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The Impact Of Young Unlicensed Driving On Passenger Restraint Use: Concern For Risk Spillover Effect?

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Young Unlicensed Drivers and Passenger Safety Restraint Use in U.S. Fatal Crashes: Concern for Risk Spillover Effect?

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ABSTRACT

Background: Despite recent prevention gains, motor vehicle crashes continue to be the leading cause of death for US adolescents and young adults. Many of these deaths involve young unlicensed drivers that are more likely to be in fatal crashes and to engage in high-risk driving behaviors like impaired driving, speeding, and driving unrestrained. In a crash context, the influence of these high-risk behaviors may spillover to adversely affect passenger safety restraint use.

Objective: To examine the effect of young unlicensed drivers on safety restraint use and mortality of their passengers.

Methods. A cross-sectional analysis of the National Highway Traffic Safety Administration's Fatality Analysis Reporting System from years 1996-2008 was conducted. Fatal crashes involving unlicensed drivers (15-24 yrs) and their passengers (15-24 yrs) were included. Multivariate logistic regression with generalized estimating equations were undertaken to assess the relationship between unlicensed driving and passenger restraint use, controlling for established predictors of restraint use, including driver restraint use, passenger gender, alcohol use, number of occupants, crash year, and crash location (rural vs. urban).

Results:

102,092 passengers were involved in fatal crashes nationally from 1996-2008 with 64,803 unique drivers. 6,732 (10.51%) were never licensed drivers and 5,603(8.8%) were drivers with suspended, revoked, or expired licenses. Rates of unlicensed driving ranged from 17.7% to 25.1% and increased over time. While passengers in fatal crashes averaged 40.9% restraint use, passengers of never and invalidly licensed drivers had a further decreased odds of wearing a safety restraint (OR 0.73, 95% CI 0.69-0.77, p<0.001) and (OR 0.84, 95% CI 0.79-0.90, p<0.001). Other factors related to passenger restraint use were driver restraint use (OR 15.40, 95% CI 14.71-16.11, p<0.001), being a front- seated passenger (OR 3.61, 95% CI 3.47-3.74, p<0.001), rural crash location (OR 0.71, 95% CI 0.68-0.74, p<0.001), and driver alcohol use (OR 0.74, 95% CI 0.70-0.77, p<0.001).

Conclusions: We found a strong inverse correlation between unlicensed driving and passenger restraint use, suggesting a significant risk spillover effect. Unlicensed driving was involved in a disproportionate and increasing number of fatal crashes and plays a detrimental role in the lifesaving safety behaviors of their passengers. Unlicensed driving not only puts the driver and public at risk,

but may also diminish passengers’ ability to mitigate risk in a crash context. Our findings highlight an alarming peer influence between unlicensed drivers and passengers that has considerable implications for US highway safety and the public’s health. Further in-depth study in this area can guide the development of targeted countermeasures and traffic safety programs.

ACKNOWLEDGEMENTS

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-Fu J, Anderson CL, Dziura JD, Crowley MJ, Vaca FE. Young Unlicensed Drivers and Passenger Safety Restraint Use in US Fatal Crashes: Concern for Risk Spillover Effect? Ann Adv Automot Med. Sep 2012.

-Fu, J. Unlicensed Drivers and Front Seat Passenger Restraint Use. Oral Presentation presented at: Society of Academic Emergency Medicine, New England Regional Meeting; Springfield, MA. March 2012.

-Fu, J. Effect of Unlicensed Drivers on Front and Rear Seat Passenger Restraint Use. Poster presented at: Society of Academic Emergency Medicine, National Meeting; Chicago, IL. May 2012.

-Fu, J., Vaca FE. Young Unlicensed Drivers. Oral Presentation presented at: Connecticut College of Emergency Physicians Scientific Assembly; Rocky Hill, CT. Oct 2012.

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-Fu, J. The impact of state level graduated driver licensing policy on rates of unlicensed driving and passenger restraint use: can stricter legislation foster a culture of safety? Oral Presentation at: Society for the Advancement of Violence and Injury Research Annual Meeting; Baltimore, Maryland. June 2013.

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INTRODUCTION

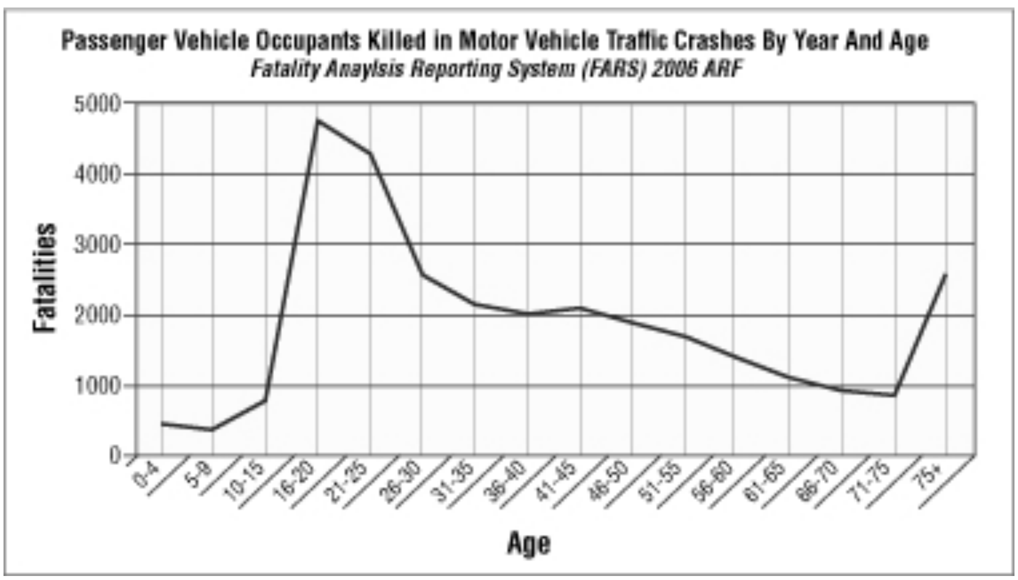
Motor Vehicle Collisions Epidemiology

Motor vehicle collisions (MVCs) continue to be a leading cause of death in the United States[1]. Each year greater than 30,000 people are killed in MVCs and in 2009 alone, over 2.3 million adult drivers and passengers were seen in emergency departments for injuries related to crashes[2]. The New York Times estimated in 2007 that the average American had a 1 in 84 lifetime risk of dying in a car crash[3]. Compounding significant morbidity, mortality, emotional distress, and inconvenience, the economic impact of MVCs is immense. One study estimated that in 2005, the cost of medical care and losses in productivity from fatal and non-fatal crash-related injuries exceeded $99 billion dollars[4].

In response to such a serious problem, a multi-disciplinary approach including increasingly stringent policy and enforcement, improved education and awareness campaigns, and improved engineering from a growing body of biomechanics research has led to an impressive 25% drop in the fatality rate over the past 10 years[5]. In fact, reductions in US MVC injuries and fatalities have been deemed one of the CDC's "Ten Great Public Health Achievements" in the 21st century[6]. While traffic safety efforts have made great strides, MVCs remain a serious problem. Startling trends are beginning to emerge in surprising populations. For the first time in history, surpassing violent crimes and attacks, MVCs are the leading cause of death in law enforcement officers. A recent study has shown that as many as 50% of these guardians of the public's safety are not wearing seat belts at the time of the crash[7]. Another startling but not particularly new subgroup comprises teens and novice drivers. Teen and young adult drivers continue to make up a disproportionate percentage of MVCs[8]. For the first time in the last decade in which teen deaths had trended downward, 16-17 year old driver crash deaths increased (11%)[9]. Our work is far from complete.

An Extremely Vulnerable Population- Young Drivers

Figure 1: Passenger Vehicle Occupants Killed in Motor Vehicle Traffic Crashes by Year and Age



As seen in the above figure, younger motor vehicle occupants have the highest fatality rates of any age. There is a significant spike in the number of fatalities in occupants older than 15 and younger than 25. The National Highway Traffic Safety Administration (NHTSA) reports that in 2009, while young drivers 15-20 years of age made up 6.4% of drivers in the US, they represented 11% of fatal crashes and 14% of all crashes. Expanding the age group, 15-24 year-olds represented 14% of the population, but accounted for nearly 30% ($26 billion) of the economic costs of motor vehicle injuries[10]. In 2009 alone, 2,336 15-20 year-olds were killed in MVCs[11]. One cannot overlook that each life lost impacts not only the victim, but also the victim's family, school, and community. While difficult to quantify the grief of a parent after the loss of a child, one study found a significant increased risk of mortality in bereaved parents[12]. It is evident that several stakeholders are involved in young drivers, especially during this paradoxically vulnerable time in their lives. While they have faster reflexes, shorter response times, and have a greater capacity for decision-making, they paradoxically are highly vulnerable to injury-related death[13-15].

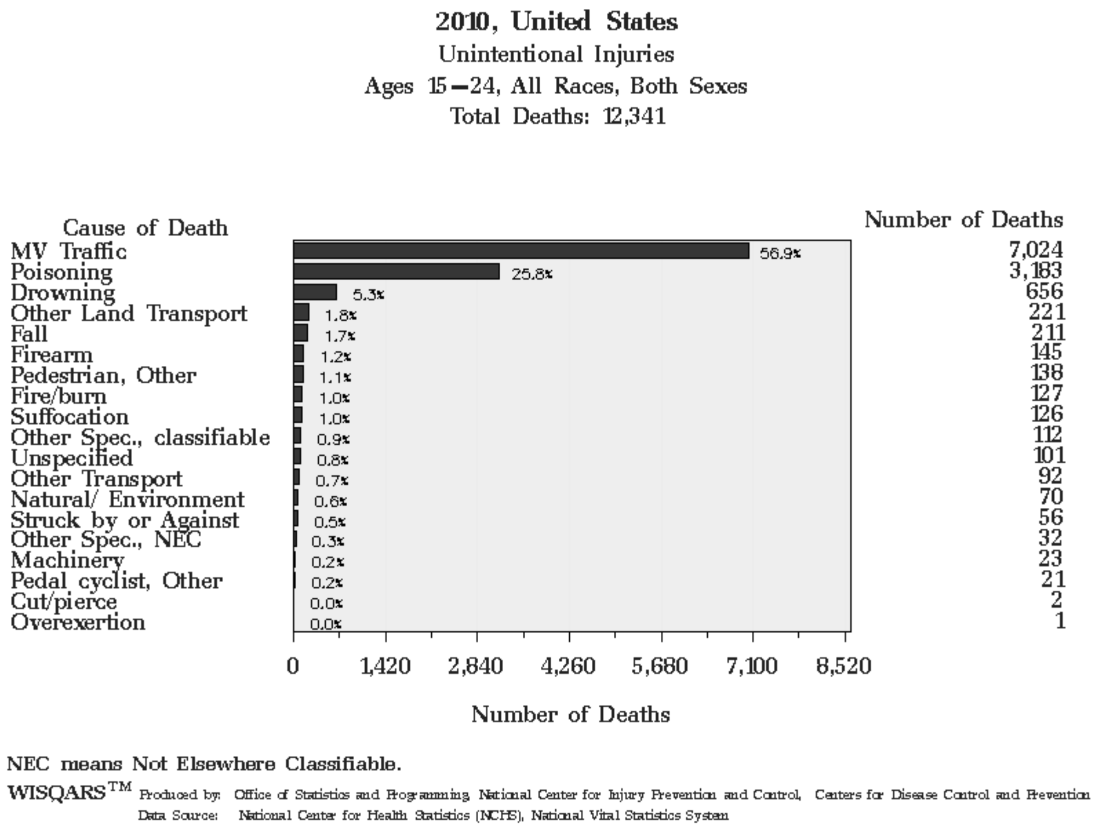
Figure 2: Leading Causes of Death by Age Group, 2010

	Age Groups					
Rank	1-4	5-9	10-14	15-24	25-34	35-44
1	Unintentional Injury 1,394	Unintentional Injury 758	Unintentional Injury 885	Unintentional Injury 12,341	Unintentional Injury 14,573	Unintentional Injury 14,792
2	Congenital Anomalies 507	Malignant Neoplasms 439	Malignant Neoplasms 477	Homicide 4,678	Suicide 5,735	Malignant Neoplasms 11,809
3	Homicide 385	Congenital Anomalies 163	Suicide 267	Suicide 4,600	Homicide 4,258	Heart Disease 10,594
4	Malignant Neoplasm 346	Homicide 111	Homicide 150	Malignant Neoplasms 1,604	Malignant Neoplasms 3,619	Suicide 6,571
5	Heart Disease 159	Heart Disease 68	Congenital Anomalies 135	Heart Disease 1,028	Heart Disease 3,222	Homicide 2,473

Data Source: National Center for Health Statistics (NCHS), National Vital Statistics System

Unintentional injuries, the majority of which are related to motor vehicle crashes, continue to be the leading cause of death for children and young adults ages 1-44[1] (Figures 2-3).

Figure 3: Breakdown of Unintentional Injury Deaths for 15-24 year olds



Data Source: National Center for Health Statistics (NCHS), National Vital Statistics System

Several well-described developmental characteristics place youth at increased MVC fatality risk. A recipe for disaster, the interplay between optimistic bias, sensation seeking, impulsivity, and peer influence put young drivers at extreme risk[16,17]. Optimistic bias is the mindset that despite high-risk behaviors, poor outcomes are more likely to befall other people[8]. Sensation seeking and lack of impulse control, thought to be due to the still underdeveloped frontal cortex and self-regulatory competencies, promote these high-risk behaviors[13,18]. Contextual features, coined the “friend influence,” also play a negative role in crash injury risk. It has been well documented that driving with increased number of passengers is positively correlated with risk of crash, up to 300% increased risk with three peer passengers[19]. One study found that female and male drivers’ risk behaviors were affected differently by their passengers, especially regarding aggressiveness and distraction[20]. Another study found that female passengers tended to lead to safer driving practices for males, whereas male passengers were associated with more dangerous driving for both male and female drivers[21]. To develop effective countermeasures, deeper understanding of peer risk spillover in young drivers is essential.

<u>Graduated Driver Licensing and the Rise of Unlicensed Driving</u>

Given the complexity, magnitude, and impact of adolescent fatalities, programs and policies that reflect current understanding of young drivers have been implemented. In an attempt to mitigate crash injury and death, graduated driver-licensing (GDL) programs in particular have continued to develop and prove themselves beneficial. GDL was adopted first in 1996 by Florida, and various versions of GDL have now been adopted by all 50 states. Summaries of varying state-level GDL components can be found in the appendix. GDL requires new drivers to follow restrictions targeted at known high-risk situations such as night driving and carrying passengers[22]. As drivers garner valuable experience, restrictions are lifted in stepwise fashion. In robust evaluation studies, GDL has been shown to be effective in achieving safe independent driving and reducing young driver fatal crashes[23-26]. The major limitation of GDL is that for it to have a positive effect, young drivers and their families must participate. Stricter restrictions may even steer young drivers to avoid licensing programs altogether[27]. As of 2008, as many as 20% of young drivers involved in crashes are not complying with GDL laws, bypassing training and licensing altogether[28,29]. By circumventing GDL laws, unlicensed drivers are a risk to themselves, their passengers, and to the public's safety[30].

Young Unlicensed Drivers-a difficult population to study

Young unlicensed driving is a relatively new and less recognized risk factor in MVCs[31,32]. Initial studies have shown a substantially increased risk of morbidity and mortality in young unlicensed drivers compared to licensed youths. One population-based case control study found that after controlling for age and gender, compared to licensed drivers, unlicensed drivers were at significantly higher risk for crash injury, an estimated 11-fold increased risk of injury[31]. A cohort study out of Western Australia found that driving prior to receiving a learner permit and the individual driver's risk-taking propensity were the two most important factors for getting into a MVC once licensed[32]. Driving before licensure increased crash risk, even after getting licensed, and this risk persisted for up to 12 months.

Given the illegal nature of unlicensed driving, young unlicensed drivers have been a difficult population to study. With historically low rates of prosecution and conviction, they are difficult to detect unless they commit a traffic violation or are involved in a crash[33]. Consequently, characterization of unlicensed drivers and estimating rates of unlicensed driving have been difficult. Most data is limited to self-report and from fatal crash databases where licensure status is a variable[34,35].

One such self-report study involved interviewing a nationally representative group of 5,665 9th-11th grade students about their driving behaviors[36]. In sum, 4.2% of students reported driving at least one hour/week without a license, although the authors recognize that underreporting may have occurred. The survey further teased out demographic and risk-taking differences between licensed and unlicensed drivers. Unlicensed drivers were more likely to report being Black or Hispanic and more to live in rural areas or city centers. They were found to have lower GPAs in school, and were far less likely to attend driver's education (28%). Once in the car, unlicensed drivers reported decreased safety restraint use and had an increased prevalence of high-risk behaviors like drinking, using drugs, and speeding[36]. Other self-reports studies have varied in geography and quality. Reported rates of unlicensed driving were as high as 58% in one US state.

Highlighting the international nature of this problem, over 18% of males in New Zealand reported unlicensed driving[34,35]. Another survey study of indigenous Polynesian drivers in New Zealand found that 65% of urban and 83% of rural Maori drivers had experience driving unlicensed[37]. Overall, given different populations with different training and licensing requirements and studies with different sampling methods, the numbers are not easily comparable; however, it is clear that unlicensed driving is occurring and at rates higher than previously thought.

A wealth of US fatal crash studies have helped further quantify and characterize unlicensed driving in the crash context. One study that looked at the Fatality Analysis Reporting System (FARS) database found that unlicensed drivers under 15 years were involved in 378 fatal crashes with 436 deaths over a 5-year period[38]. Another study of 33 states found that amongst fatal crashes, 57% of 15-year-old and 10% of 16-year-old drivers were driving without a valid license at the time of the crash[39]. Another study found similar results: 9% of 16-year-old drivers were unlicensed at the time of crash[40]. A 2003 study found that over a 7-year period, unlicensed drivers under the age of 20 were involved with 4,947 (12.1%) fatal crashes in the United States[28].

More recent studies have found that in fatal crashes, unlicensed drivers tend to be males, especially those close to licensing age[27,41]. In a study of 4,170 accidents recorded by the Department of Public Safety in Texas, adolescents driving under the age limit were more likely to be male, to be driving in the late afternoon/evening, and to be in a crash that resulted in injury or death[41]. Young unlicensed drivers in severe crashes also tend to come from families of lower socioeconomic status[42]. Lastly, an Australian study found that unlicensed drivers in crashes were more likely to be males, driving with passengers <18 years old, and more likely being pursued by the police[43].

While unlicensed drivers have repeatedly been found to be more likely to engage in high-risk behaviors, little is known on the impact unlicensed drivers and the milieu of risk-affinity they endorse may have on their passengers risk behaviors.

Risk Spillover and the Peer Influence

There is a growing body of evidence as well as a strong intuitive understanding that the abstract concept of “riskiness” may transfer among peers: how a friend or peer behaves may significantly impact how a young person behaves[13,16,44,45]. Some studies have shown that amongst many factors influencing a young passenger’s decision to wear a seat belt or not, the safety practices and risk behaviors of their drivers may strongly affect the safety restraint usage of their passengers[46-49]. Nambisan et al., summarizes this effect simply and effectively:

> The results indicate that if drivers use seat belts, their passengers are very likely to use seat belts. Conversely, if drivers do not use seat belts, their passengers are not likely to use seats belts.

They found that this effect was universal in male-male, female-male, and female-female peer interactions[46]. Another analysis of FARS found that for younger passengers, driver restraint use was the strongest predictor of passenger restraint use[47]. If a driver wore their seat belt, the child was 75% more likely to be wearing a seat belt. Conversely, if the driver was not wearing a seat belt, restraint use was 27% amongst passengers. Other factors associated with decreased passenger restraint use were younger driver and alcohol use at the time of crash.

The Importance of Restraint Use

It comes as no surprise that passenger safety restraint usage is a primary predictor of crash survival[50]. In 2010, the National Highway Traffic Safety Administration estimated that seat belts saved 12,546 lives, raising the total from 2006-2010 to over 69,000. The National Center for Statistics and Analysis estimates that an additional 3,341 lives would have been saved in 2010 if all unrestrained passengers in fatal crashes had chosen to wear their seat belts[51]. These numbers are based on estimates of seat belt effectiveness combined with fatal crash data. Seat belts are estimated to reduce serious crash-related injuries and fatalities between 40-50%[52,53]. Airbags alone provide risk reduction of 10-15% and should not be used as substitute for safety restraints. The combination of seat belts and air bags provide the greatest amount of protection, approximately a 50% fatality risk reduction[53]. A study of patients presenting to emergency departments found that seat belt use was a key predictor of whether a patient was to be admitted to the hospital for severe injuries (OR 2.6)[54]. Putting on a seat belt remains the most important course of action a passenger can take when entering a vehicle.

To date, no literature has assessed the effect of unlicensed drivers and their safety practices on the safety restraint usage and mortality of same-vehicle passengers. Characterizing this relationship is essential to understanding the factors associated with passenger crash-related fatality in this significant and under-characterized population group.

Statement of Purpose/ Hypotheses and Specific Aims

Given widespread implementation of GDL programs and reports of increased unlicensed driving, we sought to quantify the prevalence of unlicensed driving and explore its impact on the most important risk factor for passenger morbidity and mortality: safety restraint use. Using statistical modeling, we attempt to also quantify the peer-influence risky unlicensed drivers have on their passengers, in essence, exploring a possible risk spillover effect.

Hypothesis 1. Representation of unlicensed young drivers in fatal crashes is increasing in the setting of existing broad application of state Graduated Driver Licensing (GDL) laws.

Hypothesis 2(null). In vehicles involved in fatal crashes, there is no relationship between unlicensed driving and passenger restraint use.

Specific Aim 1: Using the National Highway Traffic Safety Administration's (NHTSA) Fatality Analysis Reporting System (FARS) from years 1996-2008, evaluate the trends in unlicensed driving for young drivers ages 15-24 years.

Specific Aim 2: Using the NHTSA FARS database, evaluate the relationship between unlicensed driving and passenger restraint use in U.S. fatal crashes.

METHODS

We explored US fatal MVCs in the years 1996-2008. Data were obtained from the National Highway Traffic Safety Administration's Fatality Analysis Reporting System (NHTSA-FARS) database. The FARS database is a compilation of all police-reported fatal traffic accidents on public roadways in the United States. It includes accidents that resulted in the death of the driver, an occupant, or a non-occupant within 30 days of the accident. State-employed FARS analysts organize the data into a standard format. Every case includes over 100 coded variables that are divided into forms: Accident Form, Vehicle Form, Driver Form, and Person Form. De-identified data are publicly accessible through the FARS Query System or downloadable from its ftp server at ftp://ftp.nhtsa.dot.gov/FARS/. Quality control is a built in program to the FARS database that includes consistency checks and statistical control charts. Data were cleaned, formatted, compiled, and thoroughly reviewed by Jonathan Fu for this project.

Database Construction

Person, vehicle, and accident files were downloaded for each year 1996-2008 from the ftp server. Files were converted from .sas7bdat to .dta format using Stat Transfer 11.0. Using the *merge 1:m* function in Stata, each file in a given year was merged together using the indexing variable *st_case,* the vehicle number *veh_no*, and the person number *per_no.* Combined year cases were then appended using the Stata function *append* to create a master database.

Case Selection

We included fatal MVCs during the years 1996-2008. We began in 1996 to capture the early effects of GDL. All subsequent years available in the database were used. All fatal crashes involving a driver aged 15-24 and at least one passenger also aged 15-24 were included. Age ranges were limited to examine peer-to-peer influences between drivers and passengers. Likewise, crashes with no passengers were excluded. Cases involving buses, farming equipment, bicyclist, pedestrians, motorcycles, and other non-passenger vehicles or vans were excluded to focus on interactions within a passenger vehicle.

Variable Definitions

Variables were labeled and categorized using the FARS Analytic Reference Guide 1975-2009[55]. Driver license status was categorized as licensed and unlicensed based on the variable *l_status* included amongst the vehicle variables. Unlicensed driving was further divided into invalidly licensed (revoked, expired, suspended) and never licensed. Provisional license statuses, defined by FARS as a learner's permit or intermediate license, was inconsistently collected and made up less than 1% of cases. As such, they were excluded from the analysis. Passenger status was determined based on seating position, based on the variable *seat_pos* included in the person variables. Passengers in row one were coded as front seat, and passengers in rows two or three were coded as rear seat. Passengers with incorrect or no restraint use, as judged by the law enforcement officer reporting the crash, were coded as unrestrained based on the variable *rest_use* included in the person variables.

Variables of Interest

Variables of interest were license status (*l_status)*, licensing compliance (*l_compl),* driver and passenger restraint use (*rest_use)*, passenger gender (*sex)*, driver alcohol use (*dr_drink)*, number of occupants (*ocupants)*, crash year *(year)*, and rural vs. urban crash location (*road_fnc)*. Race was a variable of interest, but was not collected consistently during this time period, so it was not included in the modeling. The variable *inj_sev* was used to determine if the occupant was hurt or killed in the collision.

Statistical Analysis

Rates of unlicensed driving were tabulated over time and analyzed graphically. FARS multiple imputation protocol were used to assess proportion of drivers with positive blood alcohol level[56]. Chi-square analysis and univariate logistic regression were used to assess variables with putative associations with passenger restraint use. These variables were controlled for in the multivariate model. To account for passengers in the same vehicle having the same driver, logistic regression with generalized estimating equations (GEE) analysis, clustering on the vehicle, was carried out. This method prevented overestimating the impact of drivers with multiple passengers and helped account for missing data. Bootstap variance methodology was used to more accurately estimate standard errors[57]. Results were expressed as odds ratios (ORs) with 95% confidence intervals. All statistical analysis was carried out by Jonathan Fu using Stata 11.0.

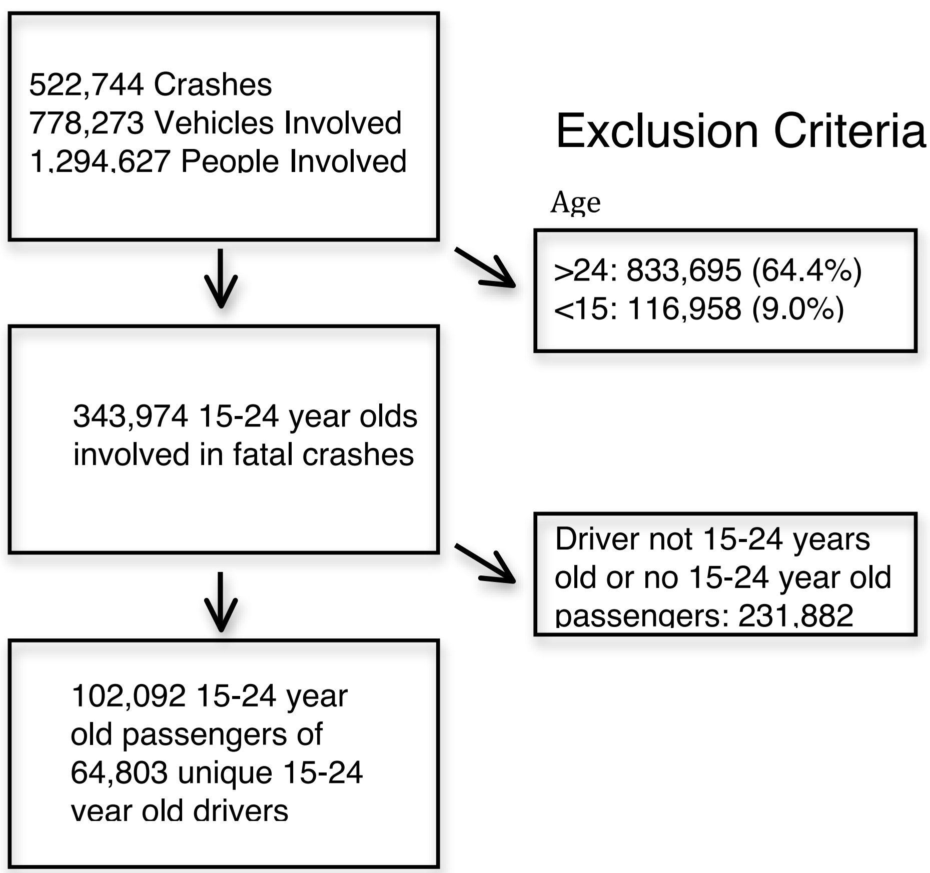
IRB

This project dealt only with de-identified data that is managed by the NHTSA and available to the general public. Yale IRB Policy 100 classifies this project as “not involving human subjects.” The study was registered with the Yale University Human Investigations Committee and exempted from review.

RESULTS

From 1996-2008 there were 522,744 recorded fatal MVCs on US public roads. 778,273 vehicles and 1,294,627 people were involved in these crashes. Of the 1,294,627 people involved, 833,695 (64.4%) were older than 24 years old, 116,958 (9.0%) were younger than 15 years old, and 343,974 (26.6%) were 15-24 year olds.

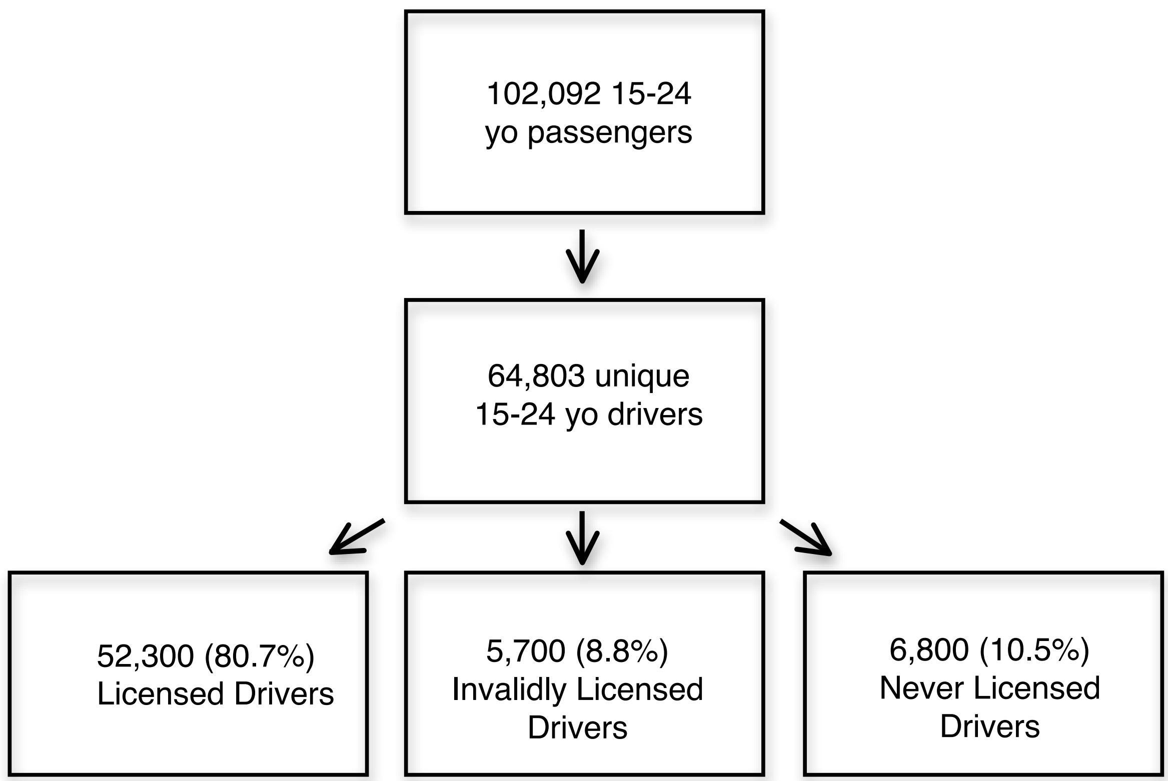
Figure 4: Case Selection 1996-2008



Of the 343,974 15-24 year olds involved in fatal crashes, 231,882 were excluded from analysis because they were either 15-24 year old passengers with drivers not 15-24 years old or 15-24 year old drivers without passengers. 102,092 passengers met our inclusion criteria of being 15-24 year old passengers being driven by 15-24 year old drivers (Figure 4).

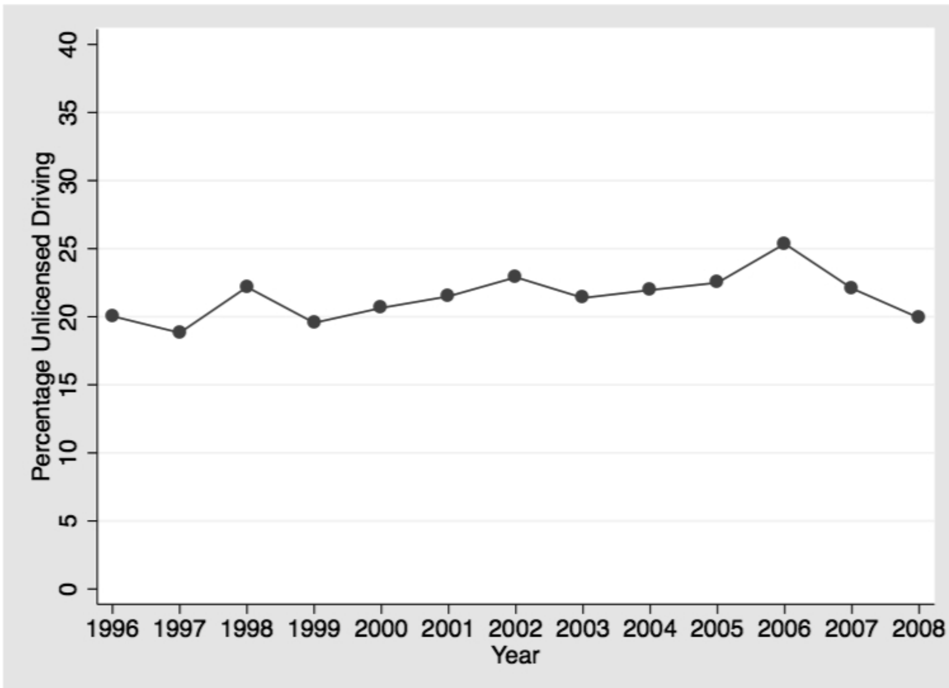
There were 64,803 unique 15-24 year-old drivers and 102,092 15-24 year-old passengers involved in fatal crashes. Of these drivers, 10.5% had never been licensed, 8.8% had a suspended, revoked, or expired license, and 80.7% were driving with a valid license (Figure 5).

Figure 5: Licensure Status of Drivers Involved in Fatal Crashes



Rates of invalid or never licensed driving ranged from 17.7% to as high as 25.1% and had a slight upward trend over time (Figure 6).

Figure 6: Rates of Unlicensed Driving over Time (n=64,803 unique drivers)



Males were more likely than females to be driving with a suspended, revoked, or expired license (10.1% vs. 4.5%). Males were also more likely to drive if they never had a driver's license (10.5% vs. 8.0%). Drivers 15 years of age involved in fatal crashes were more likely than young drivers of other ages to drive without a license. Rates of invalidly licensed driving increased from 1.9% in 15 year olds to 14.8% in 24 year olds. Presumably, as drivers increased in age, they had more time to have their license suspended, revoked, or expired (Table 1).

Table 1- Driver Demographics by Licensing Status

Driver Demographic		Licensed	Invalid License	Never Licensed	p
Gender	Female	13,443 (87.5%)	685 (4.5%)	1,229 (8%)	
	Male	38,259 (78.6%)	4,918 (10.1%)	6,731 (10.5%)	<0.001
Age	15	313 (35.8%)	17 (1.9%)	545 (62.3%)	
	16	5,240 (85.1%)	97 (1.6%)	820 (13.3%)	
	17	6,989 (84.8%)	313 (8.8%)	937 (11.4%)	
	18	8,573 (84.9%)	595 (5.9%)	935 (9.3%)	
	19	7,473 (82.8%)	765 (8.5%)	787 (8.7%	
	20	6,198 (80.1%)	836 (10.8%)	704 (9.1%)	
	21	5,704 (79.1%)	882 (12.2%)	628 (8.7%)	
	22	4,546 (76.4%)	825 (13.8%)	578 (9.7%)	
	23	3,715 (76.6%)	698 (14.4%)	439 (9.1%)	
	24	2,952 (76.0%)	575 (14.8%)	359 (9.2%)	<0.001

Characterizing passengers, 63.5% were males. 60.9% of these passengers were sitting in the front seat compared to 39.1% in the rear seats. 51.4% of crash vehicles had one passenger, 25.0% had two passengers, 14.3% had three passengers, and 9.3% had four or more passengers. 58.0% of crashes occurred on roadways classified as rural.

Overall restraint use among passengers averaged 40.9% compared to 52.8% among drivers. Passengers of never licensed drivers wore their seat belt 31.1% of the time versus 30.3% in passengers of drivers with invalid licenses. Passengers of licensed drivers had the highest restraint use of 43.5% ($p<0.001$) (Table 2). Restraint use among young passengers in fatal crashes varied by gender and seat position. On average, males wore safety restraints 37.6% of the time compared to 46.7% in females. Front seat passengers were much more likely than rear seat passengers to wear a safety restraint (50.6% vs. 27.3%). Restraint non-use increased with increasing number of occupants in the vehicle. 52.4% of passengers in vehicles with two occupants wore their safety restraint.

Table 2- Passenger Restraint Use in Fatal Crashes by Driver, Passenger, and Crash Characteristics

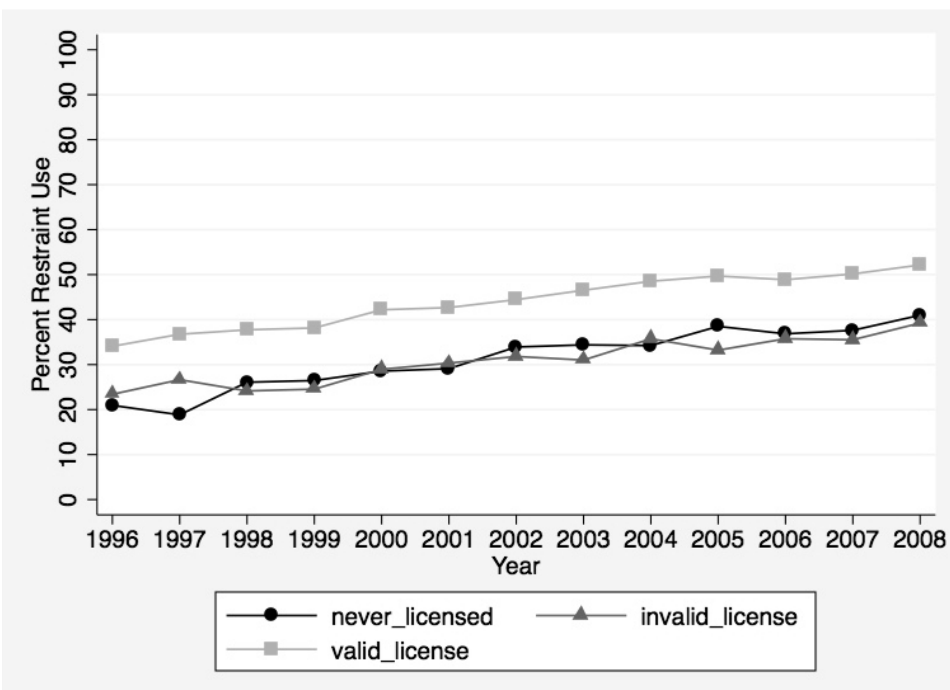
Factors		Restraint Use	n	Unadjusted OR	95% CI
Driver License Status	Licensed	43.5%	74,088		
	Invalid License	30.3%	7,805	0.60*	[0.57, 0.63].
	Never Licensed	31.1%	10,087	0.62*	[0.59, 0.65]
Passenger Gender	Female	46.7%	34,352		
	Male	37.6%	58,810	0.69*	[0.67, 0.71]
Passenger Seat Position	Front Seat	50.6%	55,989		
	Rear Seat	27.3%	35,522	2.73*	[2.65, 2.81]
Number of Occupants	2	52.4%	30,742		
	3	40.1%	24,743		
	4	37.4%	19,822		
	5+	26.3%	17,865	0.71*	[0.70, 0.71]
Crash Location	Urban	47.1%	37,375		
	Rural	36.8%	55,475	0.65*	[0.64, 0.67]
Driver Alcohol Use	No	47.1%	63,683		
	Yes	27.5%	29,521	0.43*	[0.41, 0.44]
Driver Restraint Use	Unrestrained	13.9%	42,869		
	Restrained	66.0%	46,861	12.0*	[11.6, 12.4]

*significant with p<0.001

This percentage trended downwards to 26.3% when there were five or more occupants in the vehicle. Restraint use also varied with driver drinking and crash location. Passengers in vehicles with driver alcohol use wore safety restraints 27.5% compared to passengers of drivers who were not drinking alcohol 47.1%. Passengers in rural crashes wore safety restraints 36.8% compared to passengers in urban crashes 47.1%.

From 1996-2008, overall passenger restraint use increased from 31.9% to 49.8%. Restraint use in passengers of licensed drivers increased from 34.1% to 52.2%, compared to restraint use in passengers of invalidly licensed drivers (23.4% to 39.2%) and drivers who had never been licensed (18.8% to 41.0%) (Figure 7).

Figure 7- Passenger Restraint Use by Driver License Status and Year



In the final model, controlling for passenger gender, passenger seat position, number of occupants, crash location, driver drinking, driver restraint use, and crash year, unlicensed driving was a statistically significant risk factor for passenger restraint non-use. Compared to passengers of licensed drivers, passengers of never licensed and invalidly licensed drivers had a decreased odds of restraint use (OR 0.73, 95% CI 0.69-0.77) and (OR 0.84, 95% CI 0.79, 0.90) (Table 3).

Three variables had a positive effect on passenger restraint use. Driver restraint use was associated with the largest increase in odds of restraint use (OR 15.40, 95% CI 14.71-16.11). Being a passenger in the front seat compared to in the rear seats was also associated with an increased odds of restraint use (OR 3.61, 95% CI 3.47-3.74). Crash year was associated with a 5% increased odds of restraint use per year from the 1996 baseline.

Along with unlicensed driving, several factors had a negative effect on passenger restraint use. Driver drinking (OR 0.74, 95% CI 0.70-0.77), crashes in rural locations (OR 0.71, 95% CI 0.68-0.74), being a male passenger (OR 0.81, 95% CI 0.78-0.85), and crashes involving increased number of occupants were associated with a decreased odds of passenger restraint use. Each additional occupant in the vehicle was associated with an additional decreased odds (OR 0.84, 95% CI 0.83-0.86).

Table 3- Multivariate Logistic Regression Model for Passenger Restraint Use

Variable	OR	Bootstrap SE	95% CI	P value
Never Licensed Driver	0.73	0.02	[0.69, 0.77]	<0.001
Invalidly Licensed Driver	0.84	0.03	[0.79, 0.90]	<0.001
Male Passenger	0.81	0.02	[0.78, 0.85]	<0.001
Front Seated Passenger	3.61	0.07	[3.47, 3.74]	<0.001
Number of Occupants	0.84	0.01	[0.83, 0.86]	<0.001
Rural Crash	0.71	0.01	[0.68, 0.74]	<0.001
Driver Alcohol Use	0.74	0.02	[0.70, 0.77]	<0.001
Driver Restraint Use	15.40	0.36	[14.71, 16.11]	<0.001
Crash Year	1.05	0.01	[1.05, 1.06]	<0.001

Restraint use was missing for 8.7% of passengers. Missingness was similar across calendar years. There were slightly more missing data points in passengers of never and invalidly licensed compared to validly licensed drivers (10.5% vs. 10.5% vs. 8.2%). There were also more missing points in urban vs. rural crashes (12.4% vs. 6.0%) and for males vs. females (9.2% vs. 7.9%).

DISCUSSION

Our study found that rates of unlicensed driving in fatal crashes hovered around 20% and ranged from 17-25%. This worrisome result corroborates previous reports that unlicensed driving is involved in up to one-fifth of all fatal crashes, and demonstrates this estimate applies to younger drivers 15-24 years of age as well. Adolescents and young adults aged15-24 year olds make up only 14% of the population, and a more recent self-report study estimates that approximately 4.2% of student drivers drive unlicensed[10,36]. As a very rough estimate, multiplying these percentages estimates that less than 1% of young drivers are regularly driving unlicensed. If this is true, young unlicensed drivers are involved in a significantly disproportionate percentage of MVCs. Regardless of the numbers, young unlicensed drivers serve as a significant source of crash risk.

Designing countermeasures to unlicensed driving have been difficult at best[33]. If unlicensed drivers are identified, suspensions and revocations could help lessen exposure. It has been shown, however, that drivers with suspensions or revocations still drive up to 75% of the time[58]. Although they tend to drive less often and more carefully during their time of disqualification, they still pose an elevated crash risk[59]. In our study, compared to never licensed drivers, invalidly licensed drivers with suspensions or revoked licenses had less of an effect on passenger restraint use: OR 0.84 compared to OR 0.73. This supports prior research showing that even though invalid drivers are still risky, they may be less "risk-endorsing." One study of California crashes found that drivers with suspended and revoked licenses and unlicensed drivers had an elevated risk of fatal crash involvement when compared to average drivers: 3.7:1 and 4.9:1, respectively[60]. To further reduce risk, there is some evidence that impoundment and immobilization laws against driving while suspended or unlicensed may be effective.

Voas et al. found that compared to suspended drivers who did not have their vehicle impounded, drivers who had their vehicle impounded were less likely to drive while suspended (23.8%), commit a traffic conviction (18.1%), or get into a crash (24.7%)[61]. This Ohio-based program reduced recidivism and offenses both during the time of impoundment as well as subsequently after the suspension was lifted. It is possible that this could be an effective method for deterring young drivers from driving unlicensed. Young unlicensed drivers reported using a vehicle not belonging to them greater than two-thirds of the time, making impoundment a punishment for not only the young driver, but also the person responsible for making that vehicle available[36]. Impoundment would certainly demand parental or guardian involvement, reported by young drivers as the most influential factor in their driving experience[36]. This is still predominantly speculative and further in depth exploration on impoundment is warranted.

Graduated driver licensing (GDL) programs may serve as an alternative conduit for delivering countermeasures. With widespread dissemination of GDL, each state now has the option of altering and modifying restrictions to meet their individual state needs. GDL has been shown to decrease teen deaths, and it appears that the stricter the restrictions, the more effective the program[24,62].

In a paper from the Insurance Institute for Highway Safety, the most important components for reducing mortality were strong nighttime and passenger restrictions and delayed licensing ages. Perhaps stronger punishments for breaking restrictions or even further delaying required licensing ages could be beneficial. However, one recent study suggests that by delaying licensure, we are merely delaying the still vulnerable learning phase[63]. Masten et al found that while stronger GDL restrictions reduced fatalities in 16 and 17 year olds, there was a small but significant increase in fatalities for 18 year olds (RR 1.12, 95% CI, 1.01-1.23). In a follow up study, we explored the possible effects of GDL on unlicensed driving (under review, see appendix for abstract). We found a stepwise increase in unlicensed driving in states with stronger GDL programs, but this increase was counterbalanced by increased passenger restraint use. We postulate that while stronger GDL programs may discourage new drivers from engaging in the licensure process, they may also help foster a culture of safety that encourages passengers to make safer decisions. Paralleling the increased safety restraint use in states with primary (motor vehicle occupants can be stopped and ticketed for not wearing a seat belt) versus secondary seat belt laws (motor vehicle occupants can only be ticketed for not wearing a seat belt if stopped for committing another offense), primary GDL laws may have far-reaching effects[64,65].

In our current study, our second aim was to evaluate the relationship between unlicensed driving and passenger restraint use. In the univariate analysis, we found that unlicensed driving was associated with passenger restraint non-use. Furthermore, we found a strong inverse relationship between teen/young adult unlicensed driving and passenger restraint use when controlling for other predictors in the multivariate analysis.

The influence unlicensed drivers have on their passengers may be explained by developmental characteristics of risk, including: friend influence and optimistic bias[16]. Contextual features, coined the "friend influence," suggest that for adolescents and young adults, perception and judgment by peers may be most important. One study of fatal crashes found that having others in the car increased crash risk for drivers under 30 but decreased crash risk for those over 30[66]. Optimistic bias is the mindset that despite high-risk behaviors, poor outcomes are more likely to befall other people. A young adult getting into the car with an unlicensed driver exhibits this type of bias and will most likely be less likely to wear a safety restraint. One dynamic that our study did not look at was gender or race interplay. The gender of both the driver and passenger seem to alter driving behaviors[20,21]. It is also possible that these effects could vary across cultures. While race was not routinely collected during the earlier years of our study, the FARS database now gathers more in depth ethnicity data that would make such a study possible.

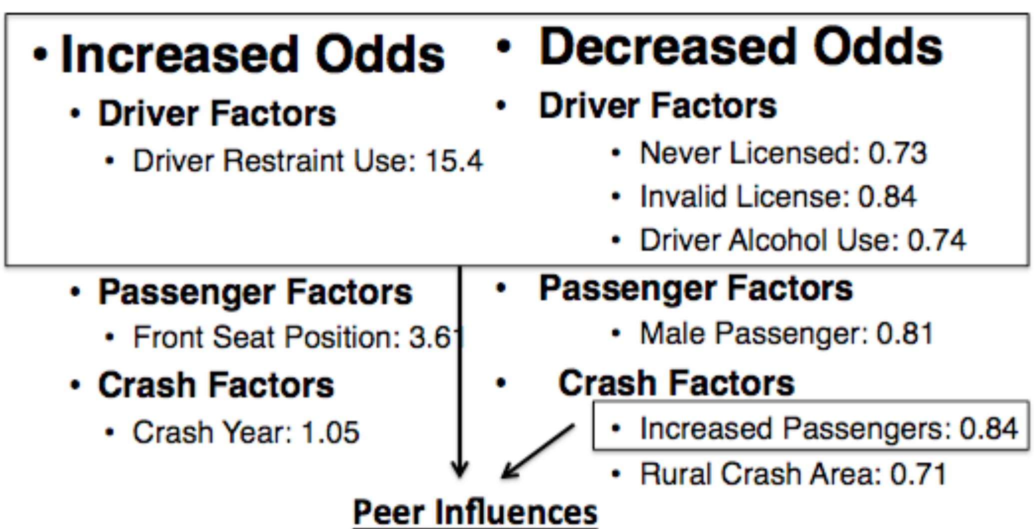
Despite reports of persistently high rates of unlicensed driving[29], passenger restraint use continued to increase from 1996-2008, suggesting that education campaigns and enforcement programs like “click it or ticket” have been effective[67]. In multivariate models, each year from the baseline 1996 was associated with positive odds of restraint use. While this is good news indeed, the overall restraint use in fatal crashes is far from promising.

Sitting in rear seats was associated with a significant decreased odds of restraint use. Rear seat passengers in this population wore safety restraints a mere 27.3%, leaving significant room for improvement. Such low restraint use suggests that programs are missing rear seat passengers. Being in the rear seat may come with a false sense of security that can lead passengers to wear their restraints less. This misconception may be perpetuated by typically less stringent rear seat restraint legislation and enforcement. For both front and rear passengers, however, safety restraint use is associated with a significant decreased risk of ejection and death. Future education campaigns and enforcement programs may prove more successful if they emphasize rear seat restraint use.

Our findings support prior work that described an association between driver restraint use, passenger gender, crash location, crash year, alcohol involvement, increased number of occupants, and passenger restraint use[48]. Alcohol has been associated with restraint non-use[54,68], and we also found that alcohol involvement had a significant effect on passenger restraint use in our study population. Rural crash location was also found to be a predictor in a study involving adult emergency department patients in Wisconsin[54]. Another study of Swedish unlicensed drivers found that unlicensed drivers in rural areas had a much greater risk for crashes[42]. In sum, several complex factors play a role in a young passenger's decision to wear a safety belt. While crash factors (crash year, crash location), passenger factors (male passenger, seat position), play a significant role, we further explored the strong influence peers had on restraint use (Figure 8).

The riskiness of the driver as inferred from their license status, use of alcohol, and the choice to wear a safety restraint as well as the influence of other passengers in the vehicle, all contribute heavily. While young passengers are

Figure 8: Summary of Peer Influences on Passenger Restraint Use



susceptible to optimistic bias, they are also exquisitely, and seemingly uniquely receptive to both the positive and negative influences of their peers. Perhaps education campaigns aimed at accountability and the safety of peers moreso than the safety of self may prove effective. Further exploration into the friend influence and the powerful risk spillover associated with unlicensed driving can help in the development of targeted countermeasures against the disproportionate amount of unlicensed-driving-related MVC injury.

This study included only crashes found in the FARS database, limiting its conclusions to fatal motor vehicle crashes on public motorways. Fatal crashes may involve more unlicensed driving and high-risk behaviors, so data may be skewed and less easily generalized to the population of all crashes. The database consistency, completeness, and accuracy are dependent on the data collection of many different law enforcement officers. Under high stress situations, law enforcement officers may make data collection and even their own safety less of a priority as seen by sometimes conflicting and missing data points[7]. While the National Highway Traffic Safety Administration, manages FARS with well validated consistency checks and statistical control charts to optimize validity, missing data points are an inherent limitation to this database. We attempted to mitigate such concerns by employing generalized estimating equations, which are robust to a moderate amount of missing data[57].

CONCLUSION

Teens and young adults continue to have the lowest restraint use and the highest crash fatality rates of any age group. Our study found that a large portion of these deaths involve young unlicensed driving. Passengers of unlicensed drivers had a decreased odds of wearing safety restraints compared to the passengers of licensed drivers, placing them at much increased risk of crash injury. Young passengers are especially susceptible to the risk influences of their peers, creating a unique opportunity for targeted intervention. Our findings highlight a risk spillover effect that has significant implications for highway safety and injury prevention programs. Further in depth study of driver-passenger peer interactions can guide future countermeasures and traffic safety programs.

Appendix

Abstract 2:

Title: The impact of state level graduated driver licensing policy on rates of unlicensed driving and passenger restraint use: can stricter legislation foster a culture of safety?

Hypotheses and Specific Aims:

Hypothesis 1: From 1996-2010, states with graduated driver licensing (GDL) programs having stricter restrictions will have higher rates of unlicensed driving.

Hypothesis 2: States with stronger state-level GDL programs will have higher rates of passenger restraint use.

Specific Aim 1: Using the National Highway Traffic Safety Administration's (NHTSA) Fatality Analysis Reporting System (FARS) from years 1998-2010, evaluate the state-level trends in unlicensed driving, comparing states with strong, fair, marginal, and weak GDL restrictions.

Specific Aim 2: Using the NHTSA FARS database, evaluate the relationship between Insurance Institute for Highway Safety GDL strength ratings and passenger restraint use in U.S. fatal crashes.

Purpose: Since 1996, states have begun implementing graduated driver licensing (GDL) programs. Increased restrictions could steer new drivers towards driving unlicensed. Unlicensed driving is associated with increased fatal crashes and high-risk behaviors that have been shown to adversely affect passenger safety behaviors like restraint use. The objective of this study was to assess the impact of varying state level GDL programs on rates of unlicensed driving and on passenger restraint use.

Methods: De-identified data from the National Highway Traffic Safety Administration's Fatality Analysis Reporting System from years 1996-2010 was

analyzed. Fatal crashes involving drivers (15-24 yrs) and their passengers (15-24 yrs) were included. Using a validated system, each state's GDL laws at a given month were rated as poor, marginal, fair, or good. The association between GDL strength and unlicensed driving was analyzed graphically and by chi-square test. Multivariate logistic regression with generalized estimating equations were undertaken to assess the relationship between GDL strength and passenger restraint use.

Results: From January 1996 to December 2010, 26,504 (23.4%) state-months were rated as poor, 21,366(18.9%) marginal, 33,603 (29.6%) fair, and 31,903 (28.1%) good. Rates of unlicensed driving ranged from 16.4% in state-months rated marginal versus 21.5% in state-months rated good ($p<0.001$). In the multivariate model, compared to states with poor GDL ratings, each additional rating boost was associated with an increased odds of passenger safety restraint use (OR 1.22 , 95% CI 1.20-1.24).

Conclusions: We found that increased GDL strength was associated with increased rates of unlicensed driving. The added risk of unlicensed driving was counterbalanced by a significant positive correlation between state GDL strength and passenger restraint use.

Significance: Our findings suggest that stronger GDL law can serve as an effective countermeasure for mitigating risk in a crash context. Increased state-level GDL programs appears to foster a culture of safety in states that have adopted stronger restrictions, despite significant risk spillover from unlicensed driving and other risk-enhancing factors. As of 2010, 5 states are still rated marginal and 10 fair. Our study provides evidence that stronger legislation in these states may reduce overall risk to young drivers and their passengers.

Figure 9: GDL Rating System Used by Insurance Institute for Highway Safety

Learner's Phase	**Criteria**	**Points**
Minimum Permit Age	16 or older	1 point
	<16	0 points
Permit Holding Period	6+ months	2 points
	3-5 months	1 point
	<3 months	0 points
Required Practice Hours	30+ hours	1 point
	<30 hours	0 points
Intermediate Phase	**Criteria**	**Points**
Restriction on Night Driving	10pm or earlier	2 points
	After 10pm	1 point
	No Restriction	0 points
Restriction on Underage Passengers	0-1 passenger	2 points
	2 passengers	1 points
	3+ passengers or no restriction	0 points
Duration of Night Driving Restriction	12+ months from minimum licensing age	1 point
	<12 months	0 points
Duration of Passenger Restriction	12+ months from minimum licensing age	1 point
	<12 months	0 points
Graduated licensing rating*		

Good	6+ points
Fair	4-5 points
Marginal	2-3 points
Poor	<2 points

*If state awards intermediate licensing status to teens younger than age 16 or if night driving and passenger restrictions are both lifted before age 16, 6 months, state is rated as marginal, regardless of point totals.

Table 4: State GDL Ratings Over Time

State	Effective Dates	Total Points	GDL Rating
Alabama	pre-10/2002	0	Poor
	10/2002-7/2010	6	Good
	7/2010-	8	Good
Alaska	pre-1/1/1999	0	Poor
	01/1999-01/2005	2	Marginal
	01/2005-	6	Good
Arizona	pre-01/2000	0	Poor
	2000-2008	1	Poor
	2008-	6	Good
Arkansas	Pre-05/1999	0	Poor
	05/1999-07/2009	2	Marginal
	07/2009-	7	Good
California	Pre-07/1998	0	Poor
	07/1998-12/2005	8	Good
	01/2006-	9	Good
Colorado	Pre-07/1999	1	Poor
	07/1999-07/2005	4	Fair
	07/2005-	8	Good
Connecticut	Pre-01/1997	3	Marginal
	01/1997-10/2005	5	Fair
	10/2005-08/2008	7	Good
	08/2008-	9	Good
Delaware	Pre-07/1999	0	Poor

	07/1999- 08/2006	6	Good
	08/2006-	10	Good
DC	Pre-01/2001	1	Poor
	01/2001-	9	Good
Florida	Pre-07/1996	1	Poor
	07/1996- 10/2000	4	Fair
	10/2000-	5	Fair
Georgia	Pre-07/1997	0	Poor
	07/1997- 12/2001	6	Good
	01/2002-	8	Good
Hawaii	Pre-07/1997	0	Poor
	07/1997- 12/2005	1	Poor
	01/2006-	8	Good
Idaho	Pre-01/2001	3	Marginal
	01/2001- 05/2007	5	Fair
	05/2007-	9	Marginal*
Illinois	Pre-01/1998	2	Marginal
	01/1998- 06/2004	3	Marginal
	06/2004- 06/2006	5	Fair
	06/2006- 12/2007	6	Good
	01/2008-	9	Good
Indiana	Pre-07/1998	0	Poor
	07/1998- 07/2010	4	Fair
	07/2010-	9	Good
Iowa	Pre-01/1999	0	Poor
	01/1999-	4	Fair
Kansas	Pre 07/1999	0	Poor
	07/1999- 01/2010	3	Marginal
	01/2010-	7	Good
Kentucky	pre10/1996	1	Poor
	10/1996- 10/2006	3	Marginal
	10/2006-4/2007	4	Fair

	04/2007-	10	Good
Louisiana	Pre- 01/1998	2	Marginal
	01/1998- 08/2001	3	Marginal
	08/2001- 09/2004	3	Marginal
	09/2004- 01/2009	4	Fair
	01/2009-	5	Fair
Maine	Pre-08/1998	1	Poor
	08/1998- 08/2000	2	Marginal
	08/2000- 09/2003	4	Fair
	09/2003-	6	Good
Maryland	Pre- 07/1999	2	Marginal
	07/1999- 10/2005	4	Fair
	10/2005-	7	Good
Massachusetts	pre-11/1998	3	Marginal
	11/1998- 09/2007	7	Good
	09/2007-	8	Good
Michigan	Pre-04/1997	0	Poor
	04/1997- 03/2011	5	Fair
	03/2011-	9	Good
Minnesota	Pre-02/1997	0	Poor
	02/1997- 01/1999	2	Marginal
	01/1999- 08/2008	3	Marginal
	08/2008-	7	Good
Mississippi	Pre-07/2000	0	Poor
	07/2000- 07/2009	4	Marginal*
	07/2009-	4	Fair
Missouri	Pre-01/2001	0	Poor
	01/2001- 08/2006	4	Fair
	08/2006- 01/2007	7	Good
	01/2007-	8	Good

Montana	Pre-07/2007	0	Poor
	07/2006-	7	Marginal*
Nebraska	Pre 01/1999	0	Poor
	01/1999-01/2008	3	Marginal
	01/2008-	7	Good
Nevada	Pre-10/1998	0	Poor
	10/1998-07/2001	1	Poor
	07/2001-10/2005	4	Marginal*
	10/2005-	8	Good
New Hampshire	Pre 01/1998	0	Poor
	01/1998-01/2003	3	Marginal
	01/2003-05/2004	4	Fair
	05/2004-06/2009	4	Fair
	06/2009-	5	Fair
New Jersey	Pre-01/2001	1	Poor
	01/2001-	7	Good
New Mexico	Pre 01/2000	0	Poor
	01/2000-	8	Marginal*
New York	Pre- 09/2003	3	Marginal
	09/2003-02/2010	5	Fair
	02/2010-	7	Good
North Carolina	Pre 12/1997	0	Poor
	12/1997-12/2002	4	Fair
	12/2002-01/2012	6	Good
	01/2012-	7	Good
North Dakota	Pre-08/1999	1	Poor
	08/1999-01/12	2	Marginal
	01/12-	5	Marginal*
Ohio	Pre 01/1999	1	Poor
	01/1999-04/2007	5	Fair
	04/2007-	8	Good
Oklahoma	Pre- 11/2004	0	Poor

	11/2004- 11/2005	2	Marginal
	11/2005- 11/2009	6	Good
	11/2009-	7	Good
Oregon	Pre 03/2000	0	Poor
	03/2000-	8	Good
Pennsylvania	Pre-12/1999	2	Marginal
	12/1999- 12/2011	5	Fair
	12/2011-	7	Good
Rhode Island	Pre 01/1999	1	Poor
	01/1999- 07/2003	5	Fair
	07/2003- 07/2005	6	Good
	07/2005-	9	Good
South Carolina	Pre 07/1998	3	Marginal
	07/1998- 03/2002	4	Marginal*
	03/2002-	8	Marginal*
South Dakota	Pre 01/1999	3	Marginal
	01/1999- 07/2004	5	Marginal*
	07/2004-	5	Marginal*
Tennessee	Pre 07/2001	1	Poor
	07/2001-	8	Good
Texas	Pre -1/2002	0	Poor
	01/2002- 05/2010	5	Fair
	05/2010-	7	Good
Utah	Pre 07/1999	0	Poor
	07/1999- 07/2001	3	Marginal
	07/2001- 08/2006	5	Fair
	08/2006-	7	Good
Vermont	Pre 07/2000	0	Poor
	07/2000-	5	Fair
Virginia	Pre 07/2001	2	Marginal
	07/2001-	8	Good
Washington	Pre-07/2001	0	Poor

	07/2001-	7	Good
West Virginia	Pre 01/2001	0	Poor
	01/2001- 07/2009	5	Fair
	07/2009-	9	Good
Wisconsin	Pre 09/2000	0	Poor
	09/2000-	6	Good
Wyoming	Pre 09/2005	0	Poor
	09/2005-	4	Fair

*States with intermediate licensing at less than 16 years old or nighttime and passenger restrictions lifted prior to 16 years and 6 months are rated marginal, regardless of total points.

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