Factors Associated With Unrestrained Young Passengers in Motor Vehicle Crashes

Douglas R. Roehler, PhD, MPH,[a] Michael R. Elliott, PhD,[b] Kyran P. Quinlan, MD, MPH,[a] Mark R. Zonfrillo, MD, MSCE[c]

abstract

BACKGROUND AND OBJECTIVE: Unrestrained child passengers are at significant risk of crash-related injury. Previous researchers using nationally representative crash data from 1992 to 1993 found an association between driver and passenger safety-belt use. Our objective in this study is to investigate factors associated with young, unrestrained passengers in fatal and nonfatal motor vehicle crashes using updated national crash data.

METHODS: We analyzed 2011–2015 Fatality Analysis Reporting System and National Automotive Sampling System data and included vehicles with a young passenger (≤19 years old) in a crash. Driver and passenger characteristics were compared by using bivariate analyses separately for fatal and nonfatal crashes. Logistic regression analyses were performed on a combined data set to predict passenger restraint use.

RESULTS: In unadjusted bivariate models, unrestrained drivers had a higher probability of having an unrestrained passenger across all passenger age groups for both fatal and nonfatal crashes. In multivariate logistic regression models that included both fatal and nonfatal crashes and were adjusted for several driver and passenger characteristics, unrestrained drivers had a higher risk of having an unrestrained young passenger across all age groups.

CONCLUSIONS: In both fatal and nonfatal crashes, a driver being unrestrained is a strong predictor of the child passenger also being unrestrained. Policy and regulation to better ensure that drivers are properly restrained (eg, expanding primary seat-belt laws to all states) may serve as effective means for increasing rates of proper child-occupant–restraint use.

[a]*Department of Pediatrics, Rush University Medical Center, Chicago, Illinois;* [b]*Department of Biostatistics, School of Public Health and Institute for Social Research, University of Michigan, Ann Arbor, Michigan; and* [c]*Department of Emergency Medicine and Injury Prevention Center, Warren Alpert Medical School, Brown University and Hasbro Children's Hospital, Providence, Rhode Island*

Dr Roehler conceptualized and designed the study, collected the data, conducted all analyses, contributed to the interpretation of the data analysis, drafted the initial manuscript, and reviewed and revised the manuscript; Dr Elliott conceptualized and designed the study, supervised data analyses, was substantially involved in the interpretation of the data analysis, and critically reviewed the manuscript for important intellectual content; Drs Quinlan and Zonfrillo conceptualized and designed the study, contributed to the interpretation of the data analysis, and critically reviewed the manuscript for important intellectual content; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Address correspondence to Douglas R. Roehler, PhD, MPH, Department of Pediatrics, Rush University Medical Center, 1645 W. Jackson Blvd, Suite 450, Chicago, IL 60612. E-mail: doug.roehler@gmail.com

WHAT'S KNOWN ON THIS SUBJECT: Motor vehicle crashes are the leading cause of death for young persons. Researchers have found that proper restraint use can reduce risk of injury significantly in the event of a crash. However, many youth are still found unrestrained.

WHAT THIS STUDY ADDS: National motor vehicle crash data (2011–2015) confirm a strong association between driver and passenger restraint use. These findings further support the notion that to best prevent unrestrained youth, policies that target unrestrained drivers are needed (eg, primary seat-belt legislation).

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Since 1999, motor vehicle crash (MVC) deaths among children and youth <21 years old have been cut nearly in half.[1] However, for the past several years, progress has plateaued.[1] One way to make meaningful progress is to investigate modifiable crash characteristics. In 2015, 39% of children who died in MVCs were unrestrained.[2] Although survey data reveal an association between a driver's attitude and passenger decision-making, little research exists in which this relationship is measured by using nationally representative crash data.[3,4] Researchers typically collect data on occupant restraint use through observational studies, which provide a unique perspective of vehicles in a naturalistic setting. However, accurately collecting these data are difficult because of subjectivity regarding occupant characteristics.[5] An analysis of crash data can be used as an alternative method for identifying associations between restraint use and crash-related injury and other crash-related factors (eg, impairment and in-vehicle characteristics). Furthermore, crash data–based studies can inform researchers and policy makers about not just who is on the road but how young passengers are at risk in crashes. To the best of our knowledge, researchers in just 1 peer-reviewed study examined the association between driver and passenger restraint use through nationally representative crash data, yet those data were from 1992 to 1993 and therefore need to be updated.[6] In that study, Miller et al[6] used the National Highway Traffic Safety Administration General Estimates System for nonfatal data and Fatality Analysis Reporting System (FARS) data for fatal crashes and found that child-passenger restraint use typically mirrored driver restraint. These data are >2 decades old, and the traffic safety culture in the United States has changed significantly in the interim.

Using state-level data from Nebraska, Han[7] found that driver seat belt use was a strong predictor of passenger seat belt use, especially for passengers <30 years of age. Moreover, compared with drivers >60 years old, drivers <30 years old were more likely to have unrestrained passengers.

With little progress being made in reducing MVC deaths among young persons over the past 7 years, it is important to revisit this association between driver and passenger because the vehicle environment has changed greatly over the past 2 decades. Our objective in this study is to provide an updated national examination of the drivers' factors related to their young passengers being unrestrained in crashes.

METHODS

Data Sources

To account for both fatal and nonfatal crashes, we combined the US Department of Transportation FARS and the National Automotive Sampling System (NASS) Crashworthiness Data System (CDS).

The FARS is a census of all crashes in the United States that involve a fatality within 30 days of the crash that occur on a public road.[8] For a case to be included in the FARS, the death must be attributed to the crash. All of the cases in our sample from the FARS involved child passengers in the same vehicle in which the fatality occurred. Because the FARS is a census of all fatal crashes in the United States, no complex sampling methods were necessary. Between 2011 and 2015, we included 1442 0- to 8-year-old passengers (32.2% died), 2120 9- to 15-year-old passengers (33.8% died), and 3899 16- to 19-year-old passengers (39.7% died).

A national probability sample of young passengers (≤20 years old) involved in nonfatal crashes was obtained from the NASS CDS from 2011 to 2015.[9] The NASS CDS includes a cross-section of crashes without regard to injury severity but relatively few fatal crashes. This data source includes a 3-stage probability sampling method from all police-reported crashes that include the use of at least 1 tow-away vehicle because of damage. Because not all vehicles involved in a crash are nondrivable, we restricted our analysis to vehicles that had to be towed away. Because of potential double counting once we combined the NASS CDS and FARS data sets, we excluded vehicles with a child fatality from the NASS CDS data set. Within the NASS CDS database, we identified 16 839 0- to 8-year-old passengers, 14 987 9- to 15-year-old passengers, and 36 312 16- to 19-year-old passengers (weighted national estimates) in a passenger car, van, pickup truck, or sports-utility vehicle involved in a nonfatal crash.

Variable Definitions

Our main variable of interest is police-reported restraint use for both the passenger and driver. For both the FARS and NASS, child restraint use is recorded as the use of a child-restraint seat (ie, forward-facing child safety seat, rear-facing child safety seat, or booster seat), the use of a seat belt, or being unrestrained. Additional variables of interest include police-reported injury severity, the age and sex of the driver (<20 vs ≥20 years old), police-reported alcohol use by the driver, the type of passenger vehicle (ie, passenger car, large van, pickup truck, sports-utility vehicle, or minivan), and the age and sex of the passenger. The injury severity items were scored as 5 (severity unknown), 4 (killed), 3 (incapacitating injury), 2 (nonincapacitating injury), 1 (possible injury), and 0 (no injury).

Statistical Analysis

Robust χ^2 tests were performed to compare driver and passenger characteristics between restrained and unrestrained passengers for each of the 3 passenger age groups (ie, 0–8, 9–15, and 16–19 years old). We

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TABLE 1 Characteristics of Unrestrained Passengers and Their Drivers in Crashes (2011–2015, United States; FARS and NASS CDS)

	0- to 8-y-Old Passengers		9- to 15-y-Old Passengers		16- to 19-y-Old Passengers	
	Fatal Crashes	Nonfatal Crashes	Fatal Crashes	Nonfatal Crashes	Fatal Crashes	Nonfatal Crashes
Passenger characteristics						
N	1442	16 839	2120	14 987	3899	36 312
Sex, *n* (%)						
Male	763 (53)	9205 (55)	1079 (51)	8126 (54)	2273 (58)	15 857 (44)
Female	679 (47)	7634 (45)	1041 (49)	6860 (46)	1626 (42)	20 455 (56)
Injury severity, *n* (%)						
0	122 (8)	5888 (35)	153 (7)	4192 (28)	219 (6)	16 554 (46)
1	168 (12)	3076 (18)	234 (11)	3892 (26)	290 (7)	9748 (27)
2	305 (21)	5638 (33)	526 (25)	4834 (32)	787 (20)	4780 (13)
3	376 (26)	2213 (13)	480 (23)	2069 (14)	1022 (26)	3604 (10)
4	465 (32)	00 (0)	716 (34)	00 (0)	1547 (40)	00 (0)
5	6 (<1)	24 (<1)	11 (1)	00 (0)	7 (<1)	1625 (4)
Driver characteristics						
N	1034	13 733	1589	11 046	2855	31 718
Age, y, *n* (%)						
≤20	55 (5)	2297 (17)	492 (31)	2009 (18)	1397 (49)	10 853 (34)
>20	979 (95)	11 436 (83)	1097 (69)	9037 (82)	1458 (51)	20 865 (66)
Mean age, y (SD)	35.1 (32.4)	30.8 (1.7)	31.6 (14.6)	35.7 (4.0)	24.1 (10.8)	28.2 (3.0)
Sex, *n* (%)						
Male	488 (47)	5438 (40)	911 (57)	5629 (51)	2166 (76)	17 775 (56)
Female	546 (53)	8295 (60)	678 (43)	5417 (49)	689 (24)	13 943 (44)
Alcohol involved, *n* (%)						
Yes	234 (23)	497 (4)	288 (18)	244 (2)	1090 (38)	4414 (14)
No	800 (77)	13 236 (96)	1301 (82)	10 801 (98)	1765 (62)	37 304 (86)
Fatality, *n* (%)						
Yes	306 (30)	00 (0)	462 (29)	00 (0)	956 (33)	00 (0)
No	728 (70)	13 733 (100)	1127 (71)	11 163 (100)	1899 (67)	32 015 (100)
Restraint use, *n* (%)						
Unrestrained	488 (47)	2828 (21)	764 (48)	4014 (36)	1599 (56)	12 801 (40)
Restrained	546 (53)	10 905 (79)	825 (52)	7032 (64)	1256 (44)	18 917 (60)
Vehicle characteristics						
Vehicle type, *n* (%)						
Passenger car	411 (40)	6199 (45)	622 (39)	4883 (44)	1487 (52)	21 757 (69)
Large van	17 (2)	1395 (10)	27 (2)	515 (5)	38 (1)	648 (2)
Pickup truck	126 (12)	1039 (8)	307 (19)	2251 (20)	607 (21)	2942 (9)
SUV	382 (16)	3751 (27)	532 (33)	2182 (20)	639 (22)	5758 (18)
Minivan	98 (9)	1349 (10)	101 (6)	1214 (11)	84 (3)	613 (2)

SUV, sport-utility vehicle.

ran bivariate analyses separately for fatal (FARS) and nonfatal (NASS CDS) crashes. Multivariate logistic regression models were used to compute the risk for passenger restraint use in each passenger age group while controlling for passenger sex, driver age and sex, driver alcohol impairment, and crash severity. For the logistic regressions, the 2 data sets were combined.

To generate national estimates, we applied weights to the NASS CDS that are equal to the inverse of the selection probability to account for any potential underrepresentation on the basis of the NASS CDS's sampling protocol. Because the FARS is a census of all known fatal crashes that match the parameters, those cases were assigned a case weight of 1. To account for the case weights of subjects and clustering of subjects by vehicle, robust χ^2 tests were performed, and logistic regression parameter variances were obtained by using Taylor series linearization.

RESULTS

Table 1 includes the characteristics of unrestrained young passengers and their drivers. Overall, ~25 in 1000 0- to 8-year-olds, 42 in 1000 9- to 15-year-olds, and 38 in 1000 16- to 19-year-olds were killed as unrestrained passengers in MVCs between 2011 and 2015. For fatal and nonfatal crashes, males made up more than half of the unrestrained young passengers in each age group except for among 16- to 19-year-olds involved in nonfatal crashes (56% female). Among fatal MVCs with unrestrained 16- to 19-year-old passengers, most (76%) drivers were male, whereas more than half of the drivers among 0- to 8-year-old unrestrained passengers were female (fatal and nonfatal MVCs). Although overall driver alcohol impairment was low across all cohorts, drivers of 16- to 19-year-old unrestrained

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TABLE 2 Bivariate Comparisons of Unrestrained and Restrained Passengers' and Their Drivers' Characteristics in Nonfatal Crashes (2011–2015, United States; NASS CDS)

	Unrestrained Passengers, *n* (%)	Restrained Passengers, *n* (%)	OR (95% CI)
0- to 8-y-old passengers			
Passenger characteristics			
Male sex	9205 (54)	448 323 (49)	1.24 (0.71–2.16)
Passenger fatality	—	—	—
Driver characteristics			
>20 y old	13 644 (81)	804 974 (89)	0.55 (0.18–1.70)
Male sex	7397 (44)	325 591 (36)	1.40 (0.74–2.67)
Driver alcohol	621 (4)	11 335 (1)	3.03 (0.80–11.52)
Driver unrestrained	4341 (26)	20 448 (2)	15.08 (5.28–43.10)***
Driver fatality	—	—	—
9- to 15-y-old passengers			
Passenger characteristics			
Male sex	8126 (54)	264 118 (46)	1.40 (0.62–3.08)
Passenger fatality	—	—	—
Driver characteristics			
>20 y old	12 937 (86)	507 217 (88)	0.85 (0.32–2.23)
Male sex	9138 (61)	151 498 (26)	4.37 (1.74–10.97)***
Driver alcohol	372 (2)	4447 (1)	3.27 (0.97–11.02)*
Driver unrestrained	4224 (28)	11 937 (2)	18.52 (3.61–95.04)***
Driver fatality	—	—	—
16- to 19-y-old passengers			
Passenger characteristics			
Male sex	15 857 (44)	197 405 (49)	0.82 (0.45–1.50)
Passenger fatality	—	—	—
Driver characteristics			
>20 y old	22 027 (61)	194 123 (48)	1.69 (0.78–3.64)
Male sex	19 544 (54)	237 576 (58)	0.8 (0.33–2.06)
Driver alcohol	5087 (14)	8294 (2)	7.82 (1.94–31.44)**
Driver unrestrained	16 102 (44)	4322 (1)	74.10 (27.63–198.70)***
Driver fatality	—	—	—

—, not applicable.
* $P \leq .05$.
** $P \leq .01$.
*** $P \leq .001$.

passengers in fatal MVCs had the most impairment (38%), and drivers of unrestrained 9- to 15-year-old passengers had the least impairment (2%). When a 16- to 19-year-old passenger was unrestrained, the driver was also unrestrained in 56% (n = 1599) of fatal crashes and in 40% (n = 12 801) of nonfatal crashes. When a 0- to 8-year-old passenger was unrestrained, the driver was unrestrained in 47% of the fatal crashes (n = 488) and in 21% (n = 2828) of the nonfatal crashes.

In Table 2, we summarize the differences in risk for being an unrestrained passenger in nonfatal crashes for each of the 3 age groups, whereas in Table 3, we display similar findings for fatal crashes. Among nonfatal crashes, unrestrained passengers were more likely than restrained passengers to have a male driver when the passenger was 9 to 15 years old (odds ratio [OR] = 4.4; 95% confidence interval [CI] = 1.74–10.97). Unrestrained 16- to 19-year-old passengers in nonfatal crashes were more likely than restrained passengers to have a driver impaired by alcohol (OR = 7.8; 95% CI = 1.94–31.44). In all 3 age groups, unrestrained passengers in nonfatal crashes were more likely than restrained passengers to have an unrestrained driver. In fatal crashes, unrestrained passengers in all 3 age groups were more likely to have a driver who was male, <20 years of age, alcohol impaired, and unrestrained. Moreover, in all 3 age groups, unrestrained passengers in fatal crashes were more likely than restrained passengers to die in the crash, and it was more likely for their drivers to die in the crash. To estimate the effects of all potential factors on passenger seat belt use, multivariate logistic regressions were performed for each of the 3 passenger age groups in Table 4. The models included passenger sex, driver age and sex, driver alcohol-impairment status, crash fatality, and driver seat belt use. Among passengers in all 3 age groups, driver restraint use was a strong predictor of passenger restraint use. Additionally, in each of the 3 passenger age groups, crash fatality was associated with drivers being unrestrained. For 16- to 19-year-old passengers, having an alcohol-impaired driver was associated with a 4-factor increase in the odds of having an unrestrained

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TABLE 3 Bivariate Comparisons of Unrestrained and Restrained Passengers' and Their Drivers' Characteristics in Fatal Crashes (2011–2015, United States; FARS)

	Unrestrained Passengers, *n* (%)	Restrained Passengers, *n* (%)	OR (95% CI)
0- to 8-y-old passengers			
Passenger characteristics			
Male sex	763 (53)	4806 (51)	1.09 (0.97–1.23)
Passenger fatality	465 (32)	1055 (11)	3.81 (3.33–4.36)**
Driver characteristics			
>20 y old	1371 (95)	9220 (97)	0.54 (0.38–0.76)**
Male sex	667 (46)	4026 (42)	1.17 (1.01–1.35)*
Driver alcohol	352 (24)	620 (7)	4.61 (3.82–5.58)**
Driver unrestrained	692 (48)	1121 (12)	6.88 (5.89–8.03)**
Driver fatality	695 (27)	1698 (18)	1.73 (1.47–2.03)**
9- to 15-y-old passengers			
Passenger characteristics			
Male sex	1079 (51)	3420 (49)	1.06 (0.95–1.18)
Passenger fatality	716 (34)	640 (9)	5.03 (4.43–5.71)**
Driver characteristics			
>20 y old	1469 (69)	5977 (86)	0.36 (0.31–0.41)**
Male sex	1223 (58)	3449 (50)	1.37 (1.21–1.55)**
Driver alcohol	364 (17)	433 (6)	3.11 (2.60–3.71)**
Driver unrestrained	1018 (48)	563 (8)	10.43 (9.01–12.07)**
Driver fatality	605 (29)	1273 (18)	1.77 (1.54–2.04)**
16- to 19-y-old passengers			
Passenger characteristics			
Male sex	2273 (58)	3235 (54)	1.20 (1.10–1.31)**
Passenger fatality	1574 (60)	916 (15)	3.77 (3.43–4.15)**
Driver characteristics			
>20 y old	1851 (47)	3292 (55)	0.75 (0.68–0.83)**
Male sex	3021 (77)	4051 (67)	1.67 (1.50–1.86)**
Driver alcohol	1553 (40)	917 (15)	3.68 (3.30–4.12)**
Driver unrestrained	2233 (57)	697 (12)	10.24 (9.10–11.51)**
Driver fatality	1267 (32)	1368 (23)	1.64 (1.47–1.82)**

* $P \leq .05$.
** $P \leq .001$.

passenger in the same vehicle. Among 9- to 15-year-old passengers, having a male driver was associated with a 3.5-factor increase in the odds of the passenger being unrestrained.

DISCUSSION

With our findings, we update and support older research and state-specific studies in which researchers found driver restraint use to be a strong predictor of young-passenger restraint use. In our bivariate analyses, we found that driver age was associated with seat belt use for all 3 age groups of passengers; drivers ≥20 years old were more likely than younger drivers to have restrained passengers. These findings are consistent with previous studies that reveal that risky driving behaviors increase among teenaged drivers when a teenage passenger is present in the vehicle.[10,11]

With our findings, we renew the importance of states enacting and enforcing primary seat belt laws across the United States to protect our most vulnerable passengers. Primary enforcement restraint laws allow police to stop and cite any individual for being unrestrained independent of any other safety violations. In studies in which researchers compare seat belt use before and after the passage of primary enforcement laws, seat belt use is consistently higher after the new law is passed, with an average increase of 14 percentage points, and fatalities are lower in states with primary laws.[12–14] Primary enforcement for failure to use a seat belt among young passengers in the rear seat is difficult to enforce given the types of restraints available in the vehicle and the size of the passenger. However, primary enforcement for a front-seat occupant is simple for police to identify. As of February 2017, only 34 states had primary seat belt laws for front-seat occupants, and just 18 states had rear-seat primary seat belt enforcement laws.[15] Given the strong associations between modifiable driver behaviors and unrestrained young passengers, several policies aimed at driver behavior may hold promise for increasing passenger restraint use, including primary enforcement for safety belt use, prohibiting driver cell phone use, and mandatory ignition interlock laws for those convicted of driving under the influence (DUI). Additionally, given the relationship between impaired driving and having

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TABLE 4 Multivariate Logistic Models for the Association Between Passengers' Non–Seat Belt Use and Their Drivers' Characteristics (2011–2015, United States; FARS and NASS CDS)

	OR (95% CI)
0- to 8-y-old passengers	
Male passenger versus female passenger	1.47 (0.94–2.28)
Driver ≥20 y old versus driver <20 y old	0.50 (0.19–1.31)
Male driver versus female driver	1.48 (0.85–2.89)
Alcohol-impaired driver versus not impaired	1.76 (0.71–4.38)
Fatal crash versus nonfatal crash	4.33 (2.62–7.16)***
Unrestrained driver versus restrained driver	16.05 (6.16–41.78)***
9- to 15-y-old passengers	
Male passenger versus female passenger	1.21 (0.60–2.45)
Driver ≥20 y old versus driver <20 y old	0.85 (0.35–2.08)
Male driver versus female driver	3.46 (1.22–9.81)*
Alcohol-impaired driver versus not impaired	0.47 (0.06–3.53)
Fatal crash versus nonfatal crash	6.63 (3.68–11.94)***
Unrestrained driver versus restrained driver	16.52 (2.97–91.78)***
16- to 19-y-old passengers	
Male passenger versus female passenger	0.79 (0.33–1.92)
Driver ≥20 y old versus driver <20 y old	1.56 (0.62–3.96)
Male driver versus female driver	0.75 (0.37–1.54)
Alcohol-impaired driver versus not impaired	4.00 (1.51–10.61)**
Fatal crash versus nonfatal crash	3.28 (2.26–4.76)***
Unrestrained driver versus restrained driver	52.60 (25.95–106.62)***

* $P \leq .05$.
** $P \leq .01$.
*** $P \leq .001$.

an unrestrained young passenger, mandatory ignition interlock laws for first-time DUI offenders reduce alcohol-impaired driving and may consequently decrease the number of unrestrained young passengers.[16]

Our methodology helped us overcome a common limitation of studies in which researchers solely use the NASS or FARS. When researchers rely solely on FARS data for analysis, findings represent driver and passenger behavior in fatal crashes only. Similarly, when researchers only rely on the NASS for national estimates, this data set tends to have few fatal crashes, which yields large CIs and introduces unstable findings. To combat potential biases, we combined the FARS and NASS data sets. By taking this approach, we removed the weighted sample of fatalities in the NASS and replaced them with the actual census of fatalities using the FARS, a method that has been previously employed.[6,17,18]

Our study is not without limitations. First, we did not delineate the different types of restraint use by passengers. Consequently, whether a young passenger is appropriately placed in a rear-facing car seat, forward-facing car seat, or a booster seat is not available in these data. Also, some subgroups had small sample sizes, and therefore wide CIs in the NASS, despite combining 5 years of data. Perhaps by combining more years of data in the future, this issue could be mitigated. Next, to be included in our sample from the NASS, the vehicle had to be in a tow-away crash on a public roadway. Such inclusion requirements may miss less-severe crashes. However, by focusing on more-severe crashes, our findings may be used to better protect young passengers from severe injury or death.

CONCLUSIONS

We found that driver restraint use is a significant, independent predictor of restraint use among young passengers in both fatal and nonfatal crashes. In this research update, we provide further support for more states to adopt primary seat belt laws for drivers. Given our finding of a strong association between unrestrained drivers and passengers, police officers must have the power to stop any vehicle with an unbelted driver to provide optimal protection for our most vulnerable passengers. Furthermore, given the strong associations between modifiable driver behaviors and unrestrained young passengers, several policies may provide secondary effects to increase child-passenger restraint use (eg, mandatory ignition interlock laws for DUI offenders and enhanced graduated driver license legislation).

ABBREVIATIONS

CDS: Crashworthiness Data System
CI: confidence interval
DUI: driving under the influence
FARS: Fatality Analysis Reporting System
MVC: motor vehicle crash
NASS: National Automotive Sampling System
OR: odds ratio

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