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The association of graduated driver licensing with non-driver transport-related injuries among adolescents

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Abstract

Background—As a phased approach to initiating driving, graduated driver licensing restricts driving by young drivers with the aim of reducing crashes. It might increase riding with parents or on buses, which might be safer, or walking or biking, which might be more dangerous. We examined whether it increases non-driver injuries, and whether it reduces total injuries combining drivers and non-drivers.

Methods—We conducted longitudinal analyses of 1995–2012 traffic injuries from 43 states. Using Poisson mixed regression, we estimated adjusted rate ratios (aRR) for visible, incapacitating, and fatal injury.

Results—Among 16 year olds, graduated driver licensing was associated with reduced passenger injuries (aRR 0.93, 95% confidence interval: 0.89, 0.97). It was not associated with increased injuries as bus riders, pedestrians, or bicyclists among 16 or 17 year olds. It was associated with a 10% reduction in total injuries among 16 year olds, but not 17 year olds.

Conclusions—Graduated driver licensing was associated with reduced passenger injuries and total injuries.

Traffic crashes, the leading cause of teenager deaths in the US, accounted for 26% (2,163) of 2013 deaths among 16–19 year olds.[1] Florida implemented graduated driver licensing in 1996, and by January 2012, all states and the District of Columbia had implemented some form of graduated driver licensing.[2,3] It typically requires drivers under 18 to proceed through phases: *extended learner permit* (supervised driving for three to twelve months);

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Conflict of Interest

The authors reported no other financial interests related to this research.

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intermediate (unsupervised driving in daylight, but restricted nighttime driving and, in many states, limited passengers); and *full licensure* (unlimited unsupervised driving).[4]

State-[3,5–13] and national-level [14–20] studies have reported 10%–40% reductions in crash rates for 16-year-old drivers after the implementation of graduated driver licensing. However, few have considered injury rates of 16- and 17-year-old passengers, bicyclists, pedestrians, and bus riders, as a result of graduated driver licensing.[10,18,21] Restricted driving may increase use of alternative transportation. Riding with parents or on buses may be safer;[22,23] however, walking and biking may be more dangerous.[24] Previous national studies used fatalities;[14–20] however, injuries, more common than fatalities, produce a sample size adequate to detect moderate associations. We conducted longitudinal analyses of traffic injuries in 43 states to estimate the association of graduated driver licensing with injuries among 16- and 17-year-old passengers, bus riders, bicyclists, and pedestrians; and with total injuries (including in drivers).

METHODS

Counts of visible injuries in crashes

We used crash data from 1995 through 2012 from 43 states to obtain counts of injuries (see the eTable, http://links.lww.com/EDE/B55, which presents crash data year and graduated driver licensing status by state). Data were obtained from police accident reports from National Highway Traffic Safety Administration's State Data System[25] and from states. Data from the remaining 7 states were not available because of no response, cost to acquire, and data format/quality issues. Police accident reports record crashes involving at least one motor vehicle traveling on a road customarily open to the public that result in injury or major property damage.[25] To ensure consistent reporting across states, we included visible, incapacitating, and fatal injuries, and excluded possible injuries and property-damage-only crashes.

Classifying graduated driver licensing

Presence of graduate driver licensing was determined for systems with a learner permit phase ≥ 3 months, plus an intermediate phase restriction on nighttime driving or number of young passengers.[2]

Population estimates

Midyear population estimates by state, age, and year were obtained from the US Census Bureau; quarterly values were linearly interpolated.[26]

Other traffic laws

The presence of other traffic safety laws may confound the relationship between graduated driver licensing and outcomes. We obtained states' impaired driving laws (minimum blood alcohol concentration, zero tolerance, and mandatory suspension for DUI) and maximum speed limits.

Economic indicators

We obtained state-specific quarterly per capita income estimates from the US Bureau of Economic Analysis.[27] The national annual consumer price index was used to adjust for inflation.[28] Each state's annual unleaded gasoline price was obtained from the Energy Information Administration,[29] then adjusted for inflation.

Statistical analysis

We estimated per person-year injury rates for passengers, bus riders, bicyclists, pedestrians, and drivers by dividing counts of visible, incapacitating, and fatal injuries by population estimates. The adjusted rate ratio (aRR) for injury under graduated driver licensing compared with no graduated driver licensing, were estimated using Poisson mixed regression. The outcome was the quarterly count of injuries with an offset equal to the log of the population for that quarter. Random intercepts were used to account for the repeated measures from each state over the study period, and robust variance estimation was employed to account for potential model misspecification (e.g., overdispersion).[30] Regression models included terms for year (linear spline terms with knots at 2002 and 2005), quarter (three indicator variables for four quarters), age (0 for 16, 1 for 17), and graduated driver licensing (0 for absence, and 1 for presence), as well as an interaction for age and graduated driver licensing to examine age variation. We further adjusted for traffic laws and state economic factors. In sensitivity analysis of model choice, we examined whether inclusion of random time trends for each state would change estimates for drivers and passengers. The study was approved by West Virginia University's IRB.

RESULTS

There were 2,400 state-quarters from 43 states; graduated driver licensing was absent for 37% of quarters. Two states (Indiana and Wyoming) did not adopt graduated driver licensing during the study period (see eTable, http://links.lww.com/EDE/B55, which presents crash data year and graduated driver licensing status by state). Among 16–17 year olds, 383,724 passengers, 3,526 bus riders, 24,808 bicyclists, 35,003 pedestrians, and 565,602 drivers were injured from crashes (Table). Graduated driver licensing was associated with reduced total injuries for age 16 (aRR 0.90, 95% CI 0.87, 0.93), but not age 17 (aRR 1.03, 95% CI 0.98, 1.08). It was associated with reduced injury rates for 16-year-old but not for 17-year-old drivers (age 16: aRR 0.87, 95% CI 0.83, 0.92; age 17: aRR 1.05, 95% CI 0.98, 1.12). It was associated with reduced injury rates for 16-year-old passengers (aRR 0.93, 95% CI 0.89, 0.97) but not 17 year olds (aRR 1.02, 95% CI 0.97, 1.07). The associations between graduated driver licensing and bus riders, bicyclists, and pedestrians were all near null (Table 1). There was a distribution of state-specific estimates of association between graduated driver licensing and bicyclist, pedestrian, and bus rider injuries. This distribution was centered on the null, and no geographic region or state characteristic was particularly common among states at the low or high end of the distribution. The inclusion of random time trends for each state in the model did not change the aRR for passengers. The aRR was 0.85 (95% CI 0.81, 0.89) and 1.02 (95% CI 0.96, 1.09) for 16- and 17-year-old drivers, similar to the main analysis.

DISCUSSION

Graduated driver licensing was associated with reduced driver and passenger injuries for adolescents particularly those aged 16 years. A New York study reported the rate ratio of fatal and incapacitating passenger injuries before and after graduated driver licensing was 1.19 (0.77, 1.84) for age 16 and 0.93 (0.61, 1.43) for 17;[10] confidence intervals were wide due to small sample sizes. A study of 1995–2012 Fatality Analysis Reporting System data reported an aRR of 0.96 (0.90, 1.03) for age 16 and 1.00 (0.93, 1.09) for age 17.[31] With 191,619 injuries, relative to 6,047 fatalities among 16-year-old passengers, the injury analysis had an adequate sample size to detect moderate effects. Restricted driving under graduated driver licensing could increase instances of adolescents riding with parents, and subsequently increase passenger fatalities.

However, riding with parents is much safer than riding with adolescents.[22] Additionally, graduated driver licensing restrictions likely reduce the number of passengers riding with high-risk adolescent drivers. Some evidence exists that graduated driver licensing may not cause adolescents to ride more frequently as passengers.[32] California adolescents surveyed said that they drove earlier (58%), rescheduled an event (45%), or had parents or other adults as passengers (59%), to adapt to the nighttime driving restriction. Others walked or rode a bus or bicycle (31%). Forty-four percent reported that they drove at night despite the restriction.[32] In this study, graduated driver licensing did not appear to be associated with more injuries to adolescent bicyclists or pedestrians. In another study of Upstate New York adolescents post and pre graduated driver licensing, rate ratios of incapacitating injuries were 1.53 (0.89, 2.62) and 1.75 (0.91, 3.34) for 16-year-old and 17-year-old pedestrians and bicyclists, respectively,[10] although the study population might not be representative of 16–17 year olds in the 43 states studied. Potential reasons for no increase in bicyclist or pedestrian injuries after graduated driver licensing may include: adolescents forgoing or rescheduling trips;[32] walking rather than riding a bus or bicycle, or simply violating the law.[32]

A study of 1992–2002 Fatality Analysis Reporting System data reported that graduated driver licensing reduced total traffic fatalities (drivers, passengers, bicyclists, and pedestrians) by 6% among 15–17 year olds.[18] Previous studies have suggested heterogeneity between ages 16 and 17.[14,31] Our study showed that for total injuries (passengers, bicyclists, pedestrians, bus riders, and drivers), graduated driver licensing was associated with a 10% reduction for age 16, but not for age 17. Adult supervision and restrictions on nighttime driving and number of underage passengers are likely common among 16 year olds. As adolescents age and restrictions are removed, the influence of graduate driver licensing should decrease. An analysis of 2006–2009 Fatality Analysis Reporting System data found that the nighttime driving restriction was in effect for 84% of 16-year-old, and 30% of 17-year-old drivers in fatal crashes.[33] In 36 of 50 states, 17 year olds could have full licensure (unlimited unsupervised driving), particularly after taking a driver education course.[4]

Strengths of this study include examination of non-drivers and drivers, which increases understanding of the broader impacts of graduate driver licensing; longitudinal analysis of injuries from 43 states; examination of injuries, which produces a sample size adequate for analysis of injuries to bus riders; and adjustment for temporal trends, seasonal factors, traffic

laws, and economic factors. Limitations include not having licensure status to estimate the effects of individual graduated driver licensing components; and calculations of adjusted economic factors included all ages, not just adolescents. Also, our use of population estimates to calculate rates did not account for exposure to driving, bus riding, bicycle riding, or walking.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Centers for Disease Control and Prevention. Web-based Injury Statistics Query and Reporting System (WISQARS). Atlanta, GA: Centers for Disease Control and Prevention; 2015. http://www.cdc.gov/injury/wisqars/ [accessed April 17, 2015]
2. Insurance Institute for Highway Safety. Graduated Driver Licensing Effective Dates. Arlington, VA: Insurance Institute for Highway Safety; 2015. http://www.iihs.org/media/028244c2-87b1-4108-8122-c055877ea5da/-1425338212/Laws/gdl_effective_dates.pdf [accessed April 7, 2015]
3. Ulmer RG, Preusser DF, Williams AF, Ferguson SA, Farmer CM. Effect of Florida's graduated licensing program on the crash rate of teenage drivers. Accid Anal Prev. 2000; 32(4):527–532. [PubMed: 10868755]
4. Williams AF, Tefft BC, Grabowski JG. Graduated Driver Licensing Research, 2010–Present. J Safety Res. 2012; 43(3):195–203. [PubMed: 22974685]
5. Males M. California's graduated driver license law: Effects on older teenagers. Californian Journal of Health Promotion. 2006; 4(3):207–221.
6. Masten SV, Hagge RA. Evaluation of California's graduated driver licensing program. Journal of Safety Research. 2004; 35(5):523–535. [PubMed: 15530926]
7. Rios A, Wald M, Nelson SR, Dark KJ, Price ME, Kellermann AL. Impact of Georgia's Teenage and Adult Driver Responsibility Act. Ann Emerg Med. 2006; 47(4):361–369.
8. Kirley BB, Feller A, Braver E, Langenberg P. Does the Maryland graduated driver licensing law affect both 16-year-old drivers and those who share the road with them? J Safety Res. 2008; 39(3): 295–301. [PubMed: 18571571]
9. Shope JT, Molnar LJ. Michigan's graduated driver licensing program: Evaluation of the first four years. J Safety Res. 2004; 35(3):337–344. [PubMed: 15288567]
10. Zhu M, Chu H, Li G. Effects of graduated driver licensing on licensure and traffic injury rates in Upstate New York. Accid Anal Prev. 2009; 41(3):531–535. [PubMed: 19393803]
11. Foss RD, Feaganes JR, Rodgman EA. Initial Effects of Graduated Driver Licensing on 16-Year-Old Driver Crashes in North Carolina. JAMA. 2001; 286(13):1588–1592. [PubMed: 11585481]
12. Willis, DK. Fatal crashes involving 16 year-old Texas drivers Pre- and Post-GDL: Who, when, where, and why?. College Station: Texas Transportation Institute; 2006.

13. Fohr SA, Layde PM, Guse CE. Graduated driver licensing in Wisconsin: does it create safer drivers? Wis Med J. 2005; 104(7):31–36.
14. Masten SV, Foss RD, Marshall SW. Graduated Driver Licensing and Fatal Crashes Involving 16- to 19-Year-Old Drivers. JAMA. 2011; 306(10):1098–1103. [PubMed: 21917580]
15. Baker, S.; Chen, L.; Li, G. Nationwide review of graduated driver licensing. Washington, DC: AAA Foundation for Traffic Safety; 2007.
16. McCartt, AT.; Teoh, ER.; Fields, M.; Braitman, KA.; Hellinga, LA. Graduated Licensing Laws and Fatal Crashes of Teenage Drivers: A National Study. Arlington, VA: Insurance Institute for Highway Safety; 2009.
17. Lyon JD, Pan R, Li J. National evaluation of the effect of graduated driver licensing laws on teenager fatality and injury crashes. J Safety Res. 2012; 43(1):29–37. [PubMed: 22385738]
18. Dee TS, Grabowski DC, Morrisey MA. Graduated driver licensing and teen traffic fatalities. J Health Econ. 2005; 24(3):571–589. [PubMed: 15811544]
19. Fell JC, Jones K, Romano E, Voas R. An Evaluation of Graduated Driver Licensing Effects on Fatal Crash Involvements of Young Drivers in the United States. Traffic Inj Prev. 2011; 12(5):423–431. [PubMed: 21972851]
20. Morrisey MA, Grabowski DC. Gas prices, beer taxes and GDL programmes: effects on auto fatalities among young adults in the US. Appl Econom. 2010; 43(25):3645–3654.
21. Pressley JCP, Benedicto CBM, Trieu LM, Kendig TM, Barlow BM. Motor Vehicle Injury, Mortality, and Hospital Charges by Strength of Graduated Driver Licensing Laws in 36 States. J Trauma. 2009; 67(1):S43–S53. [PubMed: 19590354]
22. Chen LH, Baker SP, Braver ER, Li G. Carrying Passengers as a Risk Factor for Crashes Fatal to 16- and 17-Year-Old Drivers. JAMA. 2000; 283(12):1578–1582. [PubMed: 10735394]
23. Chen LH, Braver ER, Baker SP, Li G. Potential benefits of restrictions on the transport of teenage passengers by 16 and 17 year old drivers. Inj Prev. 2001; 7(2):129–134. [PubMed: 11428560]
24. Beck LF, Dellinger AM, O'Neil ME. Motor Vehicle Crash Injury Rates by Mode of Travel, United States: Using Exposure-Based Methods to Quantify Differences. Am J Epidemiol. 2007; 166(2): 212–218. [PubMed: 17449891]
25. National Highway Traffic Safety Administration. [Accessed 9/3/2014] SDS overview. http://www.nhtsa.gov/Data/State+Data+Programs/SDS+Overview
26. Census Bureau. [accessed September 19, 2012] Population estimates. 2010. http://www.census.gov/popest/data/historical/2000s/vintage_2009/datasets.html
27. Bureau of Economic Analysis. [accessed October 29, 2014] Regional dat: GDP and personal income. 2014. http://www.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=3#reqid=70&step=1&isuri=1
28. Bureau of Labor Statistics. [accessed October 29, 2014] Consumer Price Index databases. 2014. http://www.bls.gov/cpi/#tables
29. Energy Information Administration. [accessed October 29, 2014] State Energy Data System. 2014. http://www.eia.gov/state/seds/seds-data-complete.cfm?sid=AL%20-%20PricesExpenditures
30. White H. Maximum likelihood estimation of misspecified models. Econometrica: Journal of the Econometric Society. 1982:1–25.
31. Zhu M, Zhao S, Long DL, Curry AE. Association of Graduated Driver Licensing With Driver, Non-Driver, and Total Fatalities Among Adolescents. American Journal of Preventive Medicine.
32. Williams AF, Nelson LA, Leaf WA. Responses of teenagers and their parents to California's graduated licensing system. Accid Anal Prev. 2002; 34(6):835–842. [PubMed: 12371788]
33. Carpenter D, Pressley JC. Graduated driver license nighttime compliance in U.S. teen drivers involved in fatal motor vehicle crashes. Accident Analysis & Prevention. 2013; 56(0):110–117. [PubMed: 23647699]

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Table

Counts, rates, and rate ratios for injuries by person type, age, and graduated driver licensing exposure [a]

Person type	Age (yr)	Graduated driver licensing exposure [b]	No. of injuries [c]	Rate per 100,000 person-year [d]	Crude rate ratio per quarter-person-year (95% CI)	Adjusted rate ratio per quarter-person-year (95% CI) [e]
Passenger	16	Absent	79,721	531		
		Present	111,898	291	0.55 (0.54, 0.55)	0.93 (0.89, 0.97)
	17	Absent	73,309	514		
		Present	118,796	308	0.60 (0.59, 0.60)	1.02 (0.97, 1.07)
Bus rider	16	Absent	682	5		
		Present	1,251	3	0.72 (0.65, 0.79)	0.99 (0.75, 1.32)
	17	Absent	550	4		
		Present	1,043	3	0.74 (0.67, 0.82)	1.03 (0.77, 1.37)
Bicyclist	16	Absent	4,019	27		
		Present	9,599	25	0.93 (0.90, 0.97)	0.97 (0.90, 1.04)
	17	Absent	3,229	22		
		Present	7,961	21	0.96 (0.92, 1.00)	0.99 (0.92, 1.07)
Pedestrian	16	Absent	5,217	35		
		Present	13,029	34	0.97 (0.94, 1.01)	0.99 (0.92, 1.06)
	17	Absent	4,701	31		
		Present	12,056	31	1.00 (0.97, 1.03)	1.01 (0.96, 1.07)
Driver	16	Absent	105,139	700		
		Present	136,486	355	0.51 (0.50, 0.51)	0.87 (0.83, 0.92)
	17	Absent	126,720	843		
		Present	197,257	511	0.61 (0.60, 0.61)	1.05 (0.98, 1.12)
All	16	Absent	194,778	1298		
		Present	272,263	707	0.54 (0.54, 0.55)	0.90 (0.87, 0.93)
	17	Absent	212,509	1414		
		Present	337,113	874	0.62 (0.61, 0.62)	1.03 (0.98, 1.08)

Abbreviation: CI: confidence interval.

[a] Data from the Police Crash Reports from 1995 through 2012 from 43 states (see eTable, which presents crash data year and graduated driver licensing status by state).

[b] Exposure to graduated driver licensing means living in a state that has graduated driver licensing systems with a learner permit phase of at least three months, plus an intermediate phase restriction on night driving or the number of young passengers

[c] Injuries include visible, incapacitating, and fatal injury.

[d] The numerator is the number of injuries. The denominator is the population estimates per year.

[e] Adjusted rate ratios compare the rates per quarter-person-year for persons exposed to graduated driver licensing with those not exposed, adjusted for changes in rates over year and quarter within each state (Poisson mixed regression), rural interstate speed limits, blood alcohol concentration limit for driving, zero-tolerance laws for persons under age 21 years, immediate administrative license suspension for driver with a blood alcohol concentration that exceeds the legal limit, quarterly per capita income, and annual gasoline price.