Measuring the effects of COVID-19-related night curfews: Empirical evidence from Germany*

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Preliminary version

Abstract

We estimate the impact of local night curfews in Hesse, Germany, on the growth of incidences of COVID-19 cases during the "second wave" of the COVID-19 pandemic in this state. We also analyse the effect on changes in mobility. We find no statistical evidence that the night curfews were effective in slowing down the spread of the pandemic.

1 Introduction

Since the end of 2019 a new coronavirus (SARSCoV-2 or COVID-19) spreads rapidly over the whole world and in early 2020 the WHO declared COVID-19 a pandemic.[1] After a slow down in the summer of 2020 the "second wave" of the pandemic hit Europe, including Germany, very hard. In order to limit virus transmission, German authorities declared a lockdown from November 2, 2020. Parts of that lockdown were several non-pharmaceutical interventions (NPIs). Besides the implementation of nationwide measures such as the limitation of gatherings and business closures some regions with very high infection rates additionally imposed night curfews. According to the German law system a careful assessment of the costs and benefits of an intervention is inevitable for its legal enforcement. While there was a broad consensus

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[1] https://www.who.int/docs/default-source/coronaviruse/transcripts/who-audio-emergencies-coronavirus-press-conference-full-and-final-11mar2020.pdf?sfvrsn=cb432bb3_2

on most of the NPIs, the public debate about night curfews is highly controversial and still ongoing.[2]

Similarly, there is also no consensus in the academic literature on whether night curfews present an appropriate measure to combat the pandemic. While some authors find that they are beneficial (Sharma et al., 2021) other studies are inconclusive (Dimeglio et al., 2021). However, typically multiple NPIs are imposed simultaneously which makes it challenging to isolate the effect of a single intervention (Soltesz et al., 2020).

In this study we examine the effectiveness of night curfews by taking advantage of regional and time variation in their implementation. Based on the federal system of Germany, NPIs were not imposed at the national level and even within federal states some NPIs were not imposed in all counties. In our analysis we use the federal state of Hesse as a case study to assess the effectiveness of night curfews from 9pm to 5am which were only introduced in some but not all counties during the second wave. Also, they were implemented at different points in time and with different durations. This peculiarity allows us to identify a potential effect by using a control group when measuring the treatment effects. Our results suggest that the implementation of night curfews did not contribute to decreasing incidences. Furthermore, we find no evidence that night curfews are related to a significantly reduced mobility. Note that some other NPIs were imposed simultaneously with a night curfew, e.g., limitation of the radius of movement or indoor individual sports. As we are not able to disentangle the effect of these different measures, our result - no significant effect - applies to the whole bundle of measures. In that respect our approach is a conservative one. We don't find an effect of the joint measures. This additionally supports the assumption that night curfews are not effective.[3]

2 Data and Methodology

Our data set is built from three sources. Daily information on incidences (cumulative number of newly transmitted cases per 100,000 inhabitants over the past 7 days) at the county level were downloaded from the website of the Robert Koch Institute (RKI).[4] Hessischer Rundfunk, the regional public broadcasting agency collated information on local night curfews in Hesse

[2] See for example: https://www.tagesschau.de/faktenfinder/ausgangssperren-corona-101.html

[3] Of course, this conclusion is based on the reasonable assumption that the other measures do not increase the incidences.

[4] https://www.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/Daten/Fallzahlen_Archiv.html

consisting of start and end dates per county.[5] Additionally, we use daily time series on the mobility changes (mobility compared to 2019) in the corresponding counties from the Open-ScienceFramework.[6] These data are a measurement for people's movements and use location data based on the signals from mobile phones.[7] Notably, data on mobility are not necessarily related to incidences, it is often argued that this data can be used to aid the evaluation of NPIs (Pepe et al., 2020). Our period of investigation starts on November 18, 2020 (when the RKI data start) and ends on February 28, 2021. This period roughly corresponds to the second wave in Hesse. There are 26 counties of which 15 had a night curfew during our observation period. The average duration of a night curfew was 28 days. Figure 1 and Table 1 illustrates the timing of each night curfew and shows whether or not a curfew has been implemented.

Table 1: Night curfews in Hesse

county	start date	end date	duration in days
Bergstraße	21/12/2020	04/01/2021	14
Darmstadt	–	–	–
Darmstadt-Dieburg	22/12/2020	05/01/2021	14
Fulda	12/12/2020	05/02/2020	55
Frankfurt am Main	–	–	–
Gießen	13/12/2020	18/01/2021	36
Groß-Gerau	–	–	–
Hersfeld-Rotenburg	16/12/2020	18/01/2021	33
Hochtaunuskreis	–	–	–
Kassel	–	–	–
Lahn-Dill-Kreis	–	–	–
Limburg-Weilburg	12/12/2020	21/01/2021	40
Main-Kinzig-Kreis	11/12/2020	14/01/2021	34
Main-Taunus-Kreis	16/01/2021	27/01/2021	11
Marburg-Biedenkopf	–	–	–
Odenwaldkreis	15/12/2020	06/01/2021	22
Offenbach (Landkreis)	12/12/2020	06/01/2021	25
Offenbach (Stadt)	12/12/2020	07/01/2021	26
Rheingau-Taunus-Kreis	–	–	–
Schwalm-Eder-Kreis	17/12/2020	05/01/2021	19
Vogelbergkreis	17/12/2020	24/01/2021	38
Waldeck-Frankenberg	21/12/2020	04/01/2021	14
Waldeck-Frankenberg	08/01/2021	11/01/2021	3
Werra-Meißner-Kreis	–	–	–
Wetteraukreis	15/12/2020	05/01/2021	21
Wiesbaden	–	–	–

[5] https://www.hessenschau.de/gesellschaft/hier-gelten-die-corona-ausgangssperren-in-hessen-,uebersicht-ausgangssperre-hessen-100.html. We would like to thank Jan Eggers for preparing the historical data.

[6] https://osf.io/n53cz/

[7] For more information we refer to Schlosser et al. (2020)

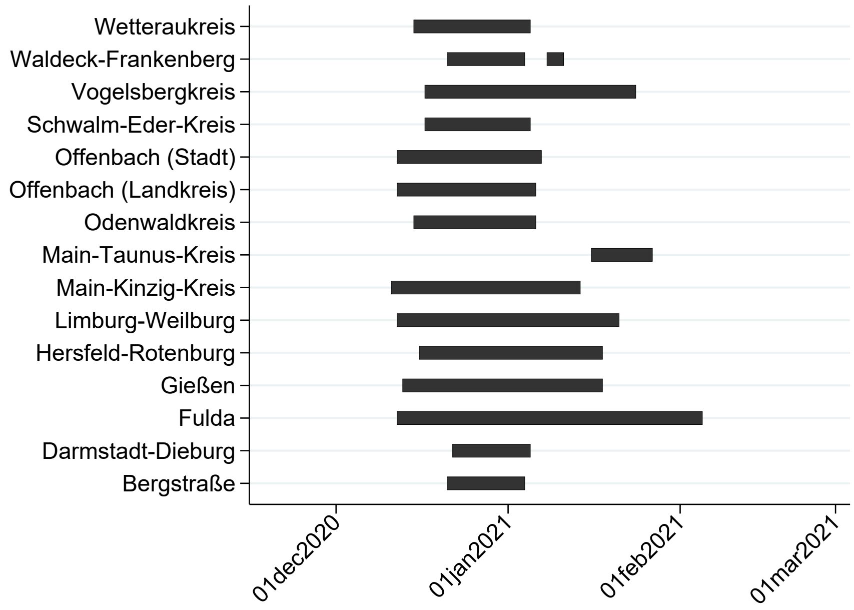

Figure 1: Night curfews in Hesse

To examine whether night curfews were effective in slowing down local incidences we apply a difference-in-differences approach. The idea is to asses whether incidences were smaller following a night curfew than they would have been in absence of it, by comparing the development of incidences in counties that have implemented night curfews with those that did not. The same approach is applied to check whether the mobility was reduced by night curfews. A similar approach was used by Kosfeld et al. (2020) to examine the effects of several NPIs during the "first wave" in Germany.

As with all NPIs aiming to reduce incidences there is a notable time delay until a measure's success can be evaluated. This is due to incubation period and delays in the recording and reporting of the incidence rates at the RKI website. The incubation period is assumed to be five days on average and the reporting lag adds two to nine days on top of that.[8] To account for the delay until night curfews actually unfold a measurable effect we move the start and end dates of each night curfew seven, ten and fourteen days ahead of their real dates and construct a binary variable “Effective curfew” which is equal to one during this period and zero otherwise. In formal terms:

[8]https://www.rki.de/DE/Content/Infekt/EpidBull/Archiv/2020/Ausgaben/17_20.pdf?__blob=publicationFile

$$\text{Effective curfew}_{i,t} = \begin{cases} 1, & \text{if } t \in [\text{Actual curfew start date}_i + 7/10/14 \text{ days};\\ & \text{Actual curfew end date}_i + 7/10/14 \text{ days}] \\ 0, & \text{otherwise} \end{cases} \tag{1}$$

Given that that there is no delay in the mobility data a night curfew should unfold its effect on this variable immediately. Thus, there is no need for a lag in the corresponding estimation.

Furthermore, a major challenge in the identification of the effectiveness of night curfews comes from the fact that they have not been introduced randomly. On the contrary, night curfews have usually been implemented in counties in which incidence rates exceeded a threshold of 200 on at least three consecutive days.[9] In other words, action was taken in counties with already higher incidences. Thus, a simple comparison of the development of incidences in counties with and counties without night curfews may be misleading if incidences in counties that implemented night curfews would have also grown faster in absence of the night curfew. We control for this, first, by estimating the effects of a night curfew on the growth rates of incidences instead on the incidences itself.[10] And, second, by additionally including a binary variable into the model. This variable is equal to one from seven days before the curfew actually starts until the "Effective curfew" ends. Before and after it is equal to zero. We label this variable "Incidence - lead". In formal terms:

$$\text{Incidence - lead}_{\,i,t} = \begin{cases} 1, & \text{if } t \in [\text{Actual curfew start date}_i \text{ - 7 days};\\ & \text{Effective curfew end date}_i] \\ 0, & \text{otherwise} \end{cases} \tag{2}$$

The same is true for the mobility data. However, given that there is no delay the lead for this variable is build on the actual curfew dates. Hence, the variable is equal to one from seven days before the curfew actually starts until the actual curfew ends. Before and after it is equal to zero. We label this variable "Mobility - lead". In formal terms:

[9] https://www.hessen.de/fuer-buerger/corona-hessen/das-hessische-eskalationskonzept-im-ampelsystem

[10] In a former version of this paper we estimate indeed the effects on the incidences itself, however, we then need to include more variables to check whether incidences would have grown faster in absence of the night curfew. Nevertheless, the results remain unchanged. Additionally, we do not use the R number given potentially corresponding problems as suggested by Adam (2020) for hyperlocal data.

$$\text{Mobility - lead}_{i,t} = \begin{cases} 1, & \text{if } t \in [\text{Actual curfew start date}_i \text{ - 7 days;} \\ & \text{Actual curfew end date}_i] \\ 0, & \text{otherwise} \end{cases} \tag{3}$$

These variables capture the difference in the growth rates of the incidences and the difference in mobility changes, respectively, just before a night curfew was implemented or got effective. Loosely speaking, they indicate whether the dynamics of the pandemic differs in the two groups (also known as "common trend assumption").

The variables are illustrated in Figure 2 which shows exemplary the infection process in two counties: Bergstrasse where a night curfew was implemented from December 22, 2020 until January 5, 2021 and Darmstadt where no night curfew was implemented.

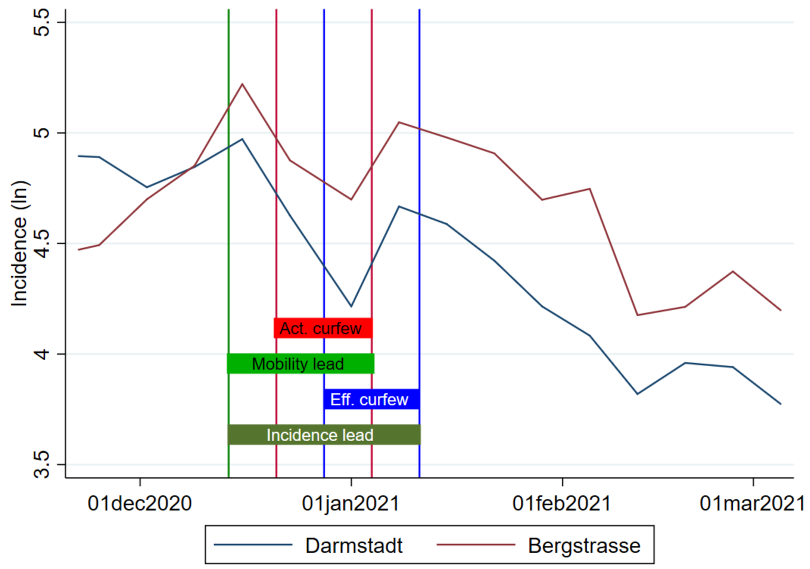

Figure 2: Exemplary infection process in two counties

The empirical model we estimate for the incidence can be written as:

$$\begin{aligned} \frac{I_{i,t} - I_{i,t-1}}{I_{i,t-1}} = {} & \beta_1 \text{Effective curfew}_{i,t} \\ & + \beta_2 \text{Incidence - lead}_{i,t} \\ & + \phi_i + \phi_i * Timetrend_t \\ & + \gamma_t + \varepsilon_{i,t}, \end{aligned} \tag{4}$$

where I denotes the incidence in county i at day t. β_1 is the coefficient of interest – the effect of the night curfew on the incidences I. We further include fixed effects for each day in our sample γ_t in order to control for general developments of the pandemic spread and for each county ϕ_i to control for time-invariant differences across counties that may effect the pandemic such as population density or demographic differences. Additionally, we include interactions of county fixed effects with a linear time trend in order to allow for different general developments over time across counties.

The empirical model we estimate for the mobility changes can be written as:

$$\begin{aligned} \text{Mobility}_{i,t} = {} & \beta_1 \text{Actual curfew }_{i,t} \\ & + \beta_2 \text{Mobility - lead}_{i,t} \\ & + \phi_i + \phi_i * Timetrend_t \\ & + \gamma_t + \varepsilon_{i,t}, \end{aligned} \tag{5}$$

where $Mobility$ denotes the mobility change in county i at day t. β_1 is the coefficient of interest – the effect of the night curfew on the mobility changes $Mobility$. As above, we include fixed effects for each day γ_t for each county ϕ_i and interactions of county fixed effects with a linear time trend in our model.

3 Results

Before we present the results from the econometric analysis we illustrate the patterns descriptively. We plot the differences in incidence growth and mobility change between counties that have implemented a night curfew during our observation period and those that did not. The left panel in Figure 3 shows the difference in incidence growth, the right one the difference in mobility change. Additionally, we add a polynomial fit and the corresponding 95% confidence interval. As these confidence interval always covers the 0, the difference is not significantly different from zero for both variables.

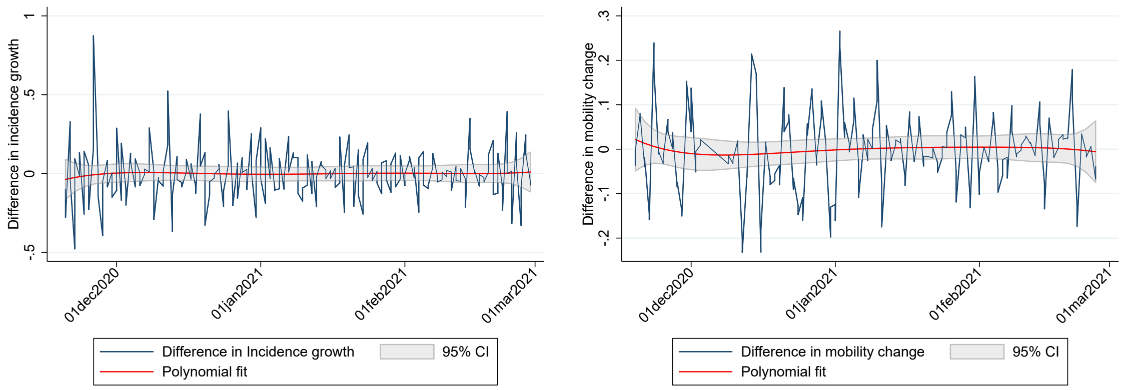

Figure 3: Differences in incidence growth (left panel) and mobility change (right panel) between counties that implemented night curfews and those that did not.

The results from the regression models from Equations 4 and 5 are shown in Table 2. In Column (1) we assume a delay of seven days between the actual start of the curfew until it gets effective. In Column (2) we assume a delay of ten days and fourteen days in Column (3). Column (4) shows the results for the regression model on mobility changes.

All models suggest that there is no evidence for differences in the pandemic spread before the night curfews get effective as indicated by the insignificant coefficients of "Incidence lead".[11] Accordingly, there is no evidence that the mobility changes differ before the night curfews. In other words we can assume common trends for growth rates of incidences and mobility changes in counties with and counties without night curfews. This is important as it enables a causal assessment whether night curfews did affect incidence growth and the mobility changes, respectively.

The key result of the paper stems from the coefficient of the variable "Effective curfew". Even though this variable is negative, it is never significant. In other words, we find no statistically significant evidence that night curfews had an impact on the pandemic spread. The same is true for the coefficient of "Actual curfew" and thus, for mobility changes.

[11]This result coincides with that for the coefficient "Curfew - lead 1" in the previous version of the paper. That coefficient was also insignificant, implying that there is no difference in the dynamics of the infection process. Only the absolute levels of incidences are different as indicated by the coefficient of the variable "Curfew - lead 2" in the previous version.

Table 2: Effects of night-time curfews on incidences in Hesse

	7 days delay	10 days delay	14 days delay	No delay
	$\frac{I_t - I_{t-1}}{I_{t-1}}$	$\frac{I_t - I_{t-1}}{I_{t-1}}$	$\frac{I_t - I_{t-1}}{I_{t-1}}$	Mobility change
Effective curfew	-0.030	-0.024	-0.019	
	(0.021)	(0.016)	(0.011)	
Incidence lead	0.012	0.005	0.004	
	(0.017)	(0.016)	(0.014)	
Actual curfew				-0.013
				(0.010)
Mobility lead				-0.013
				(0.010)
Day FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
County × Daily Time Trend FE	Yes	Yes	Yes	Yes
Obs.	2,314	2,236	2,132	2,392

Notes: Cluster-robust standard errors (clustered on county level) are presented in parentheses. Statistics are significant for $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

4 Conclusion

We estimate the impact of local night curfews in Hesse, Germany, on the growth rates of incidences of COVID-19 cases and the mobility changes during the "second wave" of the COVID-19 pandemic in this state. While our data set is limited to the federal state of Hesse, the analysis is taking advantage of regional and time variation in the implementation of night curfews. Thus, we are able to overcome potential statistical problems that are related to estimations of benefits of NPIs. Our results suggest that night curfews are not an effective measure to limit virus transmission when various other NPIs are already imposed. This might be based on the fact that there is no significant reduction in the mobility. Whether people shifted their mobility to daytime or night curfews were not enforced successfully remains an open question.

Of course, caveats are in order. As always, the results may change with another data set. For instance, night curfews could have different effects for other regions. The same is true for the observation period: Our data cover the Christmas season, where a curfew might have fewer additional effects as people tend to stay home anyway. At the same time, it covers New Year's Eve where the opposite holds. It remains a task for further research and in particular for further data gathering to expand our data set to all of Germany and extend our observation period. Additionally, examination of hourly data on mobility changes could provide further insights. Finally, it should be emphasized that other NPIs such as limitations of the radius of movement or indoor individual sports have been introduced simultaneously with night curfews. Thus, theoretically it is possible that some of these measures increase while others decrease incidence growth and sum up to null results. However, while this possibility cannot be excluded it may be a rather unrealistic explanation of our findings.

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