Title: The Effect of Driver's License Renewal Extensions on Fatal Crashes among Senior Drivers: Evidence from Maryland Across Urban and Rural Areas

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Summary Box

1. What is already known on this topic?

Stricter requirements for older drivers renewing their driver’s licenses do not guarantee lower fatal crash rates. Potential disparities may exist between rural and urban areas due to differing driving patterns.

2. What is added by this report?

This report utilized a regression model known as the synthetic difference-in-differences method to assess the causal effect of Maryland's senior driver’s license renewal cycle change and regional disparities in treatment effects.

3. What are the implications for public health practice?

Extending the renewal period for older drivers could increase social costs, especially in urban areas. A more effective strategy to lower expenses related to driver’s license administration may be to implement public transit in these locations.

Abstract

Introduction:

The proportion of senior licensed drivers in the United States has steadily increased. As older drivers age, their bodies undergo numerous changes, which can impact their driving safety. Additionally, the driving environment is different between rural and urban areas. We aim to examine the effects of Maryland's renewal period extension on fatal crashes to senior drivers. We also measure heterogeneous treatment effects between urban and rural counties.

Method:

Data for fatal crashes was from the Fatality Analysis Reporting System, and driver's license renewal cycle extensions were manually collected. We estimated county-level changes in fatal crash data due to the policy change from 2012 to 2019 by quarter using the Synthetic difference-in-differences method.

Result:

The number of fatal crashes, vehicles and people involved in the crashes, and the number of fatalities due to accidents involving at least one driver aged 65 and above increased in urban Maryland counties. This led to the treatment effects being positively estimated for the entire Maryland sample. Some of the estimates were statistically significant at the 5% level, while some were statistically significant at the 10% level. Additionally, urban counties appear to have experienced higher growth in crashes than their rural counterparts. Finally, most of the estimation results for younger drivers were statistically insignificant.

Conclusion:

Our study found evidence of a relationship between Maryland's extension of the renewal period and fatal crashes among senior drivers. Urban areas were more affected than rural areas.

1. Introduction

The U.S. Census Bureau projects the number of adults aged 65 and older in the U.S. to rise significantly by 2060 (1), leading to an increase in the number of elderly drivers. The percentage of licensed senior drivers grew from 14.4% in 2001 to 21.3% in 2021 (2). This trend raises concerns about the safety of older drivers, who are often involved in hazardous driving situations due to age-related physical and cognitive decline (3–7). To address these issues, enhancing the transition to non-driving statuses and ensuring access to safe mobility alternatives is critical, and comprehensive policies for seniors are essential. 24 states have implemented varying license renewal cycles for older drivers. For instance, Arizona mandates a 5-year renewal for those aged 60 and over, while Florida requires drivers aged 80 and above to renew every 6 years, contrasting with more extended renewal periods for younger drivers (8). On the contrary, in 2012, the State of Maryland extended the driver's license renewal period from 5 years to 8 years for all drivers.

Association between the number of fatal crashes involving drivers aged 55 and older and stricter requirements for "older" drivers to renew driver's licenses can exist (9). Moreover, it is crucial to see the regional differences since rural drivers have different driving patterns or dangerous driving behaviors, such as having more mileage than urban or suburban drivers or failing to stop at stop signs (10–13). This paper analyzes the interaction of those patterns and policy change.

The primary goal of this paper is to examine the causal effects of Maryland's renewal period extension on fatal crashes using a regression method known as the synthetic difference-in-differences method. The second objective is to check if there is a regional difference between urban and rural counties.

2. Method

Fatal crashes

We conducted this research using data from the Fatality Analysis Reporting System (FARS) on fatal crashes. FARS is a comprehensive nationwide database that annually compiles and reports data on fatal injuries from motor vehicle traffic crashes, serving as a key resource for the National Highway Traffic Safety Administration (NHTSA), Congress, and the public (14). The database collects a wide range of data for each fatal crash, including the time and location of the incident, vehicle information, and unidentifiable details about the people involved.

We filtered accidents involving drivers aged 65 and over, as well as accidents involving only drivers under 65, from 2012 to 2019 in Maryland and six surrounding control states: Massachusetts, Maine, New Hampshire, New York, Virginia, and West Virginia. The number of vehicles, people, and fatalities involved in the two age categories of crashes is aggregated at the year-quarter and county levels. During the study period, 260,516 fatal crashes occurred in the United States, 3,771 in Maryland, and 20,658 in the six control states. Due to the crashes, 405,206 vehicles were involved in the United States, 6,067 in Maryland, and 30,787 in the control states, while 588,771 people were affected in the U.S., 8420 in Maryland, and 42,294 in the control states. The crashes resulted in 283372 fatalities in the U.S., 4,065 in Maryland, and 22,081 in the control States. In the sample, fatal crashes involving at least one driver aged 65 and above take an indelible portion. In Maryland, 821 crashes happened (821/3,771 ≈ 21.78%) involving 1,483 vehicles (1,483/6,067 ≈ 24.44%) and 2,090 people (2,090/8,420≈ 24.82%), resulting in 885 fatalities (885 /4,065 ≈ 21.77%).

Driver license regulations and laws

We gathered information on motor vehicle legislation and its enactment dates from multiple sources, with a focus on states on the East Coast of the United States. We started with law compilations provided by the Insurance Institute for Highway Safety (8). We then consulted online legislation databases (15,16) to determine if any changes to driver's license renewal periods had occurred in each state from 2012 to 2019. We identified a change that took effect on October 1, 2012, in Maryland, which extended the renewal cycle of driver's licenses from 5 years to 8 years for all drivers. The other six states were selected as control states because they experienced no significant changes from 2012 to 2019 for both drivers aged 65 and above, and drivers under 65. The extension of the renewal period in Maryland had a "real" effect beginning on October 1, 2017, because drivers could have driven their cars without renewing their licenses in the first five years, regardless of the policy change. Therefore, we set the treatment to happen in the fourth quarter of 2017.

Control variables and data sources

Using FARS data, we analyzed the month of the accident to determine which quarter it fell into. Then, we collected annual average temperature and precipitation data from 2012 to 2019 at the county level from the NOAA National Climatic Data (17). We also gathered data on the percentage of overweight or obese individuals of all ages from 2012 to 2019 at the county level, sourced from the Rural Health Information Hub (18). Additionally, we utilized the American Community Survey (ACS) to obtain information on population density, the proportion of individuals aged 65 and older with a bachelor's degree or higher, and the percentage of individuals aged 65 and above with Medicare coverage from 2012 to 2019 at the county level

(19). Finally, The National Center for Health Statistics (NCHS) Urban-Rural Classification Scheme for Counties is used to categorize counties (20).

Statistical analysis

This study aggregated all data by county-year-quarter level. Although we could obtain the exact location of accidents, control variables are available at the county level. We conducted this research at the year-quarter level, not the year level, because we wanted to control seasonal aspects that could affect road conditions and drivers' behaviors.

We employed the synthetic difference-in-differences method (SDID) to examine the effect of Maryland's extension of the renewal period on fatal crashes. SDID constructs "synthetic" Maryland as a weighted average of control states and compares it with the "real" Maryland. The weights are constructed by first regressing pre-treatment outcome variables on control variables to obtain residuals. Then, the weights are set so that the pre-treatment movement of the residuals of the outcome variables for the "real" Maryland and the "synthetic" Maryland resembles each other. In addition, we compared urban counties in Maryland with urban counties in the control states, as well as rural counties in both the treated and control states, to measure heterogeneous treatment effects. We implemented SDID for the following reasons. SDID has a few advantages over other methods when there are few treated units. First, SDID could control unobserved characteristics of Maryland by matching the residuals of the pre-treatment outcomes. Second, assumptions related to parallel trends are not required, unlike traditional Difference-in-Differences methods. Although we are comparing neighboring states, their fatal accident trends may differ. Lastly, SDID can obtain consistent estimates of treatment effects when the pre-treatment trends of Maryland and synthetic Maryland do not closely resemble each other but differ by a constant amount (21).

All data cleaning is conducted with Python 3.11 (The Python Software Foundation), and Stata 18.0 (StataCorp LLC.) is used for the SDID. A two-sided P value of ≤ 0.05 was denoted as significant.

Michigan State University (MSU) Institutional Review Board (IRB) approval is unnecessary as this secondary analysis used publicly available datasets and does not involve human subjects. (Study ID: STUDY00012157)

3. Results

Table 1 provides information on the number of fatal crashes that occurred during the pre-treatment period, from the first quarter of 2012 to the third quarter of 2017 (23 quarters), in 24 counties in Maryland and 247 counties in the control states. It compares fatal crashes involving at least one driver aged 65 and above with accidents involving only drivers under 65 to determine if any unobserved changes affected drivers of all ages during the study period. The table also disaggregates the data by urban and rural counties to check if there is any distinction between different driving environments.

During the study period, the average number of fatal crashes in Maryland counties involving at least one driver aged 65 or older was 1.020 per quarter. These crashes involved 1.842 vehicles and 2.603 people and resulted in 1.103 fatalities. Meanwhile, in counties in the control states, there were 0.619 crashes per quarter. 1.023 vehicles and 1.403 people were in the crashes, and 0.666 people died due to the crashes. In urban counties of Maryland, there were 1.307 crashes involving at least one driver aged 65 and over. 2.371 vehicles and 3.317 people were affected, resulting in 1.417 fatalities per quarter. The urban county counterparts in the control states experienced 0.933 fatal crashes with 1.532 vehicles and 2.081 people involved. These ended in 0.995 fatalities. During the same period, rural Maryland counties experienced an average of 0.323 crashes involving drivers aged 65 and above per quarter. These crashes involved 0.559 vehicles and affected 0.870 people, resulting in 0.342 fatalities. In rural counties of the control states, there were 0.241 crashes involving 0.410 vehicles and 0.586 people, resulting in 0.269 fatalities.

The same numbers are calculated for fatal crashes that only involved drivers under 65 for comparison. Across all Maryland counties, an average of 2.893 crashes occurred per quarter, involving 4.496 vehicles and affecting 6.161 people, resulting in 3.114 deaths. For the entire control counties, there were 1.195 crashes involving 1.721 vehicles and 2.375 people, resulting in 1.272 fatalities. In urban Maryland counties, 3.895 crashes occurred, involving 6.090 vehicles and 8.274 people, and resulted in 4.197 fatalities. The urban control counties experienced 1.895 crashes involving 2.753 vehicles and 3.738 people, with a consequence of 2.018 deaths. In rural Maryland counties, 0.460 crashes involving only drivers under 65 occurred, with 0.627 vehicles and 1.031 people involved, resulting in 0.484 fatalities. The rural control counties had 0.351 crashes, with 0.477 vehicles and 0.731 people affected, and resulted in 0.373 fatalities.

The SDID regression at the county and year-quarter levels indicates that the reform had a significant impact on drivers aged 65 and over. The number of fatal crashes involving at least one driver aged 65 and over increased in Maryland counties by 0.222 (SD: 0.086). This led to 0.326 (SD: 0.168) more vehicles and 0.431 (SD: 0.255) more people involved, resulting in 0.200 (SD: 0.097) more deaths. The estimates for the number of crashes and fatalities are statistically significant, while those for the number of vehicles and people involved are weakly significant at the 10% level. Urban Maryland counties experienced 0.304 (SD: 0.148) more crashes with 0.554

(SD: 0.282) more vehicles and 0.813 (SD: 0.471) more people affected, resulting in 0.283 (SD: 0.159) more casualties. The estimates for the number of crashes and vehicles involved are statistically significant, while those for the number of people and fatalities are weakly significant at the 10% level. On the other hand, rural Maryland counties experienced -0.047(SD: 0.091) more crashes, with -0.167 (SD: 0.182) more vehicles and -0.248 (SD: 0.249) more people involved, ultimately -0.067 (SD: 0.105) more fatalities. However, these estimates are statistically insignificant.

The Synthetic Difference-in-Differences method estimates for fatal crashes involving only drivers under 65 yield slightly different results. The number of fatal crashes that occurred in the entire Maryland counties increased by 0.053 (SD: 0.139), involving 0.162 (SD: 0.226) more vehicles and 0.538 (SD: 0.277) more people, resulting in 0.061 (SD: 0.154) more deaths. The estimate for the number of people involved is weakly statistically significant at the 10% level, while other estimates are not statistically significant. Urban Maryland counties experienced 0.188 (SD: 0.232) more crashes involving only drivers under 65, affecting 0.400 (SD: 0.372) more vehicles and 0.835 (SD: 0.426) more people, resulting in 0.183 (SD: 0.257) more deaths. The estimate for the number of people involved is statistically significant, while other estimates are statistically insignificant. Rural Maryland counties experienced -0.030 (SD: 0.157) more crashes after the renewal cycle extension, affecting 0.133 (SD: 0.220) more vehicles and -0.179 (SD: 0.292) more people, resulting in -0.047 (SD: 0.177) more fatalities. All estimates are statistically insignificant.

4. Discussion

This study examined the relationship between the effects of Maryland's renewal period extension and fatal crashes involving senior drivers, as well as differences between rural and urban areas. The results showed a significant association between Maryland's extension of the renewal period and fatal crashes involving senior drivers. The SDID estimates indicate that there were 21.76%(≈ 0.222/1.020) more crashes, 17.70%(≈ 0.326/1.842) more vehicles, and 16.56%(≈ 0.431/2.603) more people involved, resulting in 18.13%(≈ 0.200/1.103) more fatalities compared to the pre-treatment county-year-quarter average number of fatal crashes involving at least one driver aged 65 and above. Crashes led these changes occurred in the urban Maryland counties. There were 23.26%(≈ 0.304/1.307) more crashes, 23.37%(≈ 0.554/2.371) more vehicles, and 39.07%(≈ 0.813/2.081) more people involved, resulting in 28.44%(≈ 0.283/0.995) more fatalities. The urban counties experienced relatively more vehicles and people involved in the crashes and more fatalities than the entire counties. This could be due to urban roads typically being more densely populated, resulting in higher volumes of vehicles and pedestrians compared to rural roads.

This finding is inconsistent with several previous studies on the effects of accelerated renewal cycles (9,22,23). One study compared states that accelerated the renewal cycle to those that did not implement the policy, using population-averaged negative binomial regression, and found no decrease in rates associated with the policy (9). Another study examined older driver fatality rates with and without accelerated renewal cycles using multivariate regression and an alternative specification by comparing older drivers with those aged 25 to 64 years; however, the relative risk did not decrease, even though the renewal period was longer (22). The other research analyzed whether there were heterogeneous effects between two driver groups in Illinois: the 75-80-year-old driver group and the 81-year-old or older group. However, no significant difference was found between the two groups after implementing the accelerated renewal period policy (23).

One potential explanation for this discrepancy is that another change in the driving environment in Maryland may have occurred. We assumed that younger drivers' capability to drive safely does not decline with age so that their accident rate is not affected by the extension of the renewal cycle. The statistically insignificant SDID estimates of the treatment effects related to fatal crashes only involving drivers under 65 partly confirm the validity of this assumption. However, the confidence intervals of the estimated treatment effects for crashes involving older drivers and crashes involving only younger drivers overlap significantly, as shown in Figure 1. This makes it difficult to reject the original hypothesis that another change affected both older drivers and younger drivers in Maryland.

Another explanation is that estimates from previous studies may be biased. Comparing fatal crashes with driver’s license renewal policies across states only measures the correlation between the two factors; it does not examine the impact of introducing or changing a policy. Additionally, comparing states over time does not ensure consistent results. States are not alike enough, so such comparisons could be like comparing apples to oranges.

We also found significant differences between rural and urban areas in the effects of renewal period extension. Following the extension, older drivers in urban Maryland counties experienced a higher incidence of fatal accidents, whereas their rural counterparts did not. As shown in Figure 2, confidence intervals of estimates for crashes that occurred in urban and rural counties do not overlap much. This indicates the treatment effects are statistically different from one another.

One potential reason for this difference is that older drivers are exposed to more complex urban environments, and the probability of accidents increases due to a higher cognitive burden. When driving on urban roads, a driver will encounter numerous intersections and left turns, often with multiple vehicles and pedestrians. These driving environments pose a significant hazard to older drivers. It is reported that older drivers were less effective at identifying blind spots or merging with traffic (24). Another study evaluated which errors are most prevalent among older drivers. Approximately 66% of errors in inadequate surveillance and 77% of errors in gap or speed misjudgment among older drivers occurred when making left turns at intersections (25). The other study revealed errors at yielding or stop signs, as well as right or left turns, among older drivers, and it explained that senior drivers are more likely to have difficulties controlling multiple tasks within a limited time (26). Urban areas require multiple driving tasks to be completed within a short period. Older drivers with vision impairment or mild cognitive impairment tend to make more errors in complex situations compared to older drivers (3,27).

Strengths and limitations

This work contributes to two strands of literature. First, this paper aims to identify the causal effect of the policy using the synthetic difference-in-differences method (SDID). A set of research tried to measure the effects of driver’s license renewal restrictions. Requiring in-person renewal for older drivers, renewal testing, medical reporting, or accelerated renewal cycles are the policies with empirical support (28). The previous papers either focused more on longitudinal comparison between states, or on age groups older than 65 years old (9,22,23).

The second strand of literature examines how rural and urban areas respond differently to renewal period policies for older drivers. To our understanding, this paper is the first to examine rural-urban differences after the implementation of policies or regulations related to elderly drivers.

Our study had several limitations. First, we were not able to include enough control variables. For example, emergency medical service (EMS) accessibility would significantly impact the number of fatal crashes, as it could potentially turn a potentially fatal accident into an ordinary one (29). However, we were unable to obtain the location of the EMS facilities. We attempted to substitute it with the time it takes for an EMS team to respond to the accident, which can be found in FARS. Unfortunately, we cannot use this information because the arrival time at hospitals is not available for many fatal crash records.

Second, we did not conduct a subgroup analysis by age among older drivers. One study reported that per mile traveled, the likelihood of being involved in a fatal crash for male drivers starts to increase among drivers aged 65–69, with the highest rate observed in the 85 and older age group (30). If we divide the outcome into subgroups and analyze the results, the effects of the renewal license period can vary across different age groups.

The third limitation is that our data has sparse information on crashes that occurred in rural areas. The number of rural accidents is lower than that of urban counterparts. The statistical insignificance of rural estimates may be due to this fact.

5. Conclusion

Our study found evidence of a relationship between the extension of the renewal period and fatal crashes among senior drivers. Urban areas were more affected than rural areas. Policymakers should recognize that rural and urban drivers may respond differently to license renewal policies, necessitating tailored interventions to support their continued mobility while ensuring road safety.

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Table 1 Characteristics of Outcome Variables between 2012Q1-2017Q3 by Counties

	Involving a Driver 65+		*Only Drivers 65-*	
All Counties	Maryland Counties	Control Counties	Maryland Counties	Control Counties
Crashes	1.020	0.619	2.893	1.195
	(1.366)	(1.341)	(4.474)	(2.870)
Vehicles	1.842	1.023	4.496	1.721
	(2.712)	(2.344)	(7.185)	(4.318)
Persons	2.603	1.403	6.161	2.375
	(4.096)	(3.281)	(9.744)	(6.004)
Fatalities	1.103	0.666	3.114	1.272
	(1.510)	(1.453)	(4.869)	(3.065)
Observations	552	5681	552	5681
Urban Counties				
Crashes	1.307	0.933	3.895	1.895
	(1.488)	(1.681)	(4.952)	(3.657)
Vehicles	2.371	1.532	6.090	2.753
	(2.986)	(2.932)	(7.972)	(5.525)
Persons	3.317	2.081	8.274	3.738
	(4.511)	(4.073)	(10.81)	(7.590)

Fatalities	1.417	0.995	4.197	2.018
	(1.649)	(1.811)	(5.395)	(3.902)
Observations	391	3105	391	3105
Rural Counties				
Crashes	0.323	0.241	0.460	0.351
	(0.587)	(0.544)	(0.866)	(0.865)
Vehicles	0.559	0.410	0.627	0.477
	(1.123)	(1.032)	(1.259)	(1.225)
Persons	0.870	0.586	1.031	0.731
	(1.975)	(1.588)	(2.223)	(2.264)
Fatalities	0.342	0.269	0.484	0.373
	(0.633)	(0.644)	(0.936)	(0.947)
Observations	161	2576	161	2576

Values are Mean (Standard deviation).

Observations = Number of counties * Number of quarters

Table 2 Synthetic Difference-in-Differences Results for Four Outcome variables, by Age of Drivers Involved, by Place of Incidents

	Involving a Driver 65+			Only Drivers 65-		
	All	Urban	Rural	All	Urban	Rural
Crashes						
	0.222*** (0.086)	0.304** (0.148)	-0.047 (0.091)	0.053 (0.139)	0.188 (0.232)	-0.030 (0.157)
Vehicles						
	0.326* (0.168)	0.554** (0.282)	-0.167 (0.182)	0.162 (0.226)	0.400 (0.372)	0.133 (0.220)
Persons						
	0.431* (0.255)	0.813* (0.471)	-0.248 (0.249)	0.538* (0.277)	0.835** (0.426)	-0.179 (0.292)
Fatalities						
	0.200** (0.097)	0.283* (0.159)	-0.067 (0.105)	0.061 (0.154)	0.183 (0.257)	-0.047 (0.177)
Observations	8672	4864	3808	8672	4864	3808

Values are Mean (Standard deviation).

Observations = Number of counties * Number of quarters

* p<0.10, ** p<0.05, *** p<0.01

Figure 1. Synthetic difference-in-differences estimates by driver age.

Note: The figure discusses treatment effects using the synthetic difference-in-differences method, comparing driver age groups involved in fatal accidents across counties. It concludes that the confidence intervals for the two age groups largely overlap, indicating no statistically significant difference.

Alternative Text: The figure discusses treatment effects using the synthetic difference-in-differences method, comparing driver age groups involved in fatal accidents across counties. It concludes that the confidence intervals for the two age groups largely overlap, indicating no statistically significant difference.

Figure 2. Synthetic difference-in-differences estimates by place of incidents.

Note: The figure discusses treatment effect estimates and confidence intervals for rural and urban counties regarding accidents involving drivers aged 65 and above using the synthetic difference-in-differences method. It shows that urban counties witnessed a larger increase in fatal crashes than rural counties.

Alternative Text: The figure discusses treatment effect estimates and confidence intervals for rural and urban counties regarding accidents involving drivers aged 65 and above using the synthetic difference-in-differences method. It shows that urban counties witnessed a larger increase in fatal crashes than rural counties.