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# **Covid-19: were curfews in France associated with hospitalisations?**

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## **Abstract**

A curfew was introduced in France in October 2020 to reduce the spread of Covid-19. This was done for two weeks in 16 departments, or for one week in 38 others, 42 departments not being subjected to the curfew. The ratio of the number of new hospitalisations during these two weeks and in the previous two weeks was computed in these three categories of departments. The increase in new hospitalisations was lower in departments under curfew for two weeks than in all other departments, and this result does not seem to be linked to characteristics of the departments before curfew. This result shows that the two-week curfew is linked to a lower increase of hospitalisations, but not that the curfew by itself is the cause of this result, as other factors may have played a role.

## **Key-words**

Covid-19 – curfew – hospitalisations

## **Introduction**

The Covid-19 outbreak has hit all countries since the end of 2019. Lethality, around 0.3 to 1.3% for all ages (Fontanet and Cauchemez 2020), increases sharply with age and the presence of co-morbidities. As many hospitalisations are necessary, often beyond the usual hospital capacity, state authorities have implemented drastic measures, such as lockdown and curfew, that have economic, social and psychological costs, and seriously infringe on civil liberties.

Arguments in favour or against these measures have consisted either in simulating, using compartmental models, the number of deaths and hospitalisations after implementation of restrictive measures and comparing them virtually to what would have happened in their absence, or in comparing the results of countries adopting more or less restrictive measures, which is an observational analysis of real data.

With the first method, Flaxman et al. (2020) estimated that non-pharmaceutical interventions (NPI) in 11 European countries prevented more than three million deaths before May 4<sup>th</sup> 2020, and that lockdown reduced viral transmission by 81%, while other measures had no clear effect (school closures, social distancing, etc.). Covid mortality can be established, even if errors exist (Flaxman et al. 2020), but the number of deaths avoided is the result of modelling, and this number can be estimated in excess. This was the case with variant Creutzfeldt-Jakob disease, for which a total of up to 5,000-7,000 deaths was modelled from 2001 to 2020 in the UK (Ferguson et al. 2002), whereas only 178 deaths were recorded, the last one in 2016, as reported by the National CJD Research and Surveillance Unit (2020). Modelling is therefore faced with the problem of comparing virtual deaths to real ones, and it is impossible to test whether these virtual deaths would have actually occurred.

With the second method, de Laroche Lambert et al. (2020) analysed the Covid death rate in all countries up to August 31<sup>th</sup> 2020. The strength of measures, such as lockdown, was not linked to the countries' death rate, “drastic” countries not achieving lower death rates than “lax” ones. More recently, Bendavid et al. (2021) tried to measure the effect of the most restrictive measures (lockdown) compared to less restrictive ones (social distancing, teleworking, etc.) and concluded that the countries that adopted more restrictive measures did not have a lower increase of the outbreak. However, showing that restrictive measures have no effect on the variability of mortality between countries, does not necessarily show that, within a country, they are ineffective.

A third method to test the effect of NPI could be to study, within a country, the effect of a measure or its absence in different regions. This is possible in France, because a curfew was introduced, in only some departments, in October 2020 for a period of one or two weeks before the second 2020 lockdown in the whole country. A descriptive study of new contaminations and hospitalisations conducted in the various metropolitan areas under curfew or without curfew (Spaccaverri et al. 2020) concluded that there was a temporal coincidence with curfew measures. However, as no statistical analysis was done, the reader could only look at the 7-day rolling rate of new contaminations and hospitalisations to ascertain that the curfew was associated, or not, with a positive effect. Since this article was published, it seems that no statistical analysis was done to ascertain whether the October French curfew was linked to a decreased number of new admissions to hospital: this is the purpose of the present article.

## **Material and methods**

The decision to introduce or not the curfew in a regional metropole was based on the spread of the outbreak (incidence rate higher than 250 for 100,000 inhabitants or higher than 100 in elderly people, occupation rate of intensive care units (ICU): Anonymous 2020). The curfew was

introduced at midnight on October 17<sup>th</sup> 2020, in metropolitan areas located in the 16 French departments numbered 13, 31, 34, 38, 42, 59, 69, 75 to 78, 91 to 95 (24 million inhabitants), and particularly in the whole Ile-de-France region, which includes Paris (departments 75, 77, 78, 91 to 95). Although not all towns in these departments were affected by the curfew, it will nevertheless be considered the case, since Santé Publique France (2021) publishes departmental data on daily hospital admissions, transfer to ICU, deaths and returns home.

The curfew was extended to 38 additional departments at midnight on October 24<sup>th</sup> (01, 05 to 10, 12, 14, 2A, 2B, 21, 26, 30, 35, 37, 39, 43, 45, 48, 49, 51, 60, 62 to 67, 71, 73, 74, 81 to 84, 87, i.e., 21 million inhabitants). The whole territory of these 54 (16 + 38) departments was then subjected to the curfew and not only big cities. The 42 remaining metropolitan departments (19 million inhabitants) were not subjected to the curfew (curfews were not introduced overseas except in French Polynesia, which is not taken into account here). Since the curfew was ended on October 30<sup>th</sup> in the whole country, these data are being studied up to and including October 29<sup>th</sup>.

If curfew were associated with the spread of Covid, in either direction, the number of daily new hospitalisations in departments with curfew should increase less quickly, or more quickly, than in those without curfew (D0 in the following). Similarly, those with curfew for a fortnight (D2) could be different from those with curfew for only one week (D1). The ratio of the number of hospitalisations from October 17<sup>th</sup> to 29<sup>th</sup> to this number during the period from October 4<sup>th</sup> to 16<sup>th</sup> could therefore be different in D0, D1, and D2 groups. A ratio of 1 indicates that the number of events is the same in the October 17<sup>th</sup>-29<sup>th</sup> period and in the October 4-16<sup>th</sup> one. It is higher in the October 17<sup>th</sup>-29<sup>th</sup> period if the ratio is more than 1, and lower if the ratio is less than 1. The reasoning could be extended to ICU transfers and deaths, but deaths observed from October 17<sup>th</sup> to 29<sup>th</sup> are probably related to previous contamination (Zhou et al. 2020).

The same ratio is computed for the period preceding the curfew, i.e., the number of events from October 4<sup>th</sup> to 16<sup>th</sup> divided by this number in the period from September 21<sup>th</sup> to October 3<sup>rd</sup>. Finally, the same calculation is made for the first week of the curfew, i.e., the number of events from October 17<sup>th</sup> to 23<sup>th</sup> divided by this number in the period from October 10<sup>th</sup> to 16<sup>th</sup>. The results of D0, D1 and D2 are analysed with one-way analyses of variance.

## Results

The sum of daily hospitalisations in the October 4<sup>th</sup>-29<sup>th</sup> period is not the same in the D0, D1, and D2 groups (mean  $\pm$  standard error of the mean, D0: 130.95  $\pm$  15.21, D1: 258.92  $\pm$  25.36, D2: 1252.19  $\pm$  154.00). In each category of departments, the logarithms of the number of hospitalisations, ICU transfers, deaths and returns home are very strongly correlated with each other ( $0.56 \leq r \leq 0.96$ ,  $n = 42, 38$  and  $16$  for D0, D1 and D2), these correlations being even stronger when

all departments are pooled together ( $0.85 \leq r \leq 0.98$ ,  $n = 96$ ). Thus, as expected, a department with many hospitalisations also has many ICU transfers, deaths and returns home, and one could wonder whether there is a significant correlation in each of the D0, D1 and D2 groups between the logarithm of the number of hospitalisations from October 4<sup>th</sup> to 29<sup>th</sup> and the ratio of the number of hospitalisations from October 17<sup>th</sup> to 29<sup>th</sup> on this number in the October 4<sup>th</sup>-16<sup>th</sup> period. However, this is not the case ( $-0.12 \leq r \leq 0.11$ ), and the ratio is thus not linked to the number of hospitalisations during the October 4<sup>th</sup>-29<sup>th</sup> period.

This ratio has a mean value, respectively in the D0, D1 and D2 groups, of  $2.85 \pm 0.19$ ,  $2.94 \pm 0.18$ , and  $2.01 \pm 0.09$ . The analysis of variance shows that this effect is significant ( $F(2, 93) = 4.63$ ,  $p = 0.0121$ ): D2 departments with a curfew for a fortnight have a smaller increase of hospitalisations than D0 and D1 departments, which do not differ between each other. No effect is observed for the ratio of the number of transfers to ICU ( $F(2, 90) = 2.30$ ,  $p = 0.1061$ , departments without ICU transfers from October 4<sup>th</sup> to 16<sup>th</sup> are excluded), or of deaths ( $F(2, 83) = 2.49$ ,  $p = 0.0893$ , departments without deaths from October 4<sup>th</sup> to 16<sup>th</sup> are excluded). However, as emphasised above, deaths observed from October 17<sup>th</sup> to 29<sup>th</sup> are probably related to previous contamination (Zhou et al. 2020), and thus no effect of the curfew is expected to be observed.

Can the effect on the ratio of hospitalisations be explained by characteristics specific to D2 departments observed before the curfew? This hypothesis can be tested by studying the ratio in the period before the curfew. D0, D1 and D2 groups have, respectively, a ratio of the number of hospitalisations from October 4<sup>th</sup> to 16<sup>th</sup> on this number in the period from September 21<sup>th</sup> to October 3<sup>rd</sup> of  $2.04 \pm 0.36$ ,  $1.90 \pm 0.16$ , and  $1.45 \pm 0.08$ . This effect is not significant ( $F(2, 93) = 0.71$ ,  $p = 0.4922$ ): D0, D1, and D2 departments had the same increase in the number of hospitalisations before the curfew. The high value of the standard error of D0 is due solely to department 70, which has a ratio equal to 16; removing this value modifies the mean value of D0 ( $1.70 \pm 0.12$ ), but has no effect on the result of the analysis of variance ( $F(2, 92) = 1.79$ ,  $p = 0.1723$ ). No effect is observed for the ratio of transfers to ICU ( $F(2, 88) = 1.99$ ,  $p = 0.1431$ ), or deaths ( $F(2, 78) = 0.38$ ,  $p = 0.6835$ ). Thus, D0, D1 and D2 departments did not differ from each other before the curfew.

D1 departments with only one week of curfew do not seem to differ from those without a curfew. This can be verified by studying the ratio for the October 17<sup>th</sup>-23<sup>th</sup> period, i.e., one week of curfew for D2, over the October 10<sup>th</sup>-16<sup>th</sup> period when there was still no curfew for D1. D0, D1 and D2 have, respectively, a ratio of the number of hospitalisations of  $1.78 \pm 0.11$ ,  $1.90 \pm 0.11$ , and  $1.52 \pm 0.04$ . This effect is not significant ( $F(2, 93) = 1.86$ ,  $p = 0.1620$ ): D0 and D1 departments, with no curfew, and D2 departments subjected to the first week of curfew, had the same increase in the number of hospitalisations. No effect was observed for the ratio of transfers to ICU ( $F(2, 87) = 0.27$ ,

$p = 0.7616$ ), or deaths ( $F(2, 73) = 1.38$ ,  $p = 0.2591$ ). Therefore, a single week of curfew is not associated with a lower ratio of hospitalisations.

Finally, we might wonder whether the effect observed on the ratio of hospitalisations in D2 departments is linked to the demographic importance of urban areas in this D2 group, as it comprises the most important French cities and particularly the Paris capital. However, among the D0 and D1 departments, the eight most densely populated departments that have more than one million inhabitants and big cities (D0: 33, 44, 57; D1: 06, 35, 62, 67, 83), have a ratio of the number of hospitalisations from October 17<sup>th</sup> to 29<sup>th</sup> over the October 4<sup>th</sup>-16<sup>th</sup> period of  $2.55 \pm 0.28$ , which is similar to the values for D0 or D1 indicated above ( $2.85 \pm 0.19$  and  $2.94 \pm 0.18$ ). Thus, it seems that the ratio is not linked to the number of inhabitants or to the presence of big cities.

## **Discussion**

These results indicate that D2 departments with two weeks of curfew had a lower increase in the number of hospitalisations than D0 departments without curfew or D1 departments with only one week of curfew. The effect observed in D2 is not linked to previous characteristics of these highly urbanised and populated departments. However, the limitation of the study is that, during the first week of curfew, the whole surface of D2 departments was considered to have been under curfew. While this is true for the urban Ile-de-France region (departments 75, 77, 78, 91 to 95), it is not true for other departments where only metropolitan areas were under curfew. However, the curfew can be considered to have reduced travel throughout the department, since the big cities were no longer accessible.

These results do not allow concluding that the two-week curfew is the cause of a lower increase in hospitalisations, as it could be a simple association. A causal relationship would, of course, validate the curfew option for reducing hospital admissions. However, factors other than curfew could be at work. For example, inhabitants of D2 departments could have been more concerned by the health situation, because it was more flagrant and occurred sooner than elsewhere, and perhaps barrier gestures were more strictly observed than in D0 departments. However, the absence of difference between D0 and D1 departments, or between these departments and D2 departments during the first week of curfew, could run counter to this hypothesis, since one week of curfew is not enough to demonstrate an effect. That said, it could be argued that time is needed to adopt a greater rigour of barrier gestures and consequently to decrease hospital admissions, which could explain why a one-week curfew has no effect. In short, this would mean that the curfew had no effect on its own, but that individual behaviour was the main factor, the curfew decision having only a psychological alarming effect. One could, of course, imagine that a combination of individual protective gestures and the curfew explain the results of the D2 departments.

The reason for this effect of the two-week curfew is therefore under debate, and knowing whether curfews have a positive effect is crucial, because of the economic and social consequences of this measure.

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