring in nursing homes were not counted and have been later added in a separate body of data without precision about their location and day. Moreover, in French elderly nursing homes (EHPAD) and in socio-medical facilities (EMS), resident deaths due to SARS-Cov2 are mixed with deaths stemming from other causes³.

Public data on Covid-19 epidemic are not very disaggregated in France, they are provided at the *département* level; data published on the city of residence, “commune”, and the “arrondissement” for metropolis are not systematic. The national statistical institute, INSEE, in an effort of transparency, has released individual anonymized files for 2018 to May 2020, including date of death, sex, age, “département” of residence of deceased person, “commune” of death, place of death (home, hospital, nursing home). Another body of data which has been made quickly available during spring 2020, are the files coming from the exploitation of the “fiches d’état-civil”, documenting the city of birth in France or the country and city of birth for people born

¹ We aim as far as possible at doing for several urban settings in each country a deeper analysis based on fine grained data (city or zip-code areas level).

² See Rahmandad, H., & al. 2020.

³ See data released on Sante-gouv.fr

abroad. Unfortunately, the files released do not yet include the cause of the death, which is usually provided in France with a three years lag by INSERM.

Using these data, the analysis of Covid-19 may be based on the difference in the death tallies between the spring 2020 and the same period of the previous years, considering that the main difference is the intervention of the SARS-Cov2 epidemic. Indeed, on the one hand the containment has reduced sources of mortality like car accidents, on the other some diseases which were not taken in charge because of a priority given to the epidemic may have add to the death toll imputed to the Covid-19. We hypothesize that the difference is not huge and has not a very specific profile across départements. Moreover, this protocol avoids the bias linked to discounting deaths at home for reasons which may or may not be linked to Covid-19.

Explaining data

The main drivers of the severity pattern, as it has been quickly seen through the first hospitalization reports, is defined by the age and sex structure of the population. In addition, we will consider here socio-economic factors, country of birth and health conditions.

Besides density of population and household size, we have taken in account overcrowding, which has been often hypothesized as a contributing factor to contaminations and possibly to deaths numbers. In France, collective housing is a general feature of poor districts but, if on average the household size is large in these districts, that does not mean always an overcrowding. For people living in public housing sensitive neighborhoods (QPV or ZUS), the number of square meters available per person is close to the collective housing average in France (even in Ile de France départements, see table in annex). The dwellings average size is 65 sqm in ZUS compared to 63 sqm in metropolitan France as a whole, however the average size of households is larger in these neighborhoods : respectively 2.4 persons per dwelling in ZUS against 1.9 in collective housing outside ZUS. This gives 27 sqm per person in ZUS areas, and around 33 sqm outside sensitive areas. Therefore, if there is a difference in occupation density between apartments in collective housing of sensitive areas and the average occupation rates in collective housing, it is not very huge gap. The Institute of statistics, INSEE, has released during the spring 2020 overcrowding indicators at the département level, these measures are built considering the space available in regard to family size. Overcrowding may have been associated with contamination of seniors and elderly people when containment measures were not in place or were loosely followed by the young people in these homes who find it difficult to stay at home.⁴ Another aspect, the household size – the number of people living under the same roof and interacting daily – is included in many epidemiological models and considered as a main driver of the reproduction rate R_0 . It might translate the density of interactions in the family but also the exposition to the virus outside home which is multiplied by the number of persons living together. The percentages of people under the poverty rate have also been considered.

A second series of variables are constituted by health indicators. Differences of severity are associated to health status prior the epidemic. These health conditions vary according to socio-economic levels, genetic predispositions shared by groups or specific to individual pedigree, and according to individual behavior –namely smoking, drinking, exercising. About health, the

⁴ We have used a variable built by INSEE for the purpose of analysis of the covid-19 excess of deaths : PopRPHStu1pSurocc (population des résidences principales sur-occupées hors studio de une personne) renamed population in crowded apartment.

prevalence of the main affections linked to SARS-Cov2 contaminations are not systematically published, but there are indicators on pathologic conditions related to a higher vulnerability and taken in charge by public health services. A branch of Health Ministry (DREES) releases data on serious pathologies (ALD -affections de longue durée) for which Social Security provides hospitalization, if necessary, to all citizen free of charge. Besides that, we have included the recourses to short term hospitalization for the whole array of the pathologies documented by DREES— cardiovascular, immunity, respiratory diseases, diabetes and obesity treatment.⁵ The death rates are broken by département, age-groups and sex (details given in annex). At the difference to anonymized individual files, nominative “état-civil” files indicate the place of birth (city and département). Moreover, it is possible, taking the département of death as a proxy for the département of residence, to define the death toll by birth places of people.⁶ This information on geographic origin allowed us to distinguish people born in metropolitan France and abroad, distinguishing oversea-départements or foreign countries. We have built large categories for regions of origin, namely Europe, North Africa, Asia and the French Caribbean, splitting sub-Saharan Africa between Sahel and non-Sahel regions.⁷ We have left aside indicators of public health policies. For one major reason : the period under scrutiny covers only the first wave of the epidemic up to the end of the containment, which has been uniform in France. Hence, we have no reason to build dummy variables associated to public intervention.

The French epidemic of Covid-19

We consider deaths intervening between March 1st and May 11th in 2020, end of containment period. By confronting the incidence of deaths, as from official counts released by *sante-gouv.fr*, and deaths reported weekly by municipal authorities centralized in the “état-civil” national register is quite manageable. We have evaluated the excess of deaths in 2020 by ratios. The death tallies at the national level as well as at the département level, have been calculated as the ratio of deaths during the spring 2020 and the mean over the same period of the three preceding years 2017, 2018, 2019 considered as a base line.

The annual evolution of deaths in France is characterized by a seasonal pattern, with more deaths during the winter months because of the influenza toll, marked between the end of December and the beginning of March. This seasonal pattern is also likely present in 2020. For 2017, the peak of influenza deaths is centered in early January, while it came much later in 2018 (March second week); in 2019 the deaths peak is located in between these two dates.⁸ The similarity of the seasonal pattern of SARS-Cov2 suggests that the deaths difference between 2020 and the mean of these three years is a reasonable account of the socio-regional variance of the epidemic. There is overall a good degree of concordance between the excess of deaths and the data transmitted by the French health authorities to John Hopkins Center. However, this agreement reflects a deficit

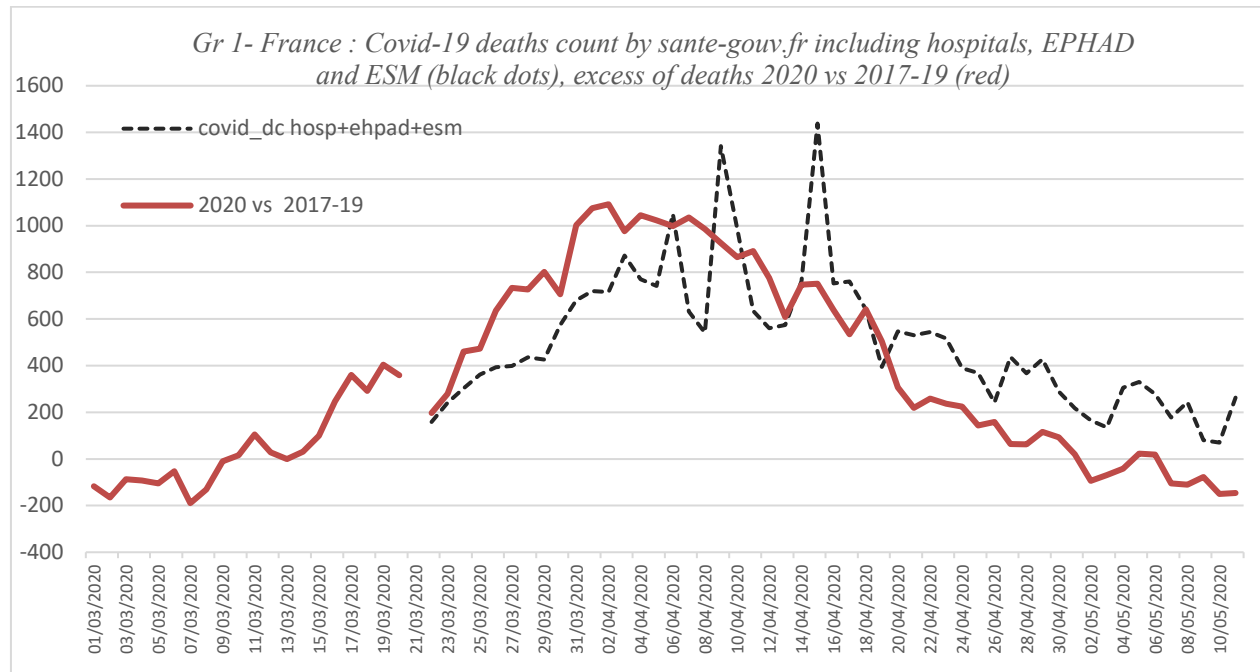
⁵ Unfortunately, the prevalence of kidney diseases which is mentioned in several studies as an important factor was not available in the same format.

⁶ We have check for 2018 where both measures are available that the correlation of the two measures is very high. The results are presented in annex material.

⁷ People born in French Caribbean and other French oversea territories are French by nationality but to a large extent of African origin. We have also included in this group people from Haiti, a French speaking country whose population is culturally similar. The American born people form a too small group of origin and has been aggregated in a residual category.

⁸ See in annex the details curves.

in the official count during March up to April 19th (see graphic below). After this date and up to May 11th, which ends the containment period, the death tallies reported by the Ministry of health are systematically higher than the differences computed with *état-civil* files. As said, it could be linked to the protocol adding lately the nursing home deaths to the hospital deaths and, may-be to the difficulty to includes deaths intervening at home.



Source: author's computations; hosp+ehpad+esm gathers the official dead counts in Hospitals, Elders nursing home and Medico-social facilities, data provided by *sante-gouv.fr*.

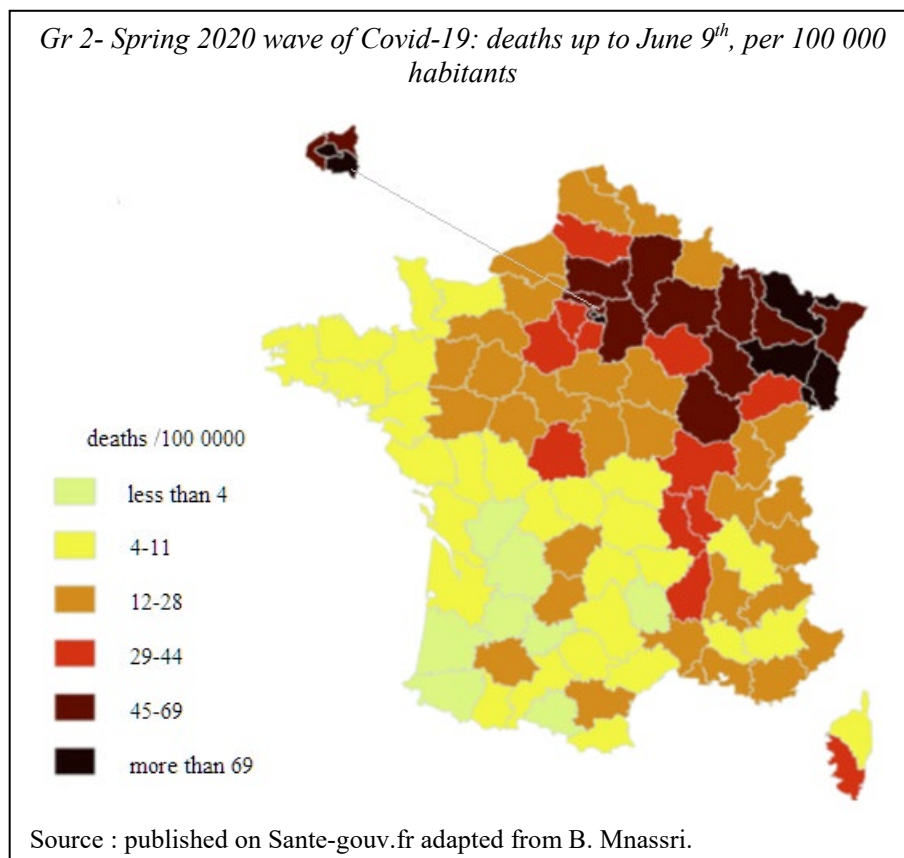
The medias commented on the disaster observed in nursing homes and, sometimes, the conditions of these deaths were truly choking. But was it generalized ? A hypothesis stem from the observation that official statistics which were in deficit on the estimated number at the beginning are in excess at the end. We know that when they were 2-3 cases of coronavirus in a care establishment, all deaths occurring were imputed to the virus without checking the serological status (conversely when no cases of contamination were detected, the resident's death was discounted from the Covid official data). The figures for nursing homes have been incorporated late in official data, this may contribute to explain that, after April 19th, the death toll, as estimated by deaths in excess, is significantly lower than the estimation adding hospital and nursing homes. It is likely that from April 19th onwards, deaths attributed to the Covid-19 in these establishments are in excess.

A spatial heterogeneous situation

The map of Covid-19 deaths in France shows that almost eighty percent of the French départements, mostly but not exclusively rural, have not experienced any significant increase in mortality during the spring 2020. In a great majority of the French départements there is no change in the mortality numbers during the first wave of Covid-19 epidemics. Conspicuously, the département of Bouches du Rhône, including Marseille the second French metropolitan area, has not experienced significantly more deaths than on previous years. Thus, for people there, the

containment measures may have been very puzzling. For the residents of these départements, the epidemic existed through the media daily account of cases and deaths and via the public containment measures. But people could not have perceived any significant incidence of deaths among their family, colleagues or friends living close by.

To ascertain that in most départements death excesses remained in the normal fluctuations range, we have computed for each département the standard-deviations of the département deaths over the 19 previous years.⁹ We may consider that the excess of deaths is significant if the absolute difference is larger than two standard deviations –95% confidence interval –, see graphics below. Among the 95 metropolitan France-départements, death numbers differ significantly from the mean of the previous years (absolute difference > 2 standard-deviations) for only 19 départements. The départements where the number of deaths during the epidemic of Covid 19 is significantly over the mean are located in the North-East quadrant of France including Ile de France (around Paris). Among these départements, six have registered less than 200 deaths before the end of the lockdown, for areas of approximately half a million people. The remaining thirteen

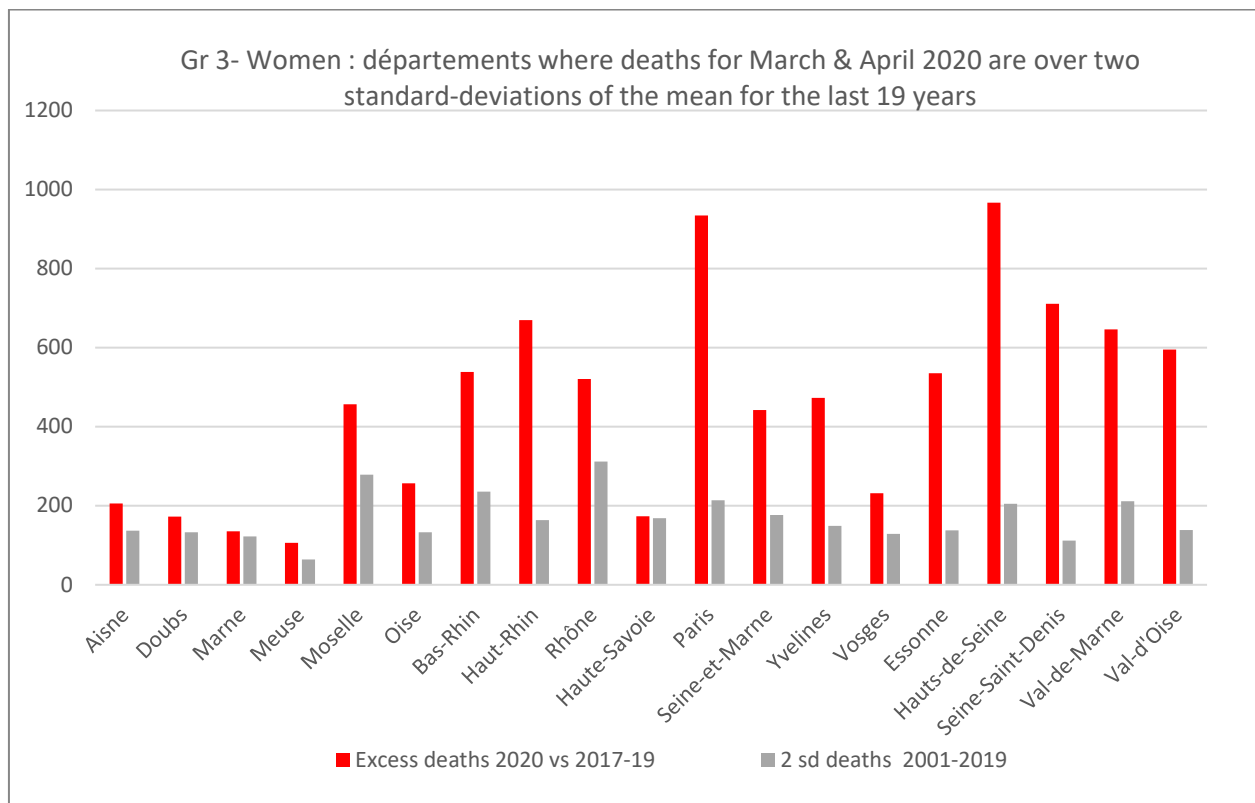


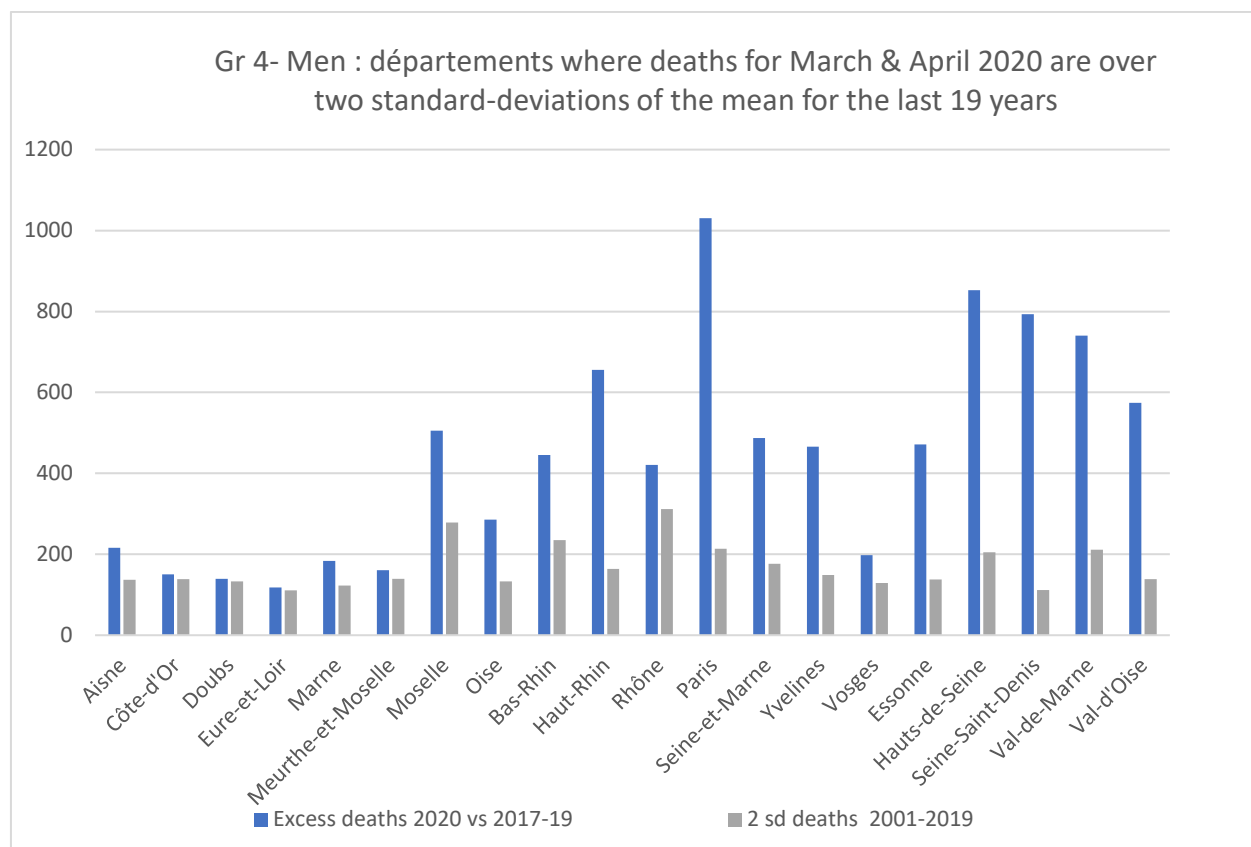
départements may be classify in two categories. Those who happen to be the first clusters (Haute-Savoie, Oise, and several départements of Eastern. If, in Savoie and Oise to a lesser degree, the first cases where quickly isolated, in several départements of the “Grand-Est”, along the Rhin, including Belfort, Vosges and Moselle, the contaminations went higher. There the epidemic outbreak was strongly boosted by a national wide gathering of a congregation of the Evangelic church in Mulhouse. While it is not impossible that

other factors contributing to the severity of the pathology had played a role, it is certain that, in these départements, containment measures came too late to stop the contagious process.

A second group where the excess of deaths is significant comprises all the départements surrounding Paris and Paris itself – Ile de France – to which might be added the Rhône (Lyon). Those are among the most urbanized areas, not all.

⁹ It is the square-root of the variance of the death mean across the sample of the yearly number of deaths over the period 2000-19, using the anonymized files- see Annex xx.





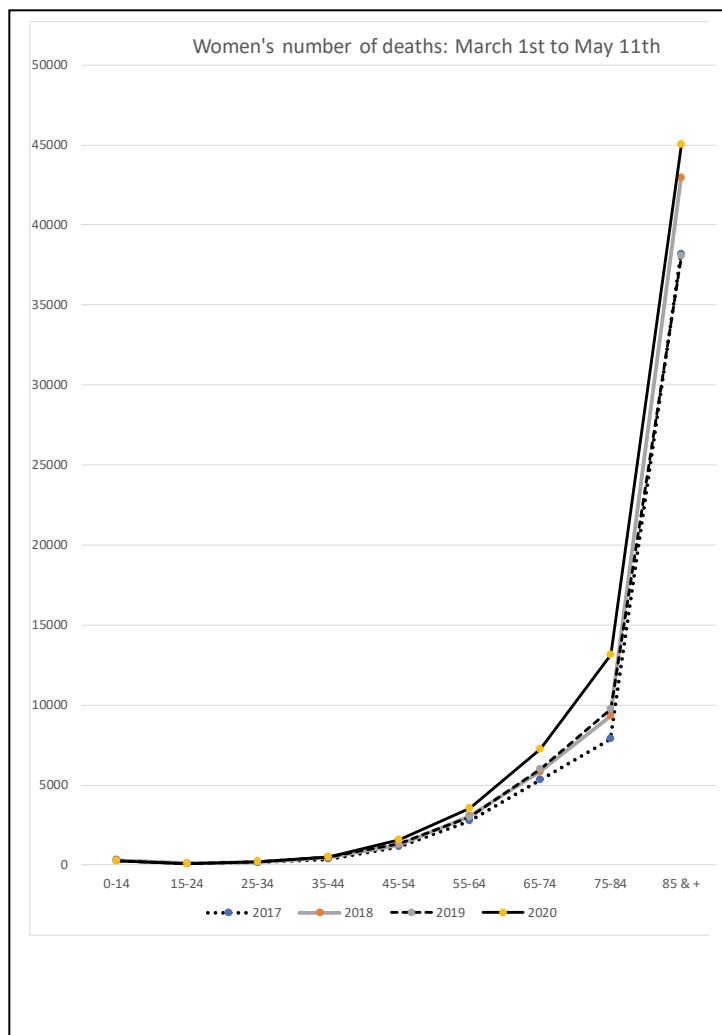
Comparing the temporal dynamic of the epidemic in the départements of the first clusters (Haut-Rhin or Oise) and the Paris region, there is an eight days lag. According to the estimation, the mean interval separating infection from death is 22 days (see Salje & al. 2020, and annex), thus the surge in contaminations started in Haut-Rhin around mid-February to peak around March 31st, while the surge of contamination in Val de Marne, Seine St-Denis and Paris itself starts around the 20th of March to peak in the very first days of April. Remarkably, Paris, Val de Marne, Seine St-Denis, Hauts-de-Seine, Val d'Oise present a large excess of deaths during the last week of March 2020. In these départements, the diffusion of the epidemic went later than in the above-mentioned clusters. It is likely that in the Paris region, contaminations continued at high rate in densely populated areas during the first two weeks of the mandatory containment period (starting March the 17th).

Age structure and gender

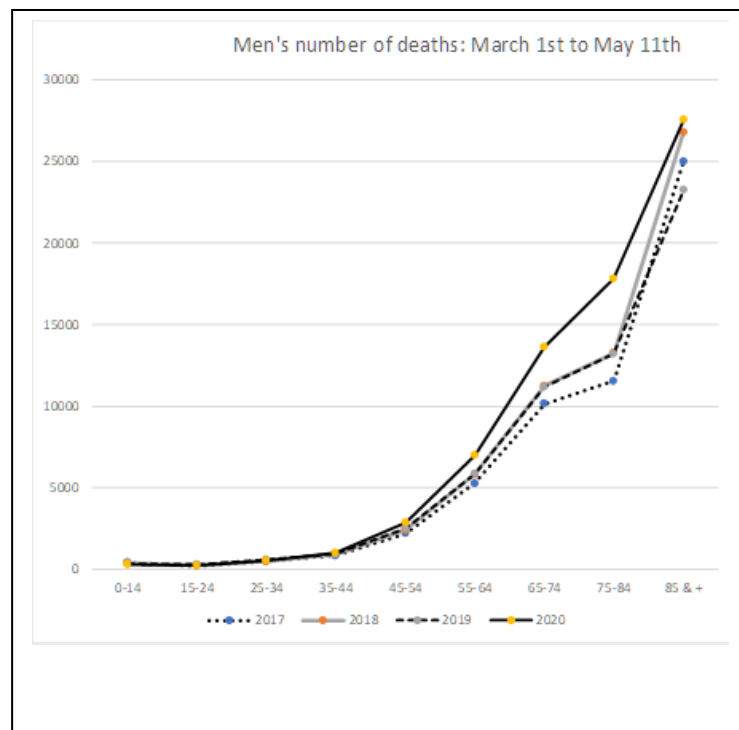
It has been said that one specificity of the Covid-19 epidemic is the exceptional death rate among senior citizen and old people. At the difference of H1N1-2009, an epidemic for which elderly were protected by their acquired immunity, old persons are more vulnerable to SARS-Cov2 than youth. But, as noted by J-P. Sardon (Sardon 2020), a close comparison shows that the age progression is not unusual and mimics fairly the whole French age distribution of mortality rates.¹⁰

¹⁰ The rates computed for 2017-19 correspond to with the numbers provided by INED for a wider period.

To check the possible differences in age structure, we have broken the death toll according to age-groups and sex. During 2020, from March 1st to May 11th, the end of lockdown, for both sexes, the divergence in the curves starts around 55-60 years. Beyond 65 years, the death excesses reported to average mortality numbers are fairly limited for women, while more significant for men – about one thousand over the average number. For each age-class over 65 years, 2020 death tallies are 15 to 30% larger; increasing earlier with age for men (climbing from 1 to 6,2 % between 65-85), slower for females (from 0,4 to 3,4 %). If, globally, Covid-19 accentuates the general deterioration of health with age without changing its structure, the toll paid by people around 60-80 years of age aggravates the usual increase in mortality rates.



Gr5- Deaths during 2020, March 1st to May 11th compared to 2017-2019 same period



Moreover, when comparing age profile of the deaths in départements most affected by the Covid-19, there is an intriguing fact: if women profiles are quite parallel across départements, that is not true for men. Three départements are singularized : Seine St-Denis and to a lesser extent Val de Marne and Val d'Oise. In these locations the number of deceased among men aged 55-74 years is proportionally greater than among men 75 years and over; which suggests that in these départements whose age structure is younger than for Paris or Hauts-de-Seine, seniors were more vulnerable and/or more exposed to contaminations.

Factors accounting for the death toll in France: first elements

Ethnicity and age structure

Almost 80% of deceased people are born in metropolitan France, and there is no over-mortality for people born in foreign European countries.¹¹ To put our results in perspective with the Anglo-

¹¹ Data documenting country of birth were available (in June 2020) for a slightly reduced period : March 1st to April 30th.

Saxon debate we payed attention to people that are usually labelled Blacks in France. At the national as at the département levels, the number of people born in Africa or the French Caribbean do not match the proportion of Blacks in young generations today. The mortality rates among African and French Caribbean born people in France is high before 70 years, hence the number of people above 55 years in 2020 born in France from African ancestry is rather small: among people of African ancestry, born in the 1950-60s, more than 80% where born in Africa. This measure, far from perfect, is not too inaccurate.¹²

Four groups of foreign origin people incurred a significant excess of mortality: people born in Black Africa, in French oversea départements and Haiti (French speaking Caribbean country), in South-east Asia and, to lesser degree, in Maghreb countries. Moreover, there is a difference between Sahel and countries boarding the Gulf of Guinea. People born in the Caribbean, Mayotte, Maurice or La Réunion are in an intermediary situation. The deaths of people from Black African or Caribbean origin are located in the Paris region : the death excesses in 2020 incurred by African and Caribbean born people hovering between 27 in the Yvelines (for 470 deaths in excess during the months considered) to 125 in Paris (for a thousand deaths during this period). Black deaths seem relatively small in absolute numbers, nevertheless related to the population born in metro-France, the proportions are significantly higher than for autochthons. The women's death rates have broadly the same ethno-geographic distribution but are 20% lower and less chaotic at département level.

To pinpoint the main determinations of the excess of mortality we computed the ratio of deaths in 2020 up to the containment with the mean 2017-19 for the same period, a measure used in several other studies (see EPI cell, PHE, 2020). In the US, the Black death rate is more than twice the White rate, while the relative death rate of Latinos is 1.09 according to APM Research Lab.¹³ Thus the African born death rate relative to autochthons in France is very similar to the Black death rate relative to White in the US. For sure, these similar rates have not the same meaning, because African American are not migrants and because of the mass involved : African American represent 12,5% of the American population while 1,8% of the French in these generations.

¹² It is also true for Maghreb people to a certain extent, even if the migration process was chronologically different.

¹³ To my knowledge, the US rates published by APM are unstandardized. But the computations are based on the ratio of death to the number of people self-identified to this race /ethnicity without standardization. In the French case the ratios are also unstandardized. But as may be seen the population of reference of people born in Africa or the Caribbean is younger than the French born thus, with the same age structure as the French born people, mortality rate would be lower.

Table 1- Mortality ratios associated to Sars-Cov2 by place of birth for France, Ethnicity in US

France	France	Afrique centrale et australe	Afrique sahélien ne	Maghre b	DOM & Haïti	Europe	Asie du Sud et Sud-est
Men excess of mortality : deaths 2020/mean deaths 2017-19	1,20	3,22	2,52	1,61	2,29	1,28	2,16
Men ratio: foreign born (Dom) / born in France metro		2,69	2,11	1,34	1,91	1,07	1,81
Women excess mort. : deaths 2020/mean deaths 2017-19	1,20	2,58	1,92	1,42	1,83	1,45	1,81
Women ratio: foreign born (Dom) / born in France metro		2,15	1,60	1,19	1,53	1,21	1,51
US	White	Black		Latino	Indigeno us	Pacific Islander	Asian
ratio: Other ethnic groups/White		2,31		1,09	1,52	1,15	0,97

Source: For France, computations based on “état-civil” files. Places of birth : france metro; dom-tom antilles & haiti : guadeloupe, martinique, antilles, haiti, comoros, french guiana, reunion, mauritius, mayotte ; north-eastern europe : austria slovakia switzerland slovenia sweden poland united kingdom norway belgium iceland denmark hungary czechoslovakia germany ireland yugoslavia finland luxembourg ; south-eastern europe : spain portugal italy greece croatia albania romania serbia; central & sub-equatorial africa: togo angola tanzania cameroon congo cape-verde ivory coast guinee, congo, central african republic, nigeria, ghana, benin gabon; sahel: mauritania chad sudan somalia senegal gambia niger mali ethiopia; maghreb: algeria, tunisia, morocco, tangier; asia _s-e (excluding china): sri lanka pakistan singapore taiwan afghanistan thailand viet-nam india indonesia coree bangladesh.

For the US, APM Research Lab, Color of Coronavirus. <https://www.apmresearchlab.org/Covid/deaths-by-race>

Is there any reason to believe that the mortality rates presented above are undercutting the number of victims in some groups compared to others? For France, it can be objected to the previous comparison that the age structures of ethnic groups are quite different. This argument is disputable. First, on a statistical viewpoint, ratios are computed with previous years age distributions thus the age structure of mortality of each ethnic group is both on the numerator and the denominator. Second, if there is a difference in the age structure for 2020, due for instance to disorders of the early maturity like obesity which effects are amplified by Covid-19, this is meaningful and must not necessarily be neutralized. The age mortality rates are indicators of the various life trajectories and there is no reason to consider that the age structure in each ethnic group is should be identical. Indeed, age standardization is not a neutral mathematical operation. To show the differences in the distribution of mortality rates, we have computed mortality rates by ethnicity for the years 2017-19 and for 2020. Below the results are presented for men, because the discrepancy in age structure is greater than for women.

Table 2- France : Men deceased in 2017-19 by age and ethnicity

2017-19						
age	All	France	Afrique centrale & australe	Afrique sahélienne	DOM & Haïti	Maghreb
0-14	1%	1%	1%	1%	2%	0%
15-24	0%	0%	2%	2%	1%	0%
25-34	1%	1%	4%	3%	2%	0%
35-44	2%	1%	5%	1%	2%	2%
45-54	4%	4%	11%	9%	6%	3%
55-64	10%	9%	33%	14%	13%	9%
65-74	18%	18%	28%	30%	19%	27%
75-84	22%	21%	12%	30%	22%	30%
85 &+	43%	45%	4%	10%	32%	29%

2020						
age	All	France	Afrique centrale & australe	Afrique sahélienne	DOM & Haïti	Maghreb
0-14	0%	1%	0%	0%	2%	0%
15-24	0%	0%	1%	2%	1%	0%
25-34	1%	1%	2%	1%	2%	1%
35-44	1%	1%	6%	3%	2%	1%
45-54	4%	4%	10%	9%	6%	4%
55-64	10%	9%	30%	14%	14%	10%
65-74	19%	18%	33%	42%	22%	27%
75-84	25%	25%	12%	23%	24%	32%
85 &+	39%	41%	6%	5%	26%	24%

In most groups, the Covid-19 excess of mortality is homothetic to the global mortality. However, the mortality rates of men born in Central Africa or Sahel are very different from those in the majority group, born in France, and even in most foreign-born men groups. The mortality profiles of people born in Africa differ from the general mortality profile by age and sex. It is noticeable that both in 2017-19 and during the spring 2020 Covid-19 crisis, African born men mortality rates are higher for seniors in the 50-70 age-groups than among elderly; in addition the mortality profile of African born people during Covid-19 in 2020 is strictly parallel to the mortality profile anterior to the epidemic; the Covid crisis did not change much the very peculiar age profile of mortality in these groups. It is likely that underlying serious or chronic diseases specifically prevalent among people born in Africa are embedded in these death profiles. Such situation implies that age standardization would in this case creates an artifact, obscuring a social phenomenon.¹⁴

¹⁴ Attributing to people born in Africa the same mortality rates by age class could alter what is both social and individual in life expectancy. It reflects both exposure to stressors or pollutants, genetic endowments which are

If the SARS-Cov2 amplifies an underlying health frailty specific to certain categories of people associated to the prevalence of health conditions, the health facility access in France being at first glance, much more homogeneous than in the US, we are induced to look for factors of the epidemic severity among health conditions differentiating individuals and groups.

Living context health and ethnicity

Most studies mention underlying health conditions involved in severity and the excess of deaths. On the one hand pathologies like immunity, respiratory troubles, cardiovascular diseases are usually suspected, on the other hand many studies point obesity disorders, diabetes-II, and kidney diseases. Petrakis & al. (2020) in a very detailed analysis of the physiology, biology and genetics of obesity write that “obesity can reduce immune cell functionality, induce gut microbiome and virome imbalance and inflammatory cytokines phenotype ... The mechanisms involved in increased risk for Covid-19 prevalence and mortality in obese person are associated to fat-resident regulatory T-cells and promotion of Th-17 biased immunity.” They add that “activated immune cells may enter the pulmonary circulation in large numbers and exert a damaging role”. A mild overweight has not these consequences.

The excess of mortality, computed as the ratio of numbers of people deceased in 2020 and the mean number for the three previous years 2017-2019, has been confronted to health data released in 2017, classified by age and sex– namely the prevalence or short hospitalization rates for pathologies associated to obesity, diabetes prevalence and two long term disease index (ALD) related to immunity and diabetes.

If immune deficiency, respiratory pathologies and cardiovascular diseases (ischemic or cerebrovascular) seem to play a role in the analysis of data at the level of the communes of the Paris region, these data mobilized by the Ile de France Health Agency are not public. The variables that we were able to match are less precise due to the heterogeneity of many departments. Among the thirty long-term pathologies (ALD) covered by the Social Security, equation (1) summarizes the selection of those significantly associated with mortality due to SARS-Cov2 : diabetes and immunodeficiency.

linked to genetic pool that individuals inherits, but also active self-exposition to harmful situations or conversely conducts like practicing sport, abstaining from drinking too much or balanced diets which improve life expectancies and resistance to viruses. Each health status is a reflect of social and personal determinations sociability, interpersonal security or stress. To consider these determinations as purely given for all is a manner of denying the part of personal responsibility that each of us has.

Table 3 -Regressions of the excess of deaths by département on underlying health indicators

Dep. Var: Ratio Excess of deaths 2020 / 2017-19	eq_1		eq_2		eq_3		eq_4	
Men	coef	coef	se	coef	se	se	coef	se
Diabetes ALD_8	1,920***	0,246			1,361***	0,260		
Deficit immunity ALD_7	1,854***	0,164			1,402***	0,180		
Diabetes MCO rates males<14			0,384***	0,069	0,234***	0,077	0,330***	0,067
Obesity MCO rates males<14			0,220***	0,036	0,152***	0,038	0,198***	0,035
Diabetes MCO std/raw men							2,203***	0,234
Diabetes raw prevalence men			1,309***	0,161				
cte	0,080	0,123	-0,335**	0,152	0,208*	0,118	1,019***	0,203
Number of observations	180		180		180		180	
Adjusted R2	0,456		0,526		0,521		0,566	
note: .01 - ***; .05 - **; .1 - *.								

Women	coef	se	coef	se	coef	se	coef	se
Diabetes ALD_8	1,654***	0,238			0,979***	0,233		
Deficit immunity ALD_7	1,642***	0,159			1,198***	0,154		
Diabetes MCO rates females<14			0,456***	0,056	0,301***	0,060	0,339***	0,053
Obesity MCO rates females<14			0,130***	0,020	0,110***	0,020	0,134***	0,018
Diabetes MCO std/raw women							2,022***	0,216
Diabetes raw prevalence women			0,841***	0,133				
cte	0,222*	0,119	-0,100	0,156	0,345***	0,106	0,773***	0,178
Number of observations	180		180		180		180	
Adjusted R2	0,409		0,494		0,539		0,585	
note: .01 - ***; .05 - **; .1 - *.								

For the detail meaning of variables see annex.

In terms of health, the main factor of excess mortality at the departmental level is linked to the obesity/diabetes syndrome. Départements most seriously affected by the Covid-19 are places where short-term hospitalization rates of children under 14 years is frequent (eq. 2 , 3, 4). Our hypothesis is that childhood hospitalization rates for obesity indicate a long-term prevalence of obesity-related pathologies in families with parents aged 40-60 years, however obesity is not as systematically observed in the adult population, which is less systematically examined, than in children.¹⁵ We have tested heart diseases, and respiratory problems which are often linked in clinical observations to SARS-Cov2 seriousness but they reveal less predictive than obesity/diabetes measures. The last variable used in eq. (2), diabetes raw prevalence, expresses the impact of diabetes at relatively young ages. Alternatively, in eq. (4) the ratio between standardized and raw diabetes prevalence for each sex has been used and accounts in a similar manner for an excess of deaths. As with obesity, when diabetes prevalence is high before 60

¹⁵ Which would be associated to “high level of Interleukin-6”, according Petrakis & al 2020.

years, the ratio standardized/unstandardized rate is higher in relatively “young départements” than in average, translating an effect specific to “young départements”.

The regressions on health variables giving the best overall determination are very similar for men and women, possibly because we deal with aggregates data. They show the important impact of underlying medical conditions on the severity of SARS-Cov2 infections. But it is not the whole story.

Among possible determinants of death excesses associated to the epidemic are also, as mentioned, factors linked to living conditions. We know that people who entertain a high number of relations or cohabit in large domestic units are likely to incur more contaminations that may end up in higher deaths rates. Living conditions present three aspects which can impact the transmission of SARS-Cov2, but also, because impacting more people, increase the seriousness of pathologies. At the macrolevel, density of the population, measured as number of people by square kilometers indicates likelihood of contacts. At the micro-level, it has been suggested that overcrowded apartments have led to mortality excesses, particularly in Ile de France where public housing is a major characteristic.

If population density in a département is positively correlated to excess of deaths, its impact almost disappears when health conditions are controlled. We have taken several measures of crowding as the number of families with more than four people in apartments of small or medium size – 2, 3, 4 rooms. None of these crowding indicators is associated to an excess of death. Crowding should impact women as well as men, even if the death tolls are unequal. In spite of its likelihood, the idea that overcrowded apartments have been factors of contamination does not match the data. In accordance with this result, we might recall that none of the Parisian neighborhoods classified as ZUS, where apartments are even smaller because of the high prices in the capital¹⁶, were involved in the incidents registered during the containment when young people were really cramped.

Conversely, at the department level, regressions show that household size is a significant factor of the mortality excess. This makes sense with aerosol diffusion of SARS-Cov2, whose impact is not limited to close contacts but stems from durable interactions in quite small groups.

We did not take in account the type of professional activity, but we introduced into the equations an income indicator, the percentage of the population of the department living below the poverty line. The poverty rate has surprisingly a negative significant effect.¹⁷ In the same manner, various measures of the age structure in the département do not bring any substantial improvement of the regressions.

In this second series of regressions, among the health indicators retained, the percentage of people receiving ALD for immunity reasons is no longer significant, while the average prevalence or short-term hospitalization rates for obesity and diabetes remain very significant even when the socio-economic context is controlled. The rate of over-occupation as well as urban density lose all explanatory power as soon as prevalence of underlying pathologies are included in the equations.

¹⁶ 25 sqm per person compared to 30 sqm outside the ZUS perimeter.

¹⁷ It could indicate that many low income rural départements have also been spared by the Covid-19, see table in annex.

Table 4- Regressions of the relative excess of deaths by département on living conditions and health indicators

Dep. Var: Ratio Excess of deaths 2020 / 2017-19	eq_5		eq_6		eq_7		eq_8	
Men	coef	se	coef	se	coef	se	coef	se
% born in Africa							0,113***	0,014
Pop of household with more than 4 people	0,027***	0,005	0,036***	0,005	0,024***	0,004	0,014***	0,002
Pop living in Sur-occupied apartments	-0,085**	0,042	-0,024	0,047				
Density(people/sq-kil)	0,086***	0,032			0,029	0,020		
PPopMen4pApP12p #			-0,192	0,193				
PPopMen4pApP34p #			-0,202	0,192				
PPopMen4pApP5pP #			-0,194	0,192				
Diabetes 12 ALD_8					1,249***	0,184	1,696***	0,161
Obesity MCO men < 14 y.					0,140***	0,031	0,175***	0,025
Obesity MCO men 44-54 y.							-0,169***	0,037
cste	1,020***	0,037	20,842	19,185	0,406***	0,087	0,266***	0,069
Number of observations	180		180		179		180	
Adjusted R2	0,556		0,551		0,689		0,803	
Women	coef	se	coef	se	coef	se	coef	se
% born in Africa							0,089***	0,014
Pop of household with more than 4 people	0,027***	0,004	0,036***	0,005	0,022***	0,003	0,016***	0,002
Pop living in Sur-occupied apartments	-0,103***	0,038	-0,011	0,043				
Density(people/sq.-kil.)	0,091***	0,028			0,031*	0,018		
PPopMen4pApP12p #			-0,123	0,175				
PPopMen4pApP34p #			-0,120	0,174				
PPopMen4pApP5pP #			-0,112	0,174				
Diabetes 12 ALD_8					1,076***	0,166	1,619***	0,168
Obesity MCO women < 14 y.					0,087***	0,016	0,100***	0,014
Obesity MCO women 34-44 y.							-0,054***	0,011
cste	1,023***	0,033	12,689	17,377	0,497***	0,079	0,373***	0,067
Number of observations weighted	180		180		180		180	
Adjusted R2	0,576		0,572		0,698		0,783	
note: .01 - ***; .05 - **; .1 - *;								

Large families (over four) in apartment of 1-2, 3-4 or 5 rooms. See annex for the sources of these variables.

Finally, the percentage of people born in Black Africa or the Caribbean plays a role, even when the underlying diseases and social context are considered. This could mean that some aspects of the fragility of African migrants have not been adequately taken in account; indeed, a plausible reason for the persistence of an effect of ethnicity on the risk of death is the lack of specification

of health status by ethnic group. It is also possible that the immune responses of African born migrants to coronavirus are less potent in northern countries. Here we reach the limit of an analysis on large and heterogeneous areas.¹⁸

Conclusion

In the context following the death of George Floyd and the huge protest movement, in the United States and to a lesser extent in the United Kingdom, many medical journals questioned the fairness of health care for members of ethnic minorities. Most of the articles published in the “opinion” rubric mention systemic racism in the functioning of medical institutions in the United States. However, almost without exception, articles based on quantitative data show that, during the Covid-19 first wave, inequalities of treatment or even of access to health care facilities has not been the determinant of the excess mortality of black or Asian infected persons. The quantitative researches cited in the introduction also show that the higher levels of contamination of minority members are mainly due to a combination of social disadvantages –including place of residence, overcrowding, low income – and average health deficit together reduce significantly the differential attributed to race or ethnicity.

In France, we cannot analyze contaminations or even hospitalizations according to ethnicity or country of birth, and the comparison is limited to the excess of deaths measured at the departmental level. The interweaving between the health situations prevailing in the departments, household size and ethnicity provides an accurate account of the disparities between departmental mortality rates due to Covid-19. People born in Black Africa clearly appear to be in a worse position than those born in the Maghreb, in Asian and European countries, not to mention indigenous people, in terms of risk of death. This is suggested by the individual health profiles and access to care identified by the clinical studies - people born in Black Africa suffer more from obesity and diabetes. Thus, the determinants are not entirely different from what has been observed in the United States and the United Kingdom. In France, however, household size is discriminating, while neither urban density nor income level appears to be a significant factor. In addition, health problems and remedies measured at the departmental level contribute more strongly to mortality disparities due to Covid-19 than they do in the US county analyses. Our study highlights the contrast in race/ethnicity concern between Europe and the United States, despite an objective incidence of mortality by ethnic group that is not so different. Of course, this analysis at the county level in France leaves many questions unanswered.

¹⁸ Two limitations of this study are the absence of measure of health service access on one hand, and on the other about self-protection of people. Namely, distancing which is sometimes measurable through smartphone data could not be mobilized.

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