Nederlands Studiecentrum Criminaliteit en Rechtshandhaving

Behavioral Compliance with Curfew Measure during Lockdown:

Results of the NSCR Amsterdam Curfew Study

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Drawing on video footage from municipal public security cameras in Amsterdam, we investigated behavioral compliance with the curfew installed as a Covid-19 mitigating measurement in a period of lockdown. This curfew was installed on January 23th, 2021, and required all citizens to stay at home between 21:00 and 4:30, with some activities being exempted.

Prior studies have shown that curfews can have the intended effects of reducing viral transmissions in the population (Baunez et al., 2020; Haug et al., 2020; Huber & Langen, 2020), suggesting the compliance with the curfew is substantial. Therefore, we expected that the curfew would also lead to lower numbers of people on the street in the current Amsterdam context.

More specifically, we utilized the curfew as a natural experimental situation in two studies. Both studies compared the number of people on the street in the weeks before and during the curfew. Study 1 (N = 1,154 one-minute clips) focused on three locations and drew on manual coding of the number of people on the street. Study 2 focused on 50 locations, and data were automatically coded using an artificial intelligence algorithm that we developed and successfully evaluated (N= 4,912 still frames). The aim of this two-study setup is to replicate our results, specifically by assessing their robustness by analyzing the same original data using two different measurement methods and sample sizes (Freese & Peterson, 2017).

The key results of Study 1 and 2 were as follows: With the introduction of the curfew, the number of people on the street decreased after 21:00 in the evening. In percentage terms, the reduction was 74% (Study 1) 51% (Study 2), evidencing that people complied with the curfew. It should be stressed, however, that the reduction of people in absolute terms was limited: The streets was relatively deserted after 21:00 before the curfew was implemented, indicating that a curfew may only have a limited effect in reducing the raw number of people in a situation where society is already under lockdown.

Note that these are preliminary results from a not yet peer-reviewed study in progress. The final results will be available at osf.io/7ek9d. The study was partly financed by ZonMw (grant number: 50-56300-98-603) and the Municipality of Amsterdam. It was conducted independently by the authors. We would like to thank Laura Hendriks and Thomas van der Veen for their contribution to the coding of the footage and data preparation, respectively.

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Reflecting this point, the overall activity level across the day was further not found to be statistically different when comparing dates before and during the curfew. Finally, we qualitatively observed all persons moving during curfew hours, as to evaluate whether they had a legitimate purpose for being outside or were violating the curfew. This analysis indicated that at least one-third (but most likely a larger proportion) had a legitimate purpose for moving outside. We discuss the potential implications of these findings for transmission risks in the light of epidemiological literature suggesting outdoor behavior involves a low Covid-19 transmission risk.

Background

For the first time since the Second World War, the Dutch government installed a curfew on Saturday 23th January, 2021, in an attempt to mitigate the spread of Covid-19. In the period between 21:00 and 04:30, citizens were enforced to stay inside their homes, with only a few exceptions allowing outside behavior. The Dutch government presented it as an "extraordinary restrictive measurement" (Rijksoverheid, 2021) installed with the purpose of limiting people's movements outside their homes, particularly the inclination to visit friends and family in their homes. At the time, the Netherlands was already in a lockdown situation in which the large majority of retail activities and indoor facilities were closed down. According to the government, this was needed because new mutations of the virus threatened to put additional strain on the healthcare system. The limitation of outdoor behavior would in that context be a welcome mitigation measure for further transmissions. In installing this measure, the government referred to studies from other countries indicating the potential effect of curfews on limiting transmission risks. Indeed, evidence from France, Germany, and Switzerland (Baunez et al., 2020; Huber & Langen, 2020), as well as an international comparison (Haug et al., 2020), suggest that curfews may limit transmission risks.

However, a limitation of the available evidence is that the installment of a mitigating measure is no guarantee of behavioral compliance (Hoeben et al., 2020). Recently, the National Institute for Public Health and the Environment surveyed 4,965 Dutch citizens to get insight into the support and self-reported compliance to various Covid-19 measures, including the curfew (RIVM, 2021). The majority of respondents (94%) indicated that they had not left their house during the curfew and thus complied with the measure. Yet, the reported support for this measure was lower (75%), indicating that people were staying inside against their will. Because these outcomes show self-reported compliance and per-ception, still little is known about whether and how people actually complied with the curfew measure.

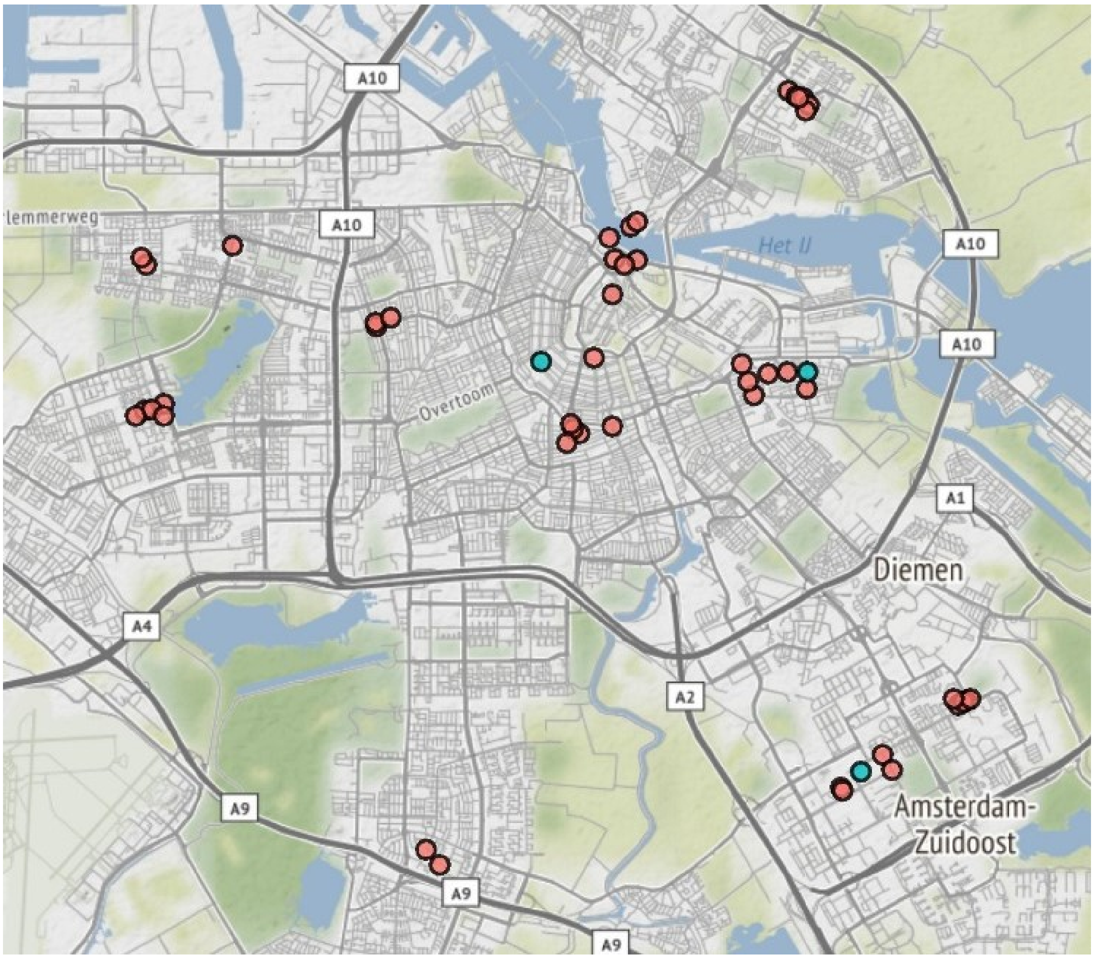
Here, we address this behavioral question by investigating whether the number of people on the streets of Amsterdam changed after the introduction of the curfew. We also report on the observable activities that we could assess from the footage indicating whether people were on the street for legitimate reasons during the curfew hours. While these findings do not say anything about the mitigating effects of the curfew on Covid-19, they do offer valuable insights into the behavioral consequences of the curfew measure, which is assumed in epidemiological studies and intended by governmental agencies.

Methods

The data comprised video footage of everyday public behavior captured by municipal security cameras in Amsterdam, Netherlands. With the permission of the Dutch Public Prosecutor, we obtained data from the Amsterdam police, and the research was approved by the Ethics Committee for Legal and Criminological Research (CERCO) at Vrije Universiteit Amsterdam. The footage used in the studies involved relatively busy areas in the period of a lockdown (e.g., around grocery stores and public transport points). Data were analyzed with a difference-in-difference approach (Goodman-Bacon & Marcus, 2020), estimated with negative binomial regression (appropriate for estimating overdispersed count outcomes), specified with robust standard errors.

Study 1 involved footage from three cameras (i.e., Leidsestraat, Javaplein, and Bijlmerplein). Data were recorded on the Saturdays and Thursdays between 9th January and 4th February, 2021. In order to document the effect of the curfew on crowding, we sampled 1,154 time-points (every 15 minutes for each camera for all days) in which we counted the number of people (pedestrians and cyclists) passing through the street for one minute in both directions (in total, we counted 7,524 individuals across the included time-points). The counts were conducted six hours before the curfew (15:00-21:00) and six hours during the curfew (21:00-03:00).

Figure 1. Placement of the municipal cameras used for Study 1 (blue dots) and Study 2 (red and blue dots)



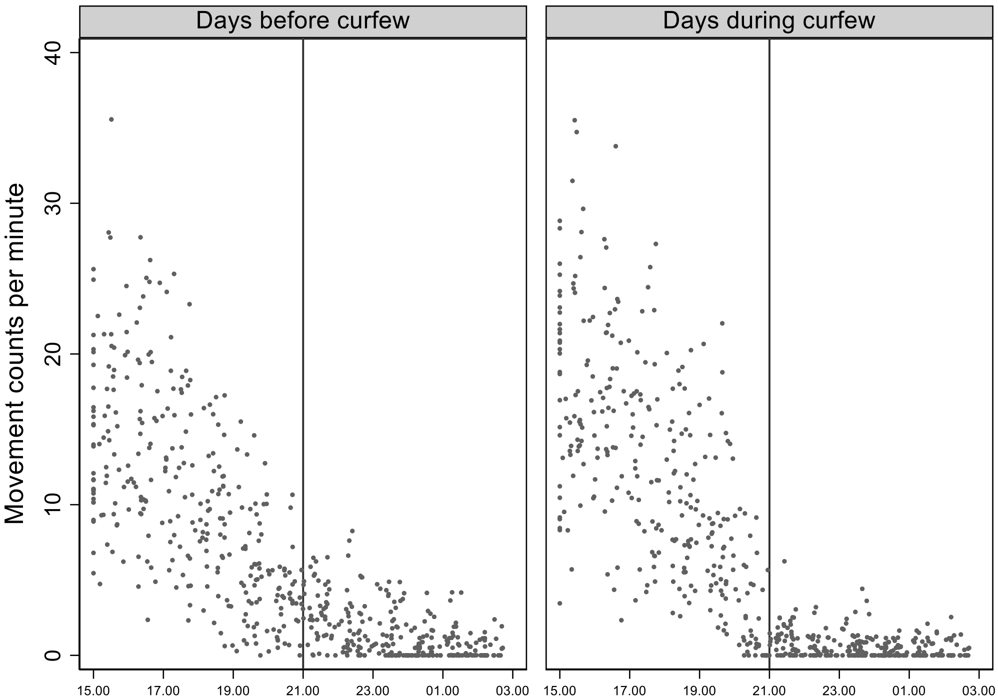
Study 2 involved footage from 50 cameras (see Figure 1). Data were recorded Saturdays and Thursdays between 7th and 28th January 2021. We sampled 4,912 still frames and automatically counted the number of people present on those still frames using a com-puter vision algorithm that we developed and that passed performance tests with excellent results (Appelman et al. 2021). An additional test that we conducted to assess the performance of the algorithm during darkness was also successful. We included 12 time points before the curfew (every full hour from 9:00 to 20:00) and three hours after (at 21:00, 22:00, and 23:00).[1] In total, the algorithm recorded 27,833 individuals across the time-periods.

Results

Study 1

Figure 2 visualizes the number of people counted across time points, with separate graphs for the days before and the days during the curfew. The overall pattern of the two graphs is similar: the number of people was highest in the afternoon and decreased throughout the evening and night hours. However, it is also noteworthy that the decrease was gradual in the days before the curfew, while the days during the curfew displayed a more sudden drop around 21:00. This suggests that people comply with the curfew by returning home earlier than they did before the curfew. Adding to this picture, it is noteworthy that the number of people was lower in hours during the curfew than in the same hours before the curfew was implemented. These patterns offer tentative visual evidence that the curfew has the intended effect of reducing the number of people in public space after 21:00.

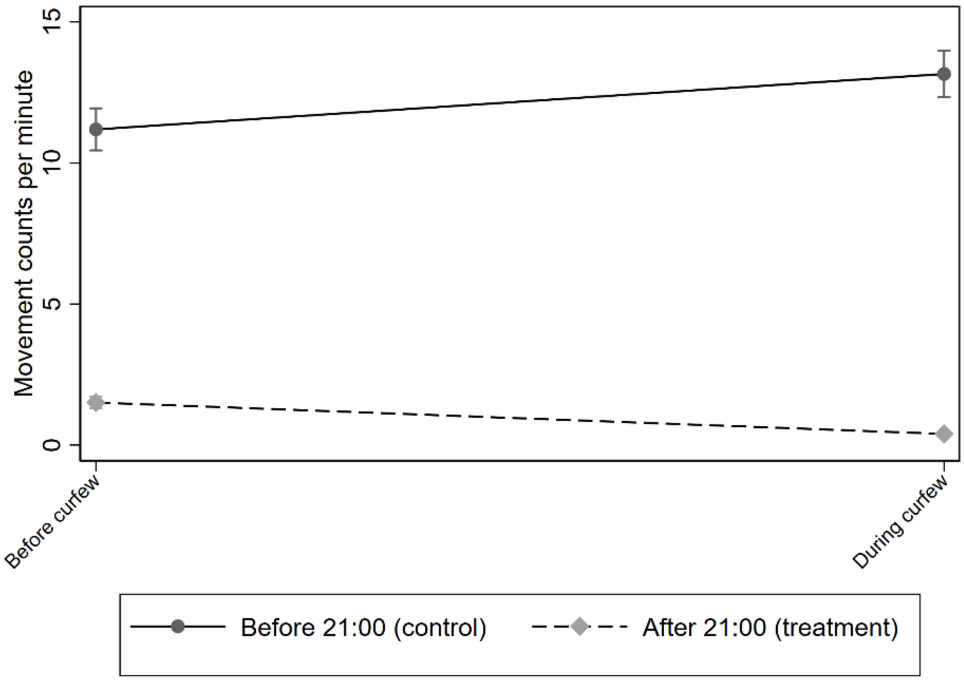
Figure 2. Number of people across the observed hours, for days before and during the curfew



[1] We selected these hours because they were made available to us for all 50 cameras during the relatively short period of the study. Ideally, as in Study 1, we would have included more night hours in the sample.

Next, we statistically tested the effect of the curfew on the number of people using a difference-in-difference (DID) model, see Figure 3. This analysis suggested that the 'control' hours before 21:00 and the 'treatment' hours after 21:00 changed differently after the implementation of the curfew (DID-estimator = -1.50, $p < .001$): The number of people was reduced from a predicted average of 1.5 persons per minute in the hours after 21:00 to a predicted average of 0.40 during the control hours before 21:00, that is a reduction of 74%. These results statistically confirm the visual pattern described above of the curfew having the intended effect of reducing the number of people after 21:00 in the evening.

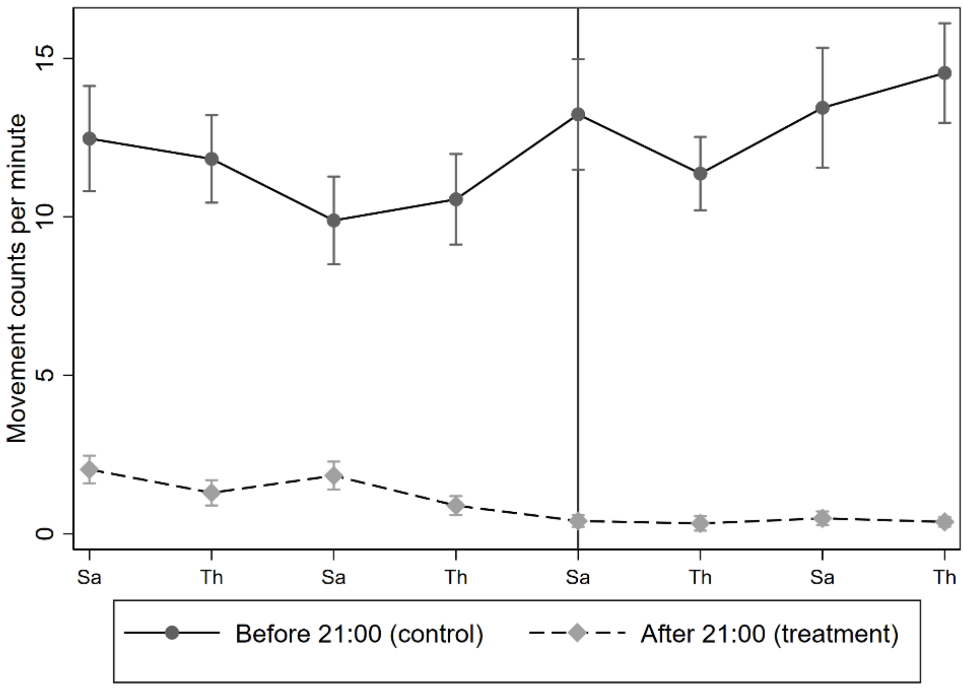
Figure 3. Difference-in-difference regression of number of people per minute



The pattern in Figure 3 - with the treatment and control graphs indicating upwards and downwards trends, respectively - is both of statistical and substantive interest. First, the noticeable increasing trend of the control hours raises the question of whether the curfew implies a displacement effect by which people relocate their outdoor activities to the hours before the curfew starts. We counted an average of 11.2 persons per minute before 21:00 on dates before the curfew was installed, while the average count was 13.2 for dates during the curfew. This difference was - despite its relatively small-scaled magnitude - statistically significant (B = 1.16, p = .001). Next, we did not find that the days before and during the curfew had different numbers of people observed (B = 0.07, p = .311). This indicates that the number of people in public places remained at the same overall level after the installment of the curfew, possibly because the post-21:00 activity is displaced to pre-21:00. These results may be interpreted as offering tentative indications that the curfew is linked with some displacement of activities, although it should be stressed that the current analysis offers a - non-experimental and thus statistically weak - test of displacement.

Second, statistically considered, the existence of a potential displacement effect would violate the key difference-in-difference assumption that the treatment (the curfew) has no effect on the control condition. Moreover, the upward tendency of the control slope could also be indicating a violation of the parallel trends assumption (Wing et al., 2018) - i.e., that the treatment and control groups follow similar pre-intervention trends. To assess this, Figure 4 presents the estimates of the treatment and control hours across the eight days included in the study, with the vertical line indicating the first curfew date. As we see, the treatment and control conditions seem to follow non-parallel trends in the days leading up to the curfew. Specifically, the counts on the second Saturday introduce vary from the pattern, which may relate to the circumstance that the weather was unusually bad on the day between 15:00 and 24:00 (with snowfall, which is atypical in the Netherlands). If this Saturday is this excluded, the parallel assumption seems better satisfied. Adding to the robustness of the current results, the difference-in-difference analysis yields comparable results after this exclusion (DID-estimator = -1.38, $p < .001$)

Figure 4. Difference-in-difference regression of number of people per minute, estimated per day

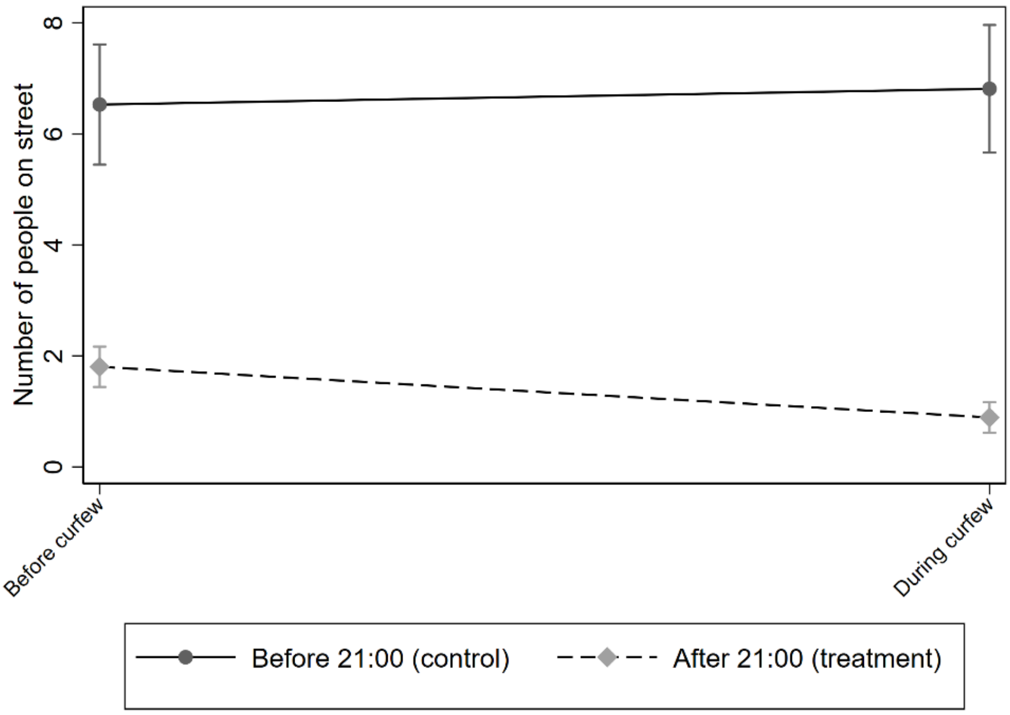


Finally, we report on the qualitatively evaluated persons observed moving during the curfew hours. Of the 87 persons we observed on the street during curfew hours, 31 (36%) of these had an apparent legitimate purpose for being outside, such as walking the dog (6 persons) or delivering food (23 persons). The remaining 64% did not seem to have a legitimate purpose, the majority of which were walking or cycling by (59%), and 6% (5 persons) walked together with someone who was walking the dog, which is not allowed according to the rules of the curfew.

Study 2

As we see in Figure 5, Study 2 yields very similar results as Study 1 (see Figure 3). Again, the observed differences are statistically significant, replicating the result that the curfew has a negative effect on the number of people (DID-estimator = -0.75, $p < .001$), corresponding to a 51% reduction of people on the street. This analysis satisfies better the assumption of parallel trends (results not shown). However, we also assessed the impact of excluding the bad-weather Saturday, and this leaves unchanged the overall result of the difference-in-dif-ference in Study 2 (B = -0.74, $p < .001$).

Figure 5. Difference-in-difference regression of the number of people on the street



The upward trend of the control hours is less apparent than in Study 1 (see Figure 3). This questions the existence of a displacement effect and makes the model better satisfy the assumption that the treatment (the curfew) has no effect on the control condition. Thus suggesting against a potential displacement effect, we did not find that the number of people in the hours before 21:00 was different when comparing dates before and during the curfew (B = 0.03, p = .280). Finally and similar to Study 1, we did not find that the overall activity level across the day is different when comparing dates before and during the curfew (B = -0.05, p = .076).

Closing remarks

Several results were found robust and replicated across Study 1 and 2. Most importantly, this concerns the negative impact of the curfew on the number of persons observed in public space after 21:00. In both studies, the curfew led to a substantial percentage reduction in people on the street, although it should also be stressed that the reduction in raw numbers was limited: Due to the lockdown in operation, the streets were already unpopulated after 21:00 before the curfew was installed. Further, it should be noted that the potential displacement effect indicated by the explorative analysis in Study 1 was not replicated in Study 2.

Finally, it is noteworthy that both studies find that the overall activity level is similar when comparing dates before and during the curfew. This suggests that the curfew measure, at least in the current context of a lockdown, may be a less efficient instrument to regulate the overall activity level of social public life.

One limitation of the current study is that we examine behavioral compliance, not an effect on transmission. Relatedly, it should be stressed that we do not know where people go when they move outside, including whether their movements are related to risk behavior (e.g., visiting friends or family).

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