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

Samuel de Haas† Georg Götz‡ Sven Heim§

April 28, 2021

Abstract

Curfews present the most restrictive measure aiming to fight the spread of the COVID 19-pandemic. A somewhat weaker form are night time curfews. Night time curfews were imposed all over the world (e.g. USA, France, Germany or Argentina) and are still in force in many countries and have been even re-enforced recently in some countries. The public debate around night curfews is heated and evidence on their effectiveness is still scarce so far. Empirical evidence is the only way to reduce the emotionality in this discourse and to provide guidance for the decisions of policymaker. In this paper we estimate the impact of local night curfews in Hesse, the fifth most populous federal state in Germany, on the growth of incidences of COVID-19 cases during the "second wave" of the COVID-19 pandemic. Using this setup we take advantage of the fact that counties in Hesse had the same measures in place with the only difference that some additionally had to implement night curfews. This allows us to identify the effect of night curfews in isolation. We find no statistical evidence that night curfews were effective in slowing down the spread of the pandemic.

Keywords: COVID-19, Night Curfew, Difference in Differences Analysis

1 Introduction

Since the end of 2019 a new coronavirus SARS-CoV-2 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

*We thank Jan Eggers for providing the historical curfew data. We also thank Benjamin de Haas, Johanna de Haas, Tomaso Duso, Lukas Jürgensmeier, Lars Feld, Kai Fischer, Paul Heim, Reinhold Kosfeld, Walter Krämer, Ulrich Laitenberger, Dominik Rehse, Simon Reif and Peter Winker for helpful comments on earlier versions of the paper. The sole responsibility lies with the authors.

†Justus-Liebig-University Giessen. E-mail: samuel.de-haas@wirtschaft.uni-giessen.de

‡Justus-Liebig-University Giessen. E-mail: georg.goetz@wirtschaft.uni-giessen.de

§Mines ParisTech, Paris, and Leibniz Centre for European Economic Research (ZEW), Mannheim. E-mail: sven.heim@mines-paristech.fr

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

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 on the effectiveness of NPIs in general and curfews in particular (e.g. Flaxman et al., 2020; Andronico et al., 2021), 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)[3].

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. 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.[4]

[2]See for example: https://www.cnbctv18.com/healthcare/does-night-curfew-help-in-containing-spread-of-covid-19-heres-a-deep-dive-8656991.htm

[3]Note that Sharma et al. (2021) also report corresponding problems concerning the isolation of the effects of night curfews (p. 10): "However, due to the broad nature of these interventions, they are also likely to interact with other active NPIs."

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

2 Data and Methodology

Our data set is built from two 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).[5] Hessischer Rundfunk, the regional public broadcasting agency collected information on local night curfews in Hesse consisting of start and end dates per county.[6] 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 (Landkreis)	–	–	–
Kassel (Stadt)	–	–	–
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.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/Daten/Fallzahlen_Archiv.html
[6] https://www.hessenschau.de/gesellschaft/hier-gelten-die-corona-ausgangssperren-in-hessen-,uebersicht-ausgangssperre-hessen-100.html.

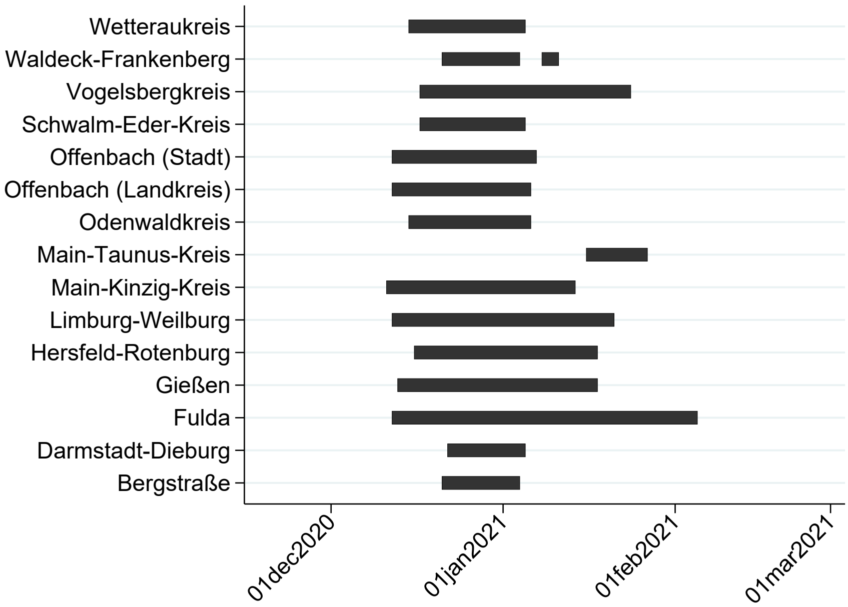

Figure 1: Night curfews in Hesse

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. A similar approach was used by Kosfeld et al. (2020) and Isphording et al. (2021) 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.[7] 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:

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

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

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 the incidence exceeded a threshold of 200 on at least three consecutive days.[8] 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 rather than of on the incidences themselves.[9] 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:

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

This variable captures the difference in the growth rates of the incidences before a night curfew got effective. Loosely speaking, it indicates whether the dynamics of the pandemic differs in the two groups (also known as "common trend assumption").

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

[9] 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.

We further add a dummy which is equal to one for the post-curfew period of the treated counties, formally:

$$\text{After effective curfew}_{i,t} = \begin{cases} 1, & \text{if } t \in [\text{Effective curfew end date}_i + 1 \text{ day}; \\ & \text{End of observation period}_i] \\ 0, & \text{otherwise} \end{cases} \tag{3}$$

Thus, we are able to control whether the growth of incidences differ in the long run.

The three variables plus the actual curfew are illustrated in Figure 2 which shows exemplary the weekly smoothed 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.

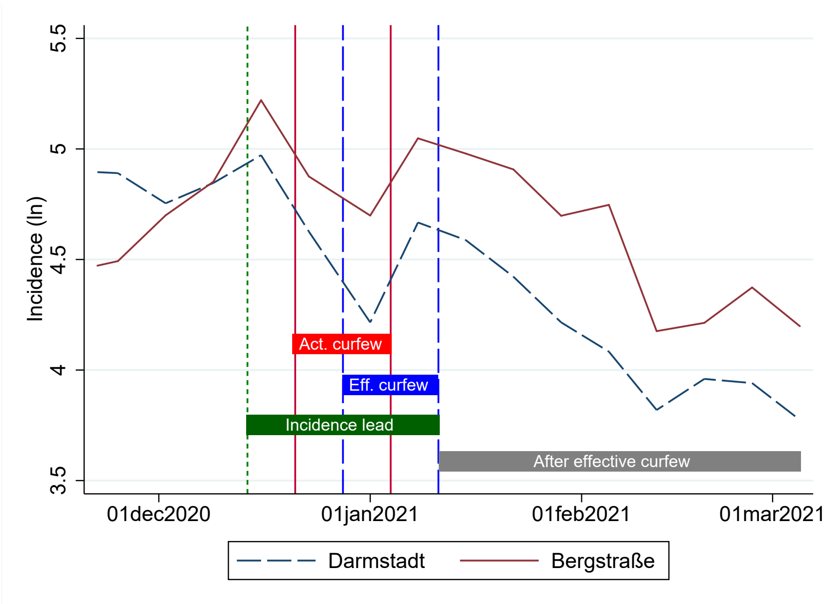

Figure 2: Exemplary infection process in two counties

The empirical model we estimate can be written as:

$$\begin{aligned} \frac{I_{i,t} - I_{i,t-1}}{I_{i,t-1}} = & \ \beta_1 \times \text{Effective curfew}_{\ i,t} \\ & + \beta_2 \times \text{Incidence lead}_{i,t} \\ & + \beta_3 \times \text{After effective curfew}_{i,t} \\ & + \phi_i + \phi_i \times \text{Time trend}_t \\ & + \gamma_t + \varepsilon_{i,t}, \end{aligned} \tag{4}$$

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 growth of 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. Thereby, we accommodate potential trend differentials in our model. This allows us a valid identification of treatment effects even for heterogeneous infection dynamics across regions in the pre-treatment period (Angrist and Pischke, 2014; Kosfeld et al., 2020; Deb et al., 2020). In our empirical analysis we drop the county Waldeck-Frankenberg for two reasons. First, there were two curfews with the second curfew lasting only three days and started only four days after the first one. Second, there were substantial reporting problems during Christmas holidays as incidences shoot up by 209 from December 26 to 27 which is a 387% higher jump than in the county with the second highest jump. However, including Waldeck-Frankenberg does not change our results as we show in Table A1 in the Appendix. Furthermore, our results remain also fully robust if we exclude Christmas holidays and New Year's day from our data set as shown in Table A2.

3 Results

Before we present the results from the econometric analysis we illustrate the patterns descriptively. We plot the difference in incidence growth between counties that have implemented a night curfew during our observation period and those that did not. Additionally, we add a polynomial fit and the corresponding 95% confidence interval. As the confidence interval always covers the 0, the difference is not significantly different from zero.

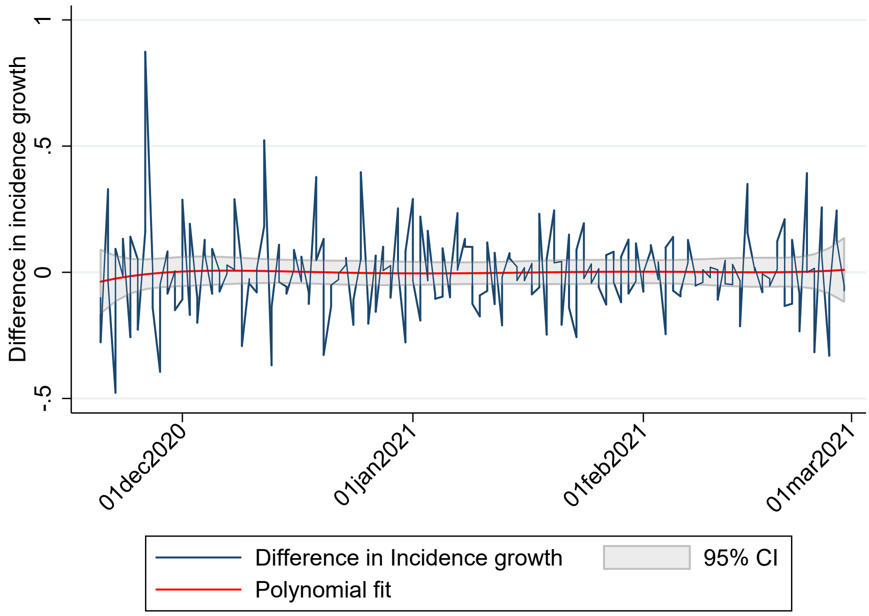

Figure 3: Differences in incidence growth between counties that implemented night curfews and those that did not.

The results from the regression models from Equation 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).

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". In other words we can assume common trends for growth rates of incidences in counties with and counties without night curfews. This is important as it enables a causal assessment whether night curfews did affect incidence growth.

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.

Also, the coefficient of the variable "After effective curfew" is never significant. Thus, there are no differences in the growth of incidences in the long run. Summed up, we neither find evidence that night curfews had an immediate nor that there was a lasting effect after the curfew had ended.

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

	7 days delay	10 days delay	14 days delay
	$\frac{I_t - I_{t-1}}{I_{t-1}}$	$\frac{I_t - I_{t-1}}{I_{t-1}}$	$\frac{I_t - I_{t-1}}{I_{t-1}}$
Effective curfew	-0.007	-0.004	-0.010
	(0.010)	(0.009)	(0.009)
Incidence lead	0.019	0.020	0.015
	(0.014)	(0.015)	(0.015)
After effective curfew	0.031	0.040	0.017
	(0.023)	(0.027)	(0.029)
Day FE	Yes	Yes	Yes
County FE	Yes	Yes	Yes
County × Daily Time Trend FE	Yes	Yes	Yes
Obs.	2,550	2,550	2,550

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

We next analyze whether there were heterogeneous effects of the night curfew. We do this by re-estimating the model from Equation 5 but this time with individually estimated parameters for each day included in the variable "Incidence lead" and individually estimated parameters for each of the first seven days of "Effective curfew" plus a further dummy which is equal to one for all remaining days of the effective curfew and a dummy which is equal to one for all days of the post-curfew period.

In other words, – with delays $X \in \{14, 17, 21\}$ –, the models we estimate can be written as:

$$\begin{aligned}\frac{I_{i,t} - I_{i,t-1}}{I_{i,t-1}} &= \sum_{T=1}^{X} \beta_{1,T} \times \text{Day } T \text{ before effective curfew }_{i,t} \\ &+ \sum_{T=1}^{7} \beta_{2,T} \times \text{Day } T \text{ of effective curfew }_{i,t} \\ &+ \beta_3 \times \text{After effective curfew}_{i,t} \\ &+ \phi_i + \phi_i \times \text{Time trend}_t \\ &+ \gamma_t + \varepsilon_{i,t},\end{aligned} \tag{5}$$

The estimated coefficients and the corresponding confidence intervals of these estimations are presented in the three panels in Figure 4. Again, the observed patterns do not point towards different trends in the development of incidence growth before the curfew got effective which makes it plausible to assume that the common trend assumption holds. Also, again we do not find any evidence that the night curfews helped to mitigate the spread of the pandemic as all curfew coefficients are statistically insignificant.

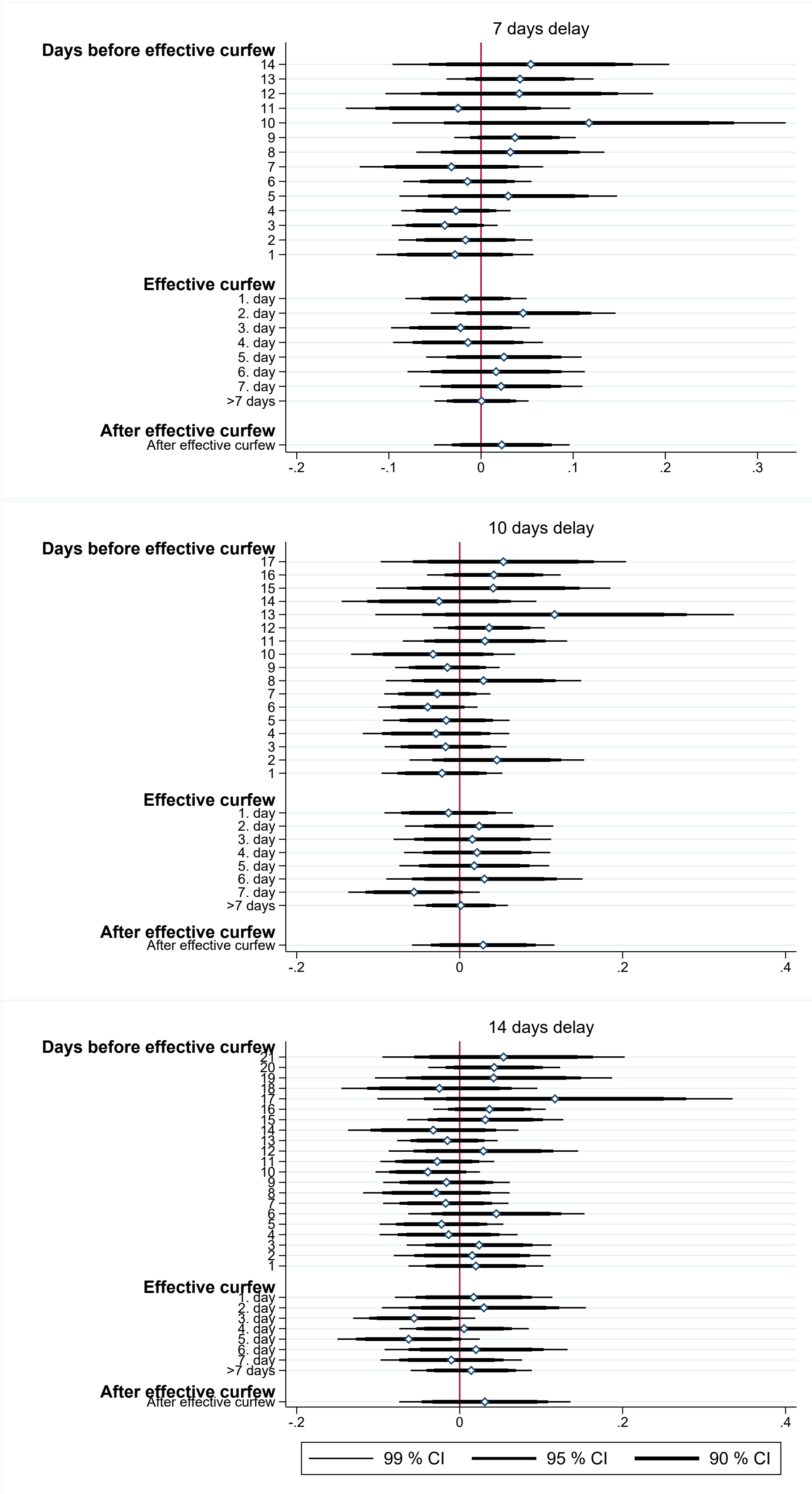

Figure 4: Coefficients and confidence intervals of heterogeneity of effects analysis

4 Conclusion

We estimate the impact of local night curfews in Hesse, Germany, on the growth rates of incidences of COVID-19 cases 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. At the same time, there is no indication that the night curfews from 9 pm to 5 am worsen the epidemic. They do not seem to increase incidences.

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 the data set to all of Germany and extend the observation period. 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.

References

Adam, D., 2020. A guide to r—the pandemic's misunderstood metric. Nature 583, 346–348.

Andronico, A., Kiem, C.T., Paireau, J., Succo, T., Bosetti, P., Lefrancq, N., Nacher, M., Djossou, F., Sanna, A., Flamand, C., et al., 2021. Evaluating the impact of curfews and other measures on sars-cov-2 transmission in french guiana. Nature communications 12, 1–8.

Angrist, J.D., Pischke, J.S., 2014. Mastering'metrics: The path from cause to effect. Princeton University Press.

Deb, P., Furceri, D., Ostry, J.D., Tawk, N., 2020. The effect of containment measures on the covid-19 pandemic .

Dimeglio, C., Miedougé, M., Loubes, J.M., Mansuy, J.M., Izopet, J., 2021. Side effect of a 6 p.m curfew for preventing the spread of sars-cov-2: A modeling study from toulouse, france. Journal of Infection .

Flaxman, S., Mishra, S., Gandy, A., Unwin, H.J.T., Mellan, T.A., Coupland, H., Whittaker, C., Zhu, H., Berah, T., Eaton, J.W., et al., 2020. Estimating the effects of non-pharmaceutical interventions on covid-19 in europe. Nature 584, 257–261.

Isphording, I.E., Lipfert, M., Pestel, N., 2021. Does re-opening schools contribute to the spread of sars-cov-2? evidence from staggered summer breaks in germany. Journal of Public Economics .

Kosfeld, R., Mitze, T., Rode, J., Waelde, K., 2020. The covid-19 containment effects of public health measures-a spatial difference-in-differences approach. Journal of Regional Science Special Issue: Covid-19 and the Regional Economy.

Sharma, M., Mindermann, S., Rogers-Smith, C., Leech, G., Snodin, B., Ahuja, J., Sandbrink, J.B., Monrad, J.T., Altman, G., Dhaliwal, G., et al., 2021. Understanding the effectiveness of government interventions in europe's second wave of covid-19. medRxiv .

Soltesz, K., Gustafsson, F., Timpka, T., Jaldén, J., Jidling, C., Heimerson, A., Schön, T.B., Spreco, A., Ekberg, J., Dahlström, Ö., et al., 2020. The effect of interventions on covid-19. Nature 588, E26–E28.

Appendix

Table A1: Effects of night-time curfews on incidences in Hesse – including Waldeck-Frankenberg

	7 days delay	10 days delay	14 days delay
	$\frac{I_t - I_{t-1}}{I_{t-1}}$	$\frac{I_t - I_{t-1}}{I_{t-1}}$	$\frac{I_t - I_{t-1}}{I_{t-1}}$
Effective curfew	-0.031	-0.019	-0.021
	(0.025)	(0.017)	(0.014)
Incidence lead	0.023	0.027*	0.017
	(0.014)	(0.015)	(0.013)
After effective curfew	0.006	0.029	0.004
	(0.029)	(0.023)	(0.028)
Day FE	Yes	Yes	Yes
County FE	Yes	Yes	Yes
County × Daily Time Trend FE	Yes	Yes	Yes
Obs.	2,652	2,652	2,652

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

Table A2: Effects of night-time curfews on incidences in Hesse – Excluding Christmas holidays and New Year's eve

	7 days delay	10 days delay	14 days delay
	$\frac{I_t - I_{t-1}}{I_{t-1}}$	$\frac{I_t - I_{t-1}}{I_{t-1}}$	$\frac{I_t - I_{t-1}}{I_{t-1}}$
Effective curfew	-0.017	-0.007	-0.016
	(0.013)	(0.010)	(0.012)
Incidence lead	0.007	0.009	0.003
	(0.015)	(0.013)	(0.013)
After effective curfew	0.002	0.019	-0.009
	(0.025)	(0.024)	(0.021)
Day FE	Yes	Yes	Yes
County FE	Yes	Yes	Yes
County × Daily Time Trend FE	Yes	Yes	Yes
Obs.	2,522	2,522	2,522

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