# COVID-19, lockdowns and motor vehicle collisions: empirical evidence from Greece

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## ABSTRACT

Reduced mobility during COVID-19 lockdowns means not only fewer vehicles at risk of collision, but also an opportunity to speed on empty streets. The objective of this paper is to examine the impact of the first wave of the pandemic and the first lockdown on motor vehicle collisions (MVCs) and associated injuries and deaths in Greece. Using monthly data at the regional unit level, I provide descriptive evidence and subsequently follow a difference-in-differences econometric approach, comparing trends in 2020 with those of the previous 5 years while controlling for unemployment and petrol prices. I found a steep decline in collisions, injuries and deaths compared with what would have been otherwise expected. In March and April 2020, there were about 1226 fewer collisions, 72 fewer deaths, 40 fewer serious injuries and 1426 fewer minor injuries compared with what would have been expected in the absence of the pandemic.

## BACKGROUND

COVID-19 has caused over 3 million deaths globally and has led to a decrease in economic activity and rising unemployment rates.[1] There have been reports that the pandemic is also affecting other health outcomes. These may include delayed diagnosis and treatment,[2] mental health problems,[3] suicide[4] and excess mortality in general.[5]

Another outcome that we would expect to be affected by the pandemic and lockdowns is that of MVCs, for a number of reasons. First, reduced mobility means fewer cars on the streets being at risk of collision. People's mobility was reduced as a result of the lockdown, as well as of their own concerns of being exposed to the virus.[6] Second, lower traffic volume would create the opportunity to speed on empty streets.[7 8] Speeding is a major collision risk factor, which is also likely to lead to more severe crashes and a higher likelihood of death. Third, COVID-19 has led to an increase in unemployment, and there is empirical evidence that collisions decrease during recessions.[9] This may be a result of fewer people driving to work and reasons relating to affordability of driving or activities associated with commuting by car. Fourth, previous research suggests that financial worries and economic uncertainty are associated with MVCs. A spike in collisions was previously reported on the first 2 days after the announcement of austerity measures in Greece,[10] and daily fluctuations in economic uncertainty have been linked to MVCs in Great Britain.[11] Possible reasons include distraction, frustration and sleep deprivation. Fifth, worrying about loved ones who have COVID-19 may also cause distraction, thus leading to car crashes, as it has been previously shown that people whose partner is hospitalised are at a higher risk of being involved in a collision.[12] Sixth, sleep length and patterns have been affected by conditions linked to the pandemic. People tended to sleep later and spend more time in bed during lockdowns, but the quality of sleep deteriorated, and circadian rhythms were disrupted.[13 14] Finally, recent evidence has shown that alcohol consumption, which is a major risk factor, increased during the pandemic.[15] However, as bars and restaurants remained closed during lockdowns (as also the case in Greece), drinking may have taken place mostly at home.

There have been reports of a decrease in collisions and injuries during lockdowns in a number of areas.[16–19] Evidence from the Tarragona province in Spain suggests that there was a sharp decrease in MVCs during the lockdown in March and April 2020,[16] and recent findings show that deaths related to MVCs decreased in Peru.[17] The total number of MVCs dropped in Connecticut after the enactment of the stay-at-home order.[18] Similarly, both collisions and injuries decreased in Florida, New York and Massachusetts during the COVID-19 pandemic.[19] However, a recent study presents evidence of an increase in MVC deaths in the USA (despite reduced traffic volume), which the author attributed to the impact of social distancing on compliance with social norms.[20] Another possible explanation might be that less congested streets provide the opportunity for speeding, which appears to have been the case in Northern Ireland, where there was a decrease in MVCs but no change in fatalities during the lockdown.[21]

The objective of this study is to examine whether there was a change in the number of MVCs, injuries and deaths during the first wave of the COVID-19 pandemic and first lockdown in Greece.

## DATA AND METHODS

I used monthly data on MVCs in Greece for the period 2015–2020, obtained from the Greek Statistics Authority.[22] Monthly data included the total number of collisions resulting in death or injury; the number of deaths; the number of serious injuries and the number of minor injuries. According to the data source, seriously injured individuals are those who suffered serious harm, such as brain damage, multiple injuries or amputation, or who were in a life-threatening condition.[22] Minor injuries are defined as those that are not life-threatening.[22] Data were reported at the regional unit level (there are

51 units in total). Data were extracted on 20 December 2020, and include some preliminary figures that may be adjusted by the source at a later date. In addition, I obtained petrol prices from Eurostat and unemployment rates from the Greek Statistics Authority.

The first COVID-19 case was reported in Greece on 26 February 2020. As a result of increasing infection rates, schools closed on 10 March, followed by closure of bars, cafés and restaurants on 13 March. The first COVID-19 death was reported a few days later, on 12 March, and Greece entered a national lockdown from 23 March to 4 May, which led to reduced mobility, as demonstrated in online supplemental figure A1. The lockdown rules allowed people to leave home only to purchase essential items, commute to work, receive medical attention, exercise, walk a pet, provide support to vulnerable people or, for divorced parents, to meet their children. Measures applied to the entire country, and a few small local areas such as villages or islands experienced tougher restrictions for a short period of time due to spikes in cases. The lockdown ended on 4 May (although remote working was encouraged where possible), and bars, cafés and restaurants reopened 3 weeks later, on 25 May 2020. Greece reopened to tourism on 15 June without any significant restrictions. However, as a response to increasing cases, bars and restaurants were ordered to close at midnight in the Attica region and some islands from 17 August 2020 onwards.

In order to study the association between the pandemic and collisions, I first used graphs to compare trends in crashes in 2020 with trends in the previous 5 years. However, there are additional factors affecting collisions, including unemployment and petrol prices, so multivariate analysis is required. Finding a control group is particularly challenging, given that COVID-19 is a global pandemic. In the absence of the pandemic, one would expect that the trends in MVCs would be the same in 2020 as in previous years, and the difference between crashes in January–February and March–April in 2020 would be similar to the difference between crashes in January–February and March–April in previous years. Therefore, in the empirical model, year 2020 is the 'treatment group' (in which COVID-19 occurred), and the period from March onwards in every year is the 'treatment period' (as that is when the first COVID-19 death occurred in Greece, and when the first lockdown was introduced). A similar approach, using a difference-in-differences econometric model with previous years as a control group, has been followed in previous studies in the absence of a control group involving a different population.[5 23 24]

The difference-in-differences econometric model is presented in Equation 1:

$$MVC_{it} = \beta_0 + \beta_1 year2020 + \beta_2 march\_onwards + \beta_3 year2020 * march\_onwards + \beta_4 unemployment + \beta_5 petrol\_price + \sum_{m=6}^{9} \beta_m month \sum_{k=10}^{60} \beta_k area + \varepsilon_{it}$$

Variable *MVC* represents collision outcomes (number of collisions; deaths; minor injuries; serious injuries); *year2020* is the 'treatment group' dummy that takes the value 1 for 2020 and 0 for previous years; *march_onwards* is the 'treatment period' dummy that takes the value of 1 for calendar months from march onwards in every year, and zero otherwise. The interaction between the treatment group and the treatment period is the main variable of interest. The *unemployment* and *petrol_price* represent the monthly unemployment rate and petrol prices, respectively. The model also includes monthly dummies to capture seasonality. Regional unit fixed effects were used to account for heterogeneity across areas, such as population, driving patterns, police presence, etc. Summary statistics are presented in online supplemental table A1. Finally, as an additional check, I also conducted an interrupted time-series analysis, to study whether there was any change in MVC outcomes after the COVID-19 outbreak. As in the difference-in-differences approach, the treatment period started in March 2020.

## RESULTS

Figure 1 shows the trends in MVCs, deaths and minor and serious injuries in years 2015–2020. It is clear from the graphs that there was a steep decline in all four outcomes during the first lockdown (in March and April 2020), compared with trends in previous years. MVC outcomes also remained below those of previous years after the end of the lockdown, although the difference was much smaller than during the lockdown in spring.

I compared the change between January–February (before the lockdown) and March–April (during the lockdown) 2020 to the corresponding changes in the previous 5 years (table 1). While the average increase in MVCs between January–February and March–April in years 2015–2019 was 19.79%, in 2020 there was a *decrease* by 49.49%. Similarly, deaths in 2020 decreased by 53.13% between January–February and March–April, while in the previous 5 years they had demonstrated a 10% increase. Minor injuries decreased by 53.20% in 2020 compared with a 21% increase in 2015–2019. The corresponding figures for serious injuries were −38.96% and 13.40%, respectively.

Results of the difference-in-differences econometric analysis are presented in table 2. Column 1 provides the results on the total number of collisions. The coefficient of the difference-in-differences interaction term is negative (coefficient=−12.020; 95% CI=−18.246 to −5.795; p<0.01), indicating that there were on average 12 fewer monthly collisions per regional unit compared with what would have been otherwise expected. This translates to 1226 fewer collisions for the entire country in total during lockdown months March and April. Results on deaths are presented in column 2. Again, the coefficient of the difference-in-differences interaction term is negative (coefficient=−0.703; 95% CI=−1.131 to −0.276; p<0.01). There were on average 0.703 fewer monthly deaths per regional unit than we would have otherwise expected, meaning that during March and April there were 72 fewer deaths in total. Column 3 presents the results on serious injuries, which also demonstrated a decrease. The coefficient of the interaction term is −0.407, indicating that there were on average 0.407 fewer monthly serious injuries per regional unit compared with what would have been otherwise expected (coefficient=−0.407; 95% CI=−0.774 to −0.039; p<0.05). Finally, as shown in column 4, there was a drop in minor injuries by 13.981 per month on average per regional unit (coefficient=−13.981; 95% CI=−21.383 to −6.580; p<0.01).

In order to study the impact of the pandemic in general (rather than just the first lockdown period) on MVCs, I extended the study period until August, before the second COVID-19 wave kicked in (online supplemental table A2). Once again, the coefficient of the difference-in-differences interaction term is negative for all four outcomes (collisions: coefficient=−7.294; 95% CI=−10.698 to −3.890; p<0.01; deaths: coefficient=−0.538; 95% CI=−0.874 to −0.203; p<0.01; serious injuries: coefficient=−0.414; 95% CI=−0.752 to −0.077; p<0.05; minor injuries: coefficient=−8.878; 95% CI=−13.123 to −4.633; p<0.01). However, the relative reduction in MVC outcomes over the entire period is on average smaller than when considering only the first 2 months of the pandemic.

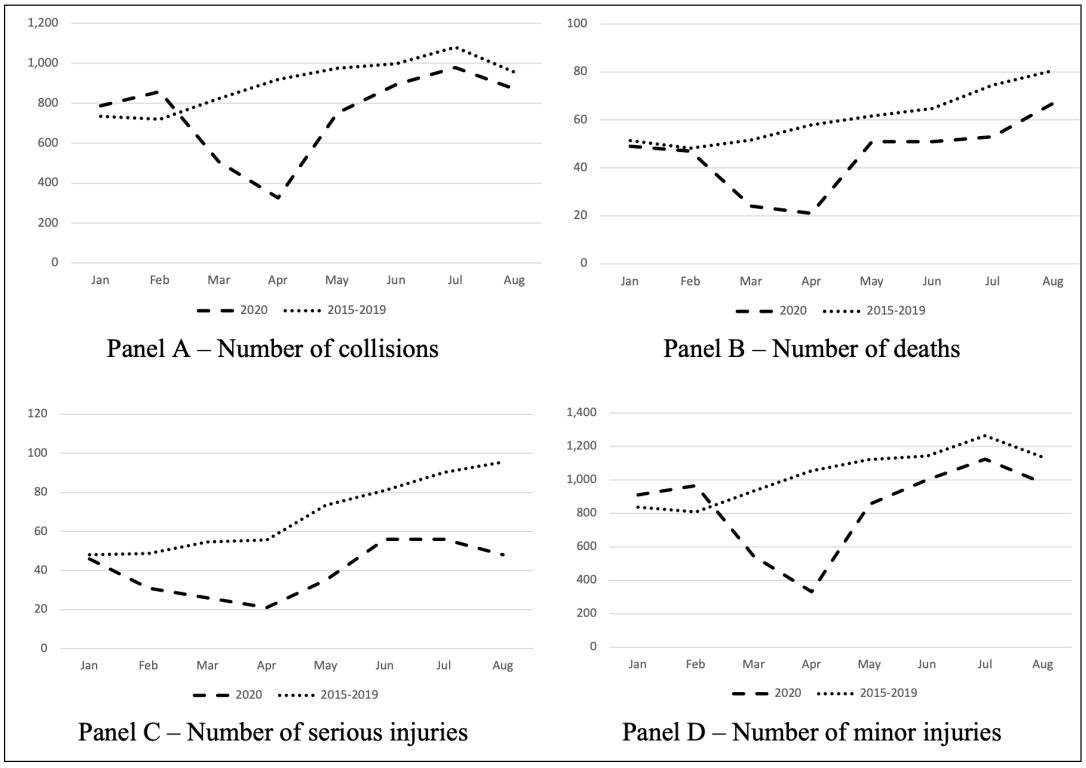


**Figure 1** (A) Monthly collisions, (B) deaths, (C) serious injuries and (D) minor injuries in Greece, 2015–2019 and 2020.

An interrupted time-series analysis was used as an additional check led to the same findings (online supplemental table A3). From March until August 2020, there were 352 fewer monthly collisions in the entire country compared with the pretreatment period (coefficient=−352.376; 95% CI=−416.800 to −287.952), followed by a decrease in the trend by 181 collisions per month (coefficient=−180.796; 95% CI=−181.008 to −180.584). Similarly, there were 29.6 fewer monthly deaths (coefficient=−29.556; 95% CI=−36.552 to −22.560), and a decrease in the trend by 2.971 deaths per month (coefficient=−2.971; 95% CI=−2.993 to −2.949). Such a pattern was also observed in serious injuries, which dropped by 15.8 in the first month of the lockdown (coefficient=−15.801; 95% CI= −24.754 to −6.848), followed by a change in the trend by −4.9 serious monthly injuries (coefficient=−4.916; 95% CI=−4.948 to −4.884). The same holds for minor injuries, which demonstrated a decrease by 426 in the first month of the lockdown (coefficient=−426.849; 95% CI=−504.818 to −348.880), followed by a change in the trend by −213 monthly minor injuries (coefficient=−212.044; 95% CI=−213.044 to −212.523).

**Table 1** Changes in collisions, deaths and injuries per regional unit before and after the first lockdown in Greece in 2020 and the corresponding months in the previous 5 years

| | Jan–Feb | Mar–Apr | % difference |
|---|---|---|---|
| | Collisions | | |
| 2020 | 1646 | 833 | −49.39 |
| 2015–2019 | 1455 | 1743 | 19.79 |
| | Deaths | | |
| 2020 | 96 | 45 | −53.13 |
| 2015–2019 | 100 | 110 | 10.00 |
| | Minor injuries | | |
| 2020 | 1874 | 877 | −53.20 |
| 2015–2019 | 1643 | 1988 | 21.00 |
| | Serious injuries | | |
| 2020 | 77 | 47 | −38.96 |
| 2015–2019 | 97 | 110 | 13.40 |

Data per regional unit (51 units in total).

## DISCUSSION

This study examined the impact of COVID-19 on MVCs in Greece during the first wave of the pandemic. I found that during March and April 2020, there were about 1226 fewer collisions (62% reduction), 72 fewer deaths (68% reduction), 40 fewer serious injuries (48%) and 1426 fewer minor injuries (63%) compared with what would have been expected in the absence of the pandemic. Extending the study period until August suggests that during the entire study period there was a total reduction by 2232 collisions, 165 deaths, 127 serious injuries and 2716 minor injuries.

There are a number of reasons behind this decrease in MVCs that are related to factors that affect traffic volume. Lockdowns, school closures and suspension of other activities inevitably meant that fewer vehicles were on the streets, and thus at risk of collision. Similarly, increased unemployment and remote working further contributed to this reduction in traffic volume. Fear of catching COVID-19 was another reason that kept people from commuting, regardless of government restrictions.[6] Apparently, the reduced risk as a result of fewer cars outweighed the increased risk as a result of the opportunity to speed on less congested streets, that was observed in other countries.[20 21] It also seems to have cancelled out factors that negatively affect driving behaviour and are associated with MVCs, such as distraction due to the COVID-19 pandemic and possible health problems of loved ones[12]; uncertainty about the financial situation[10 11];

**Table 2** Difference-in-differences regression results, months January–April

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | **Collisions** | **Deaths** | **Serious injuries** | **Minor injuries** |
| Difference-in-differences interaction term | −12.020*** | −0.703*** | −0.407** | −13.981*** |
| | (−18.246 to −5.795) | (−1.131 to −0.276) | (−0.774 to −0.039) | (−21.383 to −6.580) |
| Treatment period dummy (March–April) | 3.706*** | 0.189* | 0.194* | 4.255*** |
| | (1.592 to 5.819) | (−0.002 to 0.379) | (−0.001 to 0.388) | (1.793 to 6.717) |
| Treatment group dummy (2020) | 2.712** | 0.216 | 0.287** | 3.214** |
| | (0.340 to 5.085) | (−0.055 to 0.488) | (0.046 to 0.528) | (0.039 to 6.389) |
| Unemployment rate | 0.018 | 0.032** | 0.081*** | 0.014 |
| | (−0.168 to 0.204) | (0.004 to 0.059) | (0.044 to 0.118) | (−0.214 to 0.241) |
| Petrol prices per litre | −5.043 | −0.393 | −0.171 | −3.308 |
| | (−15.923 to 5.837) | (−1.315 to 0.528) | (−1.202 to 0.861) | (−15.720 to 9.104) |
| Constant term | 11.395 | 0.203 | −1.184 | 9.940 |
| | (−7.059 to 29.849) | (−1.600 to 2.006) | (−3.386 to 1.018) | (−11.293 to 31.173) |
| Observations | 1224 | 1224 | 1224 | 1224 |
| R-squared | 0.965 | 0.780 | 0.796 | 0.961 |
| F-statistic | 71.40 | 13.13 | 14.32 | 62.33 |

Month dummies and regional unit fixed effects are included in the regressions. Robust CIs in brackets.
***P<0.01, **p<0.05, *p<0.1.

increased alcohol consumption during the pandemic[15]; and deterioration of sleep quality and change in circadian rhythms.[13 14] In any case, the multivariate nature of the relationship between COVID-19 and MVC makes disentangling the effects of individual factors challenging.

The findings of this paper are in line with previous studies that found a reduction in MVCs in various US states,[18 19] Northern Ireland[21] and the Tarragona province in Spain,[16] and fewer deaths in Peru.[17] However, results differ from other settings, where despite an overall decrease in MVCs, there was no change in deaths in Northern Ireland,[21] and an increase in deaths in the USA.[20] Reasons behind differences in the impact of the pandemic on MVC deaths may relate to a number of factors. Importantly, results of this study are particular to the first wave of the pandemic in Greece, which was relatively mild in terms of cases and deaths. By the time the lockdown was lifted on 4 May 2020, there were a total of 2626 confirmed cases and 144 COVID-19-related deaths—or 251.94 cases and 13.82 deaths per million people.[25] This was relatively low compared with 2272.52 confirmed cases and 242.42 deaths per million people in the European Union.[25] The corresponding figures by the end of the study period on 31 August 2020 were 989.83 cases and 25.52 deaths per million people in Greece; and 4330.28 cases and 314.79 deaths per million people in the European Union.[25] This may explain part of the differences in MVCs across countries, and results are thus not necessarily generalisable to other countries or the second wave in Greece, which was much more severe than the first wave.

Generalising across settings would be challenging anyway. Changes in mobility depend on restrictions and fear of catching the virus[6] —which may relate to the number of cases and deaths. Restrictions are also a result of increased cases, and of course government responses and measures varied across countries. Therefore, disentangling the relationship between COVID-19 cases, restrictions and mobility—thus affecting MVCs—is particularly challenging. This is likely to contribute to different patterns in the impact of the pandemic on MVC deaths. Changes in other factors relating to MVCs that were affected by the pandemic may have also varied across settings, depending on the severity of the COVID-19 wave and the financial implications. These may include sleep patterns,[13 14] financial worries[10 11] and alcohol consumption.[15] Differences in road traffic enforcement across countries may also play a role, thus affecting MVCs on empty streets.[21] Any relative changes may also depend on how congested streets were in the pre-pandemic period.

The findings of this study relate to the discussion on excess mortality and other spillover effects[5] and provide evidence on yet another health outcome that was affected by the pandemic. Future research can study the long-term impact of COVID-19 on MVCs, as remote working patterns are likely to persist to some extent, thus reducing traffic volume. In addition, it is likely to have a lasting effect on the economy, which is known to affect MVCs,[9–11] so the indirect effects of the pandemic on this health outcome may persist. Future research can also provide a comparative approach between different regions or countries to study how MVCs were affected depending on the severity of the pandemic and lockdown measures.

## What is already known on the subject

- COVID-19 has had spillover effects on other health outcomes.
- The pandemic and lockdowns have affected MVC risk factors, including traffic volume, distraction, unemployment, economic uncertainty, drinking and patterns of sleep.

## What this study adds

- There has been a relative decrease in MVCs, injuries and deaths during the COVID-19 pandemic in Greece.
- During the first lockdown in March and April 2020, there was a steep reduction in collisions, deaths, serious injuries and minor injuries compared with what would have been expected in the absence of the pandemic.
- Such a reduction in MVC outcomes persisted even after the first lockdown ended.

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