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**Going Unlicensed:
Related Behaviors and Car Crash
Experience among Young Drivers**

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Going Unlicensed: Related Behaviors and Car Crash Experience among Young Drivers
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The time to repair the roof is when the sun is shining.

~John F. Kennedy

ABSTRACT

Background: Globally road traffic injuries are a major cause of injury and mortality, not least among the young. Although unlicensed driving is prevalent in that age group, the phenomenon has not received much attention.

Aims: This thesis attempts to increase knowledge about the scope of unlicensed driving in youth and its related individual and contextual attributes.

Methods: The thesis encompasses four register-based studies, three based in the US and one in Sweden. Unlicensed drivers are any young person below, at, or above the age of licensing without a license, operating a four-wheel passenger motor vehicle on a road. Study I deals with driver characteristics and crash circumstances of fatal road traffic crashes (RTCs) involving a young unlicensed driver (YUD) in the US. In Study II, attention is paid to county material deprivation and urbanicity as regards to fatal RTCs. Based on a Swedish national cohort design, Study III assessed and compares the frequency of individual young drivers who are injured in RTC at different ages and their socio-demographic characteristics. Behavior surveys of Montana high school students are used in Study IV in considering how health risks cluster in and out of the car in youth stratified by license and driving status.

Results: In the US, one of nine (10.8%) fatal crashes involved a YUD. Among those, a majority were males (74.5%), age-eligible to be licensed (72.5%), and from the southern region (49.9%). At the time of crash, dangerous driving practices like speeding (85%) and not using car restraint (53.9%) among others were noted (Article I). At the county level in the US, a positive association between material deprivation and fatal crashes involving young unlicensed drivers was observed (OR = 1.19, 95% CI 1.17, 1.21). A weak negative association between material deprivation and fatal crashes in suburban counties (OR = 0.92, 95% CI 0.90, 0.95) was found (Article II). In Sweden, crashes of unlicensed drivers increased at age 18 and remained steady through age 27. A six-fold increase in relative crash risk for unlicensed males was revealed (95% CI 5.24-8.25). Unlicensed drivers from the lowest socioeconomic families ran four times the risk (4.18, 95% CI 2.40-7.28) of a severe injury in a crash than those from the highest. Relative risk of a YUD in a crash in rural areas was 3.29 (2.47-4.39) compared to YUD in metropolitan areas (Article III). The prevalence of unlicensed driving was 5.1% of the students. Male students reported more health risk behaviors of all types than females. Both male and female YUD disclose more car driving and non-traffic health risk behaviors than their licensed peers do (Article IV).

Discussion: Crashes involving YUD are common both in the US and Sweden. They occur primarily among those age-eligible to be licensed, males, and those from lower socio-economic status. Dangerous driving practices are common at time of crash. As is the case for young licensed drivers, health risk behaviors tend to cluster among YUD to a greater extent. Where YUD live seems to matter for their crash involvement, with urbanicity and material deprivation coming into play.

Conclusion: Studies on RTC and self-reported health risk behaviors suggest that driving unlicensed among the young is rather common especially, even past the age of licensing. It is more frequent among some socio-demographic groups of young people, is accompanied by other health risk behaviors and can be more prevalent in some types of areas. To address the issue will require multi-disciplinary targeted efforts to both discourage unlicensed driving and promote developmental opportunities with safe youth mobility options.

Key words: Unlicensed, young drivers, US, Sweden, material deprivation, road traffic crashes, health risk behaviors, socioeconomic position

LIST OF PUBLICATIONS

- I. Hanna CL, Taylor DM, Sheppard MA, Laflamme L. (2006). **Fatal crashes involving young unlicensed drivers in the U.S.** *Journal of Safety Research* 37(4):385-393.
- II. Hanna CL, Laflamme L, Bingham CR. (2012). **Fatal crash involvement of unlicensed young drivers: County level differences according to material deprivation and urbanicity in the United States.** *Accident Analysis & Prevention*, 45(2):291-295.
- III. Hanna CL, Hasselberg, Laflamme L, Möller J. (2010). **Road traffic crash circumstances and consequences among young unlicensed drivers: A Swedish cohort study on socioeconomic disparities.** *BMC Public Health*, 10:14.
- IV. Hanna CL, Laflamme L, Elling B, Möller J. (2012). **Unlicensed driving and other related health risk behaviors: A study of Montana high school students.** (*submitted*)

These articles will be referred in the text by their roman numerals I-IV.

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LIST OF ABBREVIATIONS

AU	Australia
CA	California
CDC	Centers for Disease Control and Prevention (US)
CI	Confidence intervals
GDL	Graduated drivers licensing system
JFK	John F. Kennedy
KI	Karolinska Institutet
kph	Kilometers per hour
mph	Miles per hour
NHTSA	National Highway Traffic Safety Administration
NSW	New South Wales, AU
NZ	New Zealand
OR	Odds ratios
OECD	Organisation for Economic Co-operation and Development
US	United States of America
RTC(s)	Road traffic crash(es)
RTI(s)	Road traffic injury(ies)
RUCC	Rural Urban Continuum Codes
TX	Texas
USDA	United States Department of Agriculture
WHO	World Health Organization
YRBSS	Youth Risk Behavioral Surveillance System
YUD	Young unlicensed driver
YUDs	Young unlicensed drivers

PREFACE

Giving thanks.

Defending the thesis on the 22nd day of November was purposefully. First, friends and family are at home celebrating Thanksgiving Day. Secondly, 49 years ago today JFK was assassinated in Dallas. Both days, I remember for different reasons.

My impending fate with road traffic safety came in the 1960's. A drunk driver broadsided our family car at high speed right behind the front passenger door where I was sitting unrestrained. I was thrown from the car, lucky to survive. The car that hit us was a Corvair, known for the engine compartment in the back as noted by US consumer advocate Ralph Nader as "unsafe at any speed." If the engine compartment was in the front, the added force might have killed me on contact.

Unlicensed driving is a curious thesis topic that I stumbled upon in providing technical assistance. The western slope of Colorado suffered two fourteen year-olds killed while driving unlicensed. There was little written at the time, sensing an opportunity - a thesis was launched with a personal and scientific zeal!

You realize the complexity of road traffic safety as a complex global problem. In the US alone each year, there are over 36,000 victims, 600 related to young people going unlicensed each year. My commitment comes as a victim, advocate, and a parent with three young adult drivers, reminding me of the dangers of sharing the road each day. Let's get going!

BACKGROUND

TRANSPORT, MOTORIZATION AND MOBILITY

Road traffic injuries are still an increasing and major global public health problem (WHO, 2004). Motor vehicles are a primary mode of travel, providing an unprecedented degree of mobility throughout the world (Arnett, 2002). The use of cars and access to driving privileges may come at a public health cost in terms of morbidity, mortality and their other human and societal costs. Motor vehicle transport is estimated to kill 1.2 million people each year accounting for 25% of all deaths from injury. Worldwide, between 20 million and 50 million people are injured or disabled each year in road traffic crashes (RTCs) and this probably underreported (WHO, 2009).

In motorized countries cars provide important economic, social, financial, and educational opportunities for families (Hirsch, 2003). Privately owned vehicles are essential where population settlement patterns have decentralized communities separating people by distance from schools, jobs, and services. Distance plays an even greater role especially where public transportation is not available or inadequate and being mobile requires access to a car and possessing a driver license (Patel et al., 2000; McDonald & Trowbridge, 2009). The issue of unlicensed driving arises when the developmental and mobility needs precede obtaining a license to drive that can occur before and long after the age of becoming eligible to be licensed (Tsai et al., 2008). A sub-group of young people who drive unauthorized and illegally as unlicensed drivers (going unlicensed) who are primarily recognized by their involvement in RTCs (Williams et al., 1985; Williams et al., 1995).

YOUNG DRIVERS AND INJURIES ON THE ROAD

According to the WHO data, traffic crashes globally are the single greatest killer of 15-24 year-olds in motorized countries. An estimated 8,500 young drivers of motor vehicles were killed in Organisation for Economic Co-operation and Development (OECD) countries in 2004. This includes almost 4,000 in the US, over 750 in Germany, 645 in France, and over 300 in both Japan and Spain. These young people represent about 27% of all drivers killed in these countries, although within the same age group they account for about 10% of the population. Furthermore, for each young driver killed, it is likely that more than 1.3 passengers or other road users also die in the same crashes, based on findings from the US and the Netherlands (WHO, 2009). Males account for three-fourths (73%) of all road traffic deaths, with an overall rate almost three times that for females in all areas, income levels, and age groups. The sex difference in mortality rates are related to both driving exposure and risk-taking behavior (WHO, 2004). Even though globally, unlicensed driving among the young has not been fully recognized.

Driver licensing systems. A driving license is an official document that allows a person to operate a motorized vehicle legally on a public roadway. The laws, requirements, ages, and difficulty of obtaining a license vary among and between countries. In the US, the ease and age of licensing are viewed as relatively easy compared to global standards (Arnett, 2002). Basically, to qualify and prepare young people to drive, an organized sequence of education, training, and practice provide basic knowledge and skills to prepare for a license is usually provided (Vernick et al., 1999; Williams, 2009; Curry et al., 2012). In countries that provide driver training and earlier licensing, a side effect of driver training is that it provides premature access to driving. In response, these countries have added a graduated drivers licensing system (GDL) to delay early exposures to high risk driving environments and circumstances. It also contributes to continued adult supervised driving experience as the young person gains maturity prior to obtaining a full license (Dee et al., 2005; Preusser & Tison, 2007). While training or a GDL does not guarantee a safer driver, it does provide parental control and legal oversight from authorities to their on-road behavior over a given period.

In turn, GDL increases the time, costs, and commitment to obtaining a license. For some disadvantaged young people, it provides a barrier from gaining a timely license upon becoming age-eligible (Ferguson, 2003; Mayhew, 2007). Inadvertently, GDL may also contribute to some youth who may forego the process and drive as illegal unlicensed drivers (Males, 2007; Scott-Parker et al., 2012). If licensing requirements become too restrictive to get a timely license or if viewed as unfair, young people may alternatively use other forms of transport such as driving unlicensed or motorcycles (Simons-Morton et al., 2006). Unlicensed drivers miss out on the knowledge and practice opportunities provided by the education and GDL as part of the licensing process.

UNDERSTANDING YOUTH RISK BEHAVIOR IN AND OUT OF THE CAR

A body of literature primarily on licensed drivers aims to clarify the elevated risk behaviors of young people who drive and are involved in a road traffic crash (RTC) or sustaining a road traffic injury (RTI). The Transitional Teen Theory (TTT) provides a framework to examine risks consisting of four key elements that influence driving behaviors as young people approach and obtain the age of licensing (TTT) (Voas & Kelley-Baker, 2008). The elements include the internal development- and age-related factor and three external influences that are peers, the home environment, and the extended environment (see Figure 1). Developmentally during the transition stage young people seek their identity and independence. By virtue of their age, they also become eligible to drive and interested in cars that provide opportunities to explore new areas and participate in adult activities. This transition stage is recognized as a legitimate developmental step as an integral part of the maturation and socialization process for young people, especially in car dependent and motorized countries. The transition to driving as a stage of development coincides with the developmental need

to increase their independence from family life requiring increased mobility (Arnett, 1992; Bingham & Shope, 2004a; Bina et al., 2006). Challenges to obtaining mobility to gain independence can be a precursor to unlicensed driving when options such as public transportation, parental support, or transport by peers are not available (Males, 2006). The TTT model provides an opportunity to integrate developmental science, public health, and traffic safety when young people are vulnerable to unlicensed driving or riding with an unlicensed driver. The internal and three external elements are described and illustrated below.

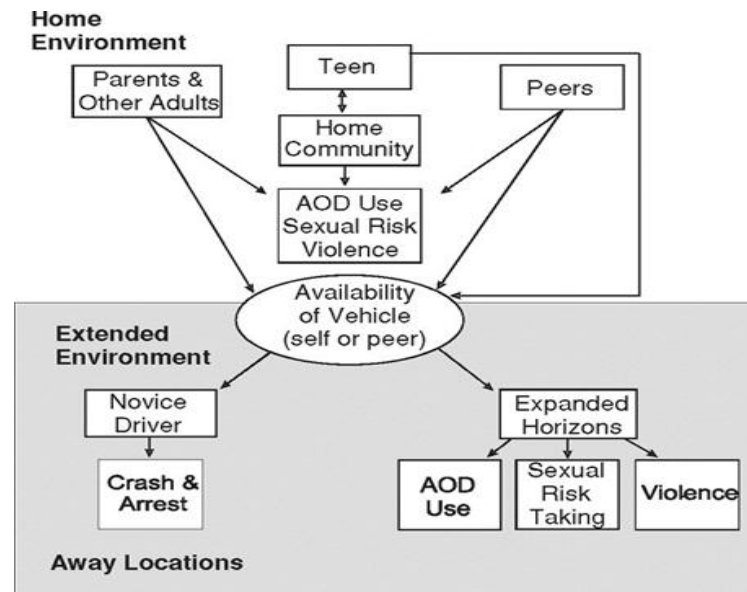


Figure 1. The Transitional Teen Theory model according to Voas & Kelley-Baker, 2008 (reprinted with permission)

Development- and age-related influences. Central to the model are the internally-controlled development- and age-related factors that influence driving behaviors of young people. These include the propensity to adopt unsafe driving practices, abilities to detect and respond to hazards, distinguish high-risk situations, maturity, and estimating one's abilities to drive (Ferguson et al., 1996; Rice et al., 2003; Ivers et al., 2009). As a result, crash risk is highest during the first years of independent driving among the youngest drivers (Mayhew et al. 2003; McCartt et al. 2003; Williams & Shabanova, 2003; Ferguson et al. 2007; Twisk & Stacey 2007) and declines each year until age 30 (IIHS, 2005). Studies of licensed young drivers (under age 20) have shown a per-mile crash rate that is up to five times that of the overall adult population, while that of 16-year-old licensed drivers are approximately ten times that of adults (McKnight & McKnight, 2003).

Peer influences. In the evolving absence of parental supervision young people seek to have an increased orientation to peers during the transition, especially into smaller

affinity groups, that fit into a car and seek others with similar behavioral norms and activities. The car as the “vehicle” provides the mobility for the peer group to experiment with other health risk behaviors. The use of cars for this purpose with peers can be considered inherently a dangerous approach to driving (Gregersen & Berg, 1994; Preusser et al., 2000) and functional in the lives of young people (Møller & Gregersen, 2008). Previous away-from-home transportation destinations were controlled and limited by adults. The increased mobility brings wider exposure to peers and environments where they perceive that they have more control over their own behavior (McCarthy & Brown, 2004).

Home environment influences. For the home environment, the model recognizes a continuing role in providing supervision and clear rule-definition with respect to vehicle access and driving expectations by parents. Continued adult supervision with car driving can impose compliance expectations, controls, and the promotion of alternative outlets to counterbalance the increasing role of peers (Bingham & Shope, 2004b). The use of GDL provides an opportunity to extend the role of parents by increasing the length of supervision (Hartos et al., 2004; Simons-Morton et al., 2006). It is the absence of parental guidance that peer influence can be influential in driving practices.

Extended environment influences. Driving behaviors and outcomes are also influenced by the extended environment where young people live and drive. Of particular interest to unlicensed drivers are the role of area and individual socioeconomic disadvantage and population density in the extended environment. Most of what is known about this comes from studies of adult populations where disadvantage and density were found to be associated with specific dangerous driving practices (e.g., restraint use, speed, and alcohol) and driving conditions (e.g., road conditions, vehicle types, and post-crash trauma care) (Baker et al., 1987; van Beeck et al., 1991; Noland & Quddus, 2004; La Torre et al., 2007; MMWR, 2009) contributing to negative RTI outcomes. Similar findings were also found to a lesser degree for the vulnerability of young drivers to socioeconomic disadvantage and low population density (Males 2009b; Chen et al., 2010a; Chen et al., 2010b) with comparable outcomes. Whether or not this is important for unlicensed drivers has not been investigated.

Within the extended environment expectations and norms related to dangerous driving practices such as unlicensed driving can also influence behaviors. Even though unlicensed driving is illegal, it is not always consistently enforced or detected in different settings (DeYoung & Gebers, 2004). By setting community standards, laws, and practices that are clearly communicated, modeled by parents, and consistently enforced to young people can define and direct driving behaviors of young people (Imai & Mansfield, 2008). Examples of such practices include zero-tolerance for alcohol laws (Williams & Ferguson, 2002), GDL systems (Williams et al., 2012), and

night curfews (Phebo & Dellinger, 1998). The challenge for parents and communities is to provide the appropriate expectations and norms and within given boundaries that do not limit opportunities for mobility, while also protecting them from the hazards.

UNLICENSED DRIVING AND RTI

The bulk of the studies dealing with RTCs are concerned with licensed drivers. Much less attention is paid to young people who drive a car illegally without a license as unlicensed drivers. The phenomenon of unlicensed driving and the subsequent RTI has been addressed in a limited number of studies, among others from Great Britain (Knox et al., 2003), Sweden (Hasselberg & Laflamme, 2009), Australia (FORS, 1997; Lam, 2003), New Zealand (Harré et al., 1996), Italy (Bina et al., 2006), and the US (Williams et al., 1995). It is of note that there are challenges to studying unlicensed driving poised by the illegal nature and wide availability of cars to all ages, in all settings (Watson, 1998). It is also suspected that the majority of unlicensed driving goes undetected limiting the true understanding of the scope and determinants of the problem (DeYoung & Gebers, 2004). When unlicensed drivers take to the road, it otherwise unknown unless they are involved in an incident reported to the police (Mayhew et al., 2000).

Unlicensed driving. Whether or not YUDs pose a greater risk for RTI has been suggested but not demonstrated from a lack of comparative crash data on the prevalence of unlicensed driving in the general population. Studies based on young adults and adult RTI and RTCs provide insight on the risk associated with unlicensed driving. In California (US) it was found that, for all ages aggregated there was a 4.9 increased risk of a RTC and severe RTI by unlicensed drivers (DeYoung et al., 1997). In turn, a study of unlicensed, suspended, revoked drivers from New Zealand showed an 11 times increase in risk for a RTC (Blows et al., 2005). In Sweden a study of 18-20 year-old unlicensed drivers revealed that they were over represented in RTC and severe RTI injuries when compared to same age licensed drivers (Hasselberg & Laflamme, 2009). The studies reveal that unlicensed and illegal driving are risky in their own right justifying further investigations of young people who drive unlicensed (DeYoung & Gebers, 2004; Blows et al., 2005).

Unlicensed driving in the US. An overview of fatal crashes from illegal driving (including suspended, revoked, cancelled, and unlicensed drivers) of all ages is provided by a series of US reports wittily titled “Unlicensed to Kill.” The reports showed that one-fifth (20%) of all fatal crashes involve an illegal driver of which 79.8% are males and less than 5% were strictly unlicensed. For younger drivers under 20 years of age, 32% of all crashes in their age group involved an unlicensed driver (Griffin & DeLaZerda, 2000; Scopatz et al., 2003). A wide geographic distribution of crashes was noted across the states (high of 23.9% in New Mexico and a low of 6.4% in Maine) with an average of 13.8% of fatal crashes involving illegal drivers (AAA Foundation for Traffic Safety, 2008).

Unlicensed driving among the young

Both self-reports and crash studies contribute to the understanding of the scope of unlicensed driving, the identity (who) of the unlicensed drivers (stratified by age, sex, socioeconomic, license status), and location (where) these crashes occur (defined as area differences, urbanicity level). Age is further stratified by distinguishing those who are generally of legal age to obtain a license or age-ineligible (underage) to be licensed based on the setting. The variance in self-reported behaviors and unlicensed driving are partially explained by study methods and to some degree the sociodemographics. These may also be more practical matters such as the availability of a vehicle, licensing practices, or public transport that are influential (Girasek & Taylor, 2010).

At the end of the chapter, overviews of the studies are summarized in Table 1 for self-reports and associated behaviors and Table 2 for crash studies for those who are both age-eligible to be licensed and underage with accompanying circumstances.

Underage drivers. The focus of many of the early unlicensed driving studies includes those who are not yet age-eligible to be licensed or underage (Williams et al., 1985). Technically any young person who can physically access a car and controls could be considered a potential unlicensed driver at any age. Underage drivers are a concern for three reasons. First, dangerous attitudes about driving that can begin well before the licensing age contribute to unlicensed driving (Waylen & McKenna, 2008). Secondly, underage drivers may not be capable of recognizing the enormity of the task or the risk and implications associated with unlicensed driving (Arnett, 2002). Third, self-reports (Begg et al., 1992; Ferguson et al., 1996; Muilenburg et al., 2007; McDowell et al., 2009) and crash studies (Lam, 2003; Huber, 2006) indicate that underage drivers can spend an inordinate amount of time on the roads prior to licensing.

Self-reported behaviors of unlicensed driving

Self-report studies provide a feasible, but limited, means to estimate and gain insights into unlicensed driving. These self-reports from various settings provide findings across the age groups, sex, settings, and crash circumstances.

Three regional studies, two in the US (Williams et al., 1985; Ferguson et al., 1996) and one in NZ (Harré et al., 1996), all done with students, found a wide variance of unlicensed driving from 18 to 58% (higher percent also included permitted drivers). In the US studies the driving patterns were generally those of supervised practice driving patterns with a family member present. It was found that males reported more driving alone, speeding, and driving after drinking compared to females. The unlicensed driving experiences varied with states in the south and those that allowed earlier ages of licensure reporting more unlicensed driving. A similar study of 15-16 year-olds in Auckland, NZ reported 18% of males and 28% of females reporting unlicensed driving at least three times per week. Unlicensed driving was also associated with speeding and

alcohol drinking. These early studies establish some of the base of age and unlicensed driving behaviors for future studies.

More recently in the US, a select group of schools in California (Heck et al., 2008) and a national sample (Elliott et al., 2008) found 12.4% and 4.2% reporting unlicensed driving respectively. The lower percent represents a more restrictive unlicensed driving definition (at least one hour per week). In California driving unlicensed and less likely to be licensed was found by those who attend a low-income school. The national study found risky driving behaviors to be more common among those with lower grades, those using alcohol, minority racial groups, those living in both rural or central city location, and among the unlicensed drivers compared to licensed drivers.

Five studies from New Zealand and Australia surveyed young people about their pre-licensed (unlicensed) driving at their completion of the first year of restricted driving. They were asked about their crash experience and driving practices in both instances. These studies differed by the fact that they were surveyed at the time of licensing determining that they did indeed get a license. Across the studies it was found that the amount and frequency of unsupervised pre-licensed driving was a good predictor of future risky driving and a crash during that first year of restricted licensing. Pre-licensed driver characteristics of those more likely to crash included more frequent driving, starting to drive at an earlier age, males, and living in economically deprived areas. Common driving behaviors among those in a crash included speeding, frequent driving, and non-use of seat belts. Non-traffic behaviors associated with the those drivers in a crash included more frequent health risk behaviors and greater sensation-seeking and aggression/hostility measures (Stevenson & Palamara, 2001; McDowell et al., 2009; Boufous et al., 2010; Scott-Parker, et al., 2012; Begg et al., 2011).

Two school-based surveys and a qualitative study of age-ineligible to be licensed students provide additional insights to unlicensed driving and related behaviors. In an impoverished area in a southern state (US) of those less than 15 years (all underage) it was found that over one-third of the students (36.8%) reported drinking and driving (Muilenberg et al., 2007). The second survey of 14-17 year-old Italian students reported unlicensed driving by 20% among a profile of health risk behaviors compared to their non-driving peers (Bina et al., 2005). A first qualitative study of underage drivers was conducted in an agricultural area in NZ that reported driving on the road and off the road commenced well before the age of licensing (many before 10 years-old). Unlicensed driving was a common and customary practice in assisting with farm chores. However, the early driving did affect later attitudes negatively for speeding and positively for avoiding drink driving (Knight et al., 2012).

Unlicensed driving in road traffic crashes

Crash studies of YUDs include RTI outcomes of all young drivers and victims and the drivers' age-eligibility to be licensed. Most of the crash studies of underage drivers are exclusively from the US.

Underage drivers. It should be noted that studies of underage unlicensed drivers generally find higher frequency (60%+) of occurrence, as most of the young people in this age group cannot obtain a license compared to studies with age-eligible drivers. Across the crash studies in general, unlicensed driving was more common among males and those approaching the age of eligibility to be license. Some studies highlighted driving behaviors where underage drivers demonstrated dangerous driving practices and assigned greater fault in the crashes (Williams, 1997). Common driving practices included single vehicle crashes, speeding, carrying same age passengers, driving without parental supervision, and night driving (Huber, 2006). A series of three region-specific studies examined underage driving finding a majority of the crashes in southern states, rural and farming areas, and states with early licensure. Males were found to be more associated with crashes and dangerous driving behaviors such as speeding and low restraint use (Frisch et al., 2003; Frisch & Plessinger, 2007; Frisch, 2007). Two additional findings were that females had the twice the risk of an occupant injury in the crash and 13% of the crashed involved a police chase (Lam, 2003). Similar in the US over four years there 49 fatal police pursuits of underage drivers that most occurred in urban areas and four states (Plessinger & Frisch, 2005). Finally, in the US 13-15 year olds in fatal crashes (some driving with a permit) were mostly males with six-fold higher fatality for occupants than the underage driver. Single vehicle crash, speeding, and no restraint use were frequent (Williams & Tison, 2012).

Age-eligible young drivers. On the other hand, age-eligible to be licensed drivers represent an older age range and present a different set of driving practices. A US study of fatal crashes of 16 year-olds, unlicensed drivers were involved in 9% of the crashes (Williams et al., 1995). Next, in the US over 10 years, 16-24 year-olds reported 7.3% of all fatal crashes. Females were involved in 3.8% and males over double (9.6%) of the crashes with alcohol use a common factor for both sexes (Tsai et al., 2008). In Sweden, 7.5% (n= 2448) of crashes of 18-20 year-olds involved an unlicensed driver (licensure age is 18 years). Compared to licensed drivers the crashes were more likely to occur in sparsely populated areas, in single vehicle crashes, crashes at night, alcohol influence, and with severe RTI (Hasselberg & Laflamme, 2009).

In California, three studies examining the pre- and post-GDL fatal crash occurrence of unlicensed drivers using different age configurations found elevated proportions. One study found for 16 year olds an increase from 23% to 34%, 17 year olds an increase of 22% to 29% over 11 years (Males, 2007). In the second study those less than 18 years-old increased from 19.4% to 22.5% and 18 to 19 year-olds from 25.7% to 28.9% over

eight years (Males, 2006). One study looking at 35 counties found both lower rates of licensing and elevated YUD fatalities in counties with more poverty (Males, 2009a). The author attributed the higher rates to not only GDL restrictions on disadvantaged youth, but also to the on-going economic and immigration issues in the state. Similar economic downturns have also had an influence on licensing practices for young people recognized in Sweden (Murray, 2003).

Summary

The knowledge at hand about unlicensed driving among young people primarily rests on studies based on self-reports and road traffic crashes. Both types of data suggest the practice is an unacceptably high risk activity subjecting young people and other road users to dangers. It is further suggested with some evidence that unlicensed driving and RTIs are not randomly distributed among socio-demographic groups of young people and living areas. Addressing unlicensed driving by young people can only serve to promote road traffic safety for all.

Table 1. Summary of the self-reported studies on unlicensed driving among young people and related behaviors

Source	Setting/Time frame	YUD defined/ age group	Purpose of Study	Main findings
Williams, et al., 1985	75 secondary schools from 2 US states and counties Spring 1983	No permit or license to drive	Driving behaviors of unlicensed and licensed drivers and car use	Scope: 21% drove once a week or more with a family member, 15% drove once or more a week with friends, and 5% drove alone. Who: 56% females Where: Southern and western states Behavior: 13% males and 5% females drove once a week by themselves
Ferguson et al., 1996	5 contiguous states in same region 1992	Age of first driving without a permit by state Secondary school seniors	Differences in state licensing practices and age of licensing	Scope: 35-58% by state Behavior: States with early age licensing also had early age unlicensed driving
Harré et al., 1996	7 secondary schools in Auckland, NZ No date indicated	No license/ three times/week Students 15-16 year-olds	Gender differences in driving attitudes and behaviors of adolescents	Who: 18% males and 28% females Behaviors: Unlicensed driving associated with speeding and drinking alcohol
Heck et al., 2008	Central Valley, California (US) 2006	No license or permit Seniors in 13 secondary schools	Driving circumstances and behaviors	Scope: 12.4% Who: More likely to be male and racial minorities. Where: Less licensed and more unlicensed driving from students attending lower income schools Behaviors: More likely to report driving for getting to school/work and go out with friends

Source	Setting/Time frame	YUD defined/ age group	Purpose of Study	Main findings
Elliott et al., 2008	66 secondary schools (US) National Young Driver Survey (representative sample) 2006	Driving at least one hour alone or learning to drive without a permit. Secondary school students	Prevalence of unlicensed driving and associated driving factors	Scope: 4.2% reported driving more than one hour per week. 5.1% reported unlicensed driving. Who: More likely to be black, Hispanic, and those with lower school grades. No differences in age or gender. Where: Live in rural or central city Behaviors: Lower seat belt use and alcohol and driving, and more trips without purpose. No differences in crashes with licensed drivers
Stevenson & Palamara, 2001	Western Australia 1997-1998	Pre-license driving at licensing centers.	Pre-disposing factors to crash in first year of driving	Who: First driving by males at 13.9 years and females at 15.2 years Where: Rural drivers more likely to begin driving earlier (12.2 years) Behavior: More alcohol consumption, driver confidence, and lower age of driving. Pre-license driving and risk level associated with crash during first year of driving
McDowell et al., 2009	North and South Islands of New Zealand 2006-2008	Pre-license driving at licensing centers. Māori youth 15-17 years	Extent and type of unlicensed driving of Māori youth	Who: No difference by sex Where: Urban (65%) and rural (83%) Behavior: Similar reasons and driving between urban and rural. Females more likely to report crash outcomes
Scott-Parker et al., 2011	Queensland, Australia 2010	Pre-license driving at licensing centers. 17-19 years newly licensed drivers	Driving prior to provisional license	Scope: 12%. Average 14.7 times. Who: 39.2% males and 60.8% females. Males drove more times Behaviors: Risky driving intentions and behaviors and traffic offenses as learners and provisional drivers

Source	Setting/Time frame	YUD defined/ age group	Purpose of Study	Main findings
Begg et al., 2011	New Zealand February 2006- 2008	Never licensed	Demographic and behavioral factors of pre-licensed driving	Scope: 54%, 51.2% male Who: Higher among males and Māori. Where: More frequent in rural and areas of high deprivation Behavior: More likely to drink alcohol, smoking, cannabis use, and more sensation seeking and aggression/hostility expressed
Boufous et al., 2010	NSW, Australia 2003-2004	County of birth using driving and crash data 12-24 year olds	Police reported crashes before learner license	Who: Asian-born less likely to drive unlicensed than Australian born. Behaviors: Earlier driving lead to more crashes as licensed drivers. Speeding and non-use of seat belts in crashes
Muilenburg et al., 2007	Mississippi Delta (US), one school in low-income area Year not indicated	No license, age-ineligible 7-8 grade old middle school students (12-14 years)	Health risk behaviors	Scope: 36.8% of those <15 years reported driving a car after drinking alcohol
Bina et al., 2005	Small and mid-size towns in northwestern Italy Pre-2004	No license All vehicles 14-17 year- olds	Association of risky driving and lifestyle	Scope: 20% Behaviors: 23% drove more than one vehicle, 11% drove more than 100 km. Higher profile of health risk behaviors among all drivers.
Knight et al., 2012	Rural NSW, AU No date given	Qualitative study in a 4 rural /farming communities 15-24 year-olds	Early driving influence on attitude	Scope: Most reported common on and off road driving beginning before age 10. Behaviors: Early driving risks clearly understood but contributed to risky driving later

Table 2. Summary of the crash studies on unlicensed driving and drivers for those underage and age-eligible to be licensed and circumstances

Source	Setting/Time frame/study base	YUD defined/ Age group	Purpose of Study	Data source	Main findings
CRASH STUDIES UNDERAGE					
Williams et al., 1997	33 US states 1989-1993	Not licensed 15-16 year-olds	Crashes of 15 year- olds of supervised learners and unlicensed drivers	FARS	Who: 57% 15 year olds and 10% 16 year olds Circumstances: Teenage passengers, carrying 2+ passengers, after midnight, and single vehicle crashes. Culpable for crash. Supervised crashes were rare
Huber, 2006	Texas (US) 1995-2000	Unlicensed <15 years	Characteristics and crash circumstances of underage drivers	TX Dept. of Public Safety	Scope: 64.7% injury crashes 1.8% fatal crash (n=2698 crashes). Who: 61% male Where: Rural, speeding, night time, passengers increased injury severity
Frisch et al., 2003	US 1996-2000	5 year rates per 10,000 children/ unlicensed 7-14 year-olds	Fatal crashes <15 years	FARS	Scope: 85 deaths per year Where: Rural roadways, higher rates in states that allow 14 year-olds to drive, most crashes occur in four states
Frisch et al., 2007	US 1999-2003	Rural Urban Continuum Codes (USDA) 7-14 years	Fatal crash rates per 100,000 children	FARS	Who: Males 66% Where: More common in states with higher percent of farm/rural population and percent of unlicensed youth. More southern and intermountain states Circumstances: Low restraint use, speeding

Source	Setting/Time frame/study base	YUD defined/ Age group	Purpose of Study	Data source	Main findings
Frisch, 2007	South and southwestern US states 1999-2004	Fatal crashes of passenger vehicles, rates per capita in Texas RUCC < 15 years	Case report of YUD crashes in Texas	FARS	Scope: 412 crashes, 477 fatalities Who: 66% male Where: Southern states 44% of all crashes, rural Circumstances: Daylight hours and less likely to involve alcohol
Lam, 2003	NSW, Australia 1996-2000	All underage crash <16 years Not age-eligible to be licensed	Characteristics and crash-related injury	Traffic Accident Database System-Road Traffic Authority of NSW	Scope: 526 crashes Who: 88% were 14-15 year-olds, 79.5% males. Circumstances: Female crashes twice risk of an occupant injury. 13.3% crashes with police pursuit (n=70), 62% carrying passengers, female injury severity increases with more passengers
Plessinger & Frisch, 2005	US 1999-2003	Unlicensed drivers < 15 years	Crashes involving a police pursuit of young drivers	FARS	Scope: 49 fatal pursuits with 69 deaths Who: 90% were 14 year-olds Where: 90% in metro areas. 22 crashes in only 4 states
Williams & Tison, 2012	US 2005-2009	No license or permit 13-15 year-olds	Crash and passenger profiles	FARS	Scope: 299 drivers and 1994 passengers died Who: 13% 15 year-olds, 63% 13-15 year-olds, 70% males Circumstances: Single vehicle, speeding, and no restraint use

Source	Setting/Time frame/study base	YUD defined/ Age group	Purpose of Study	Data source	Main findings
CRASH STUDIES AGE-ELIGIBLE					
Williams et al., 1995	US 1993	Unlicensed 16 year-olds	Crash circumstances of 16 year-olds	FARS	Scope: 9%
Tsai et al., 2008	US 1995-2004	Non-valid license and no license 16-24 year-olds	Trends in female fatal crashes	FARS	Scope: 7.3% Who: 3.8% females, 9.6% males. Proportion increased in female YUDs over 10 years Where: Increase crashes with decreased percent of licensed holders in state Circumstances: Alcohol use similar for males and females
Hasselberg & Laflamme, 2009	Sweden 2003-2004	Not licensed or revoked 18-20 year-olds	Circumstances of car crashes of young drivers	Police Register data	Scope: 7.5% of all crashes Circumstances: Severe injury, single and night crashes, and 37% alcohol influence
Males, 2007	California (US) 1995-2005	Unlicensed 16-19 years	Fatalities of 16-19 year-olds Post-GDL	FARS	Who: Increase in deaths of ages 16 (23 to 34%) and 17 (22 to 29%) post-GDL

Source	Setting/Time frame/study base	YUD defined/ Age group	Purpose of Study	Data source	Main findings
Males, 2006	California, US 1996-2004	Unlicensed Less than 18 years and 18-19 years	Fatalities post- GDL	CA Department of Finance and Motor Vehicles; FARS	Who: Increase in fatalities of ages <18 from 19.4% to 22.5% and 18-19 from 25.7% to 28.9% post GDL
Males, 2009	California, US 35 counties 1994-2007	Unlicensed driving and 8 county variables 16-19 years	Poverty and fatal crashes	FARS	Scope: 22.2% 16-19 year-olds Where: Poorer counties had lower rates of licensing and elevated rates of unlicensed drivers.

AIMS

The thesis aims to increase knowledge about the scope of unlicensed driving in youth and its related individual and contextual attributes. The studies will broaden the scope of unlicensed driving beyond the age of eligibility to be licensed (Studies I, III, IV).

Further information is also needed to shorten the gap in understanding both the individual (Study III) and area (Study II) determinants of unlicensed driving and RTI is apparent. Minimal attention has been given to the non-traffic health risk behaviors linked with unlicensed drivers that are expanded here (Study IV).

The following research questions will be addressed:

Driver characteristics and crash circumstances (Study and article I)

- What is the frequency of occurrence of young driver fatal crashes that involve YUDs?
- What are the driver characteristics and crash circumstances involving YUDs?
- Are there age and sex differences in fatal crashes involving YUDs?

County contextual factors (Study and article II)

- Does county material deprivation and urbanicity play a role with the occurrence of unlicensed car driving fatal crashes among the young?

Young driver crash characteristics and circumstances (Study and article III)

- What is the scope of unlicensed driving crashes among young people?
- What are the characteristics of unlicensed young people involved in car crashes compared to licensed drivers?
- What are the RTI and crash circumstances of YUDs involved in car crashes?

Health risk behaviors and driving practices among high school students (Study IV)

- Do health risk behaviors distinguish drivers by driving practice group?
- Do unlicensed and licensed drivers differ in their practice in car driving health risk behaviors?

METHODS

Overview of the organization of the thesis

The thesis encompasses four register-based studies, three of which deal with the crash experience of young unlicensed drivers and one with self-reported driving and health risk behaviors among high school students (see Table 1). Three studies deal with the US context and one is from Sweden. The Swedish study allowed the incorporation of individual socioeconomic register data not readily available in the US. In the remainder of the thesis, young unlicensed driver(s) will be referred to as YUD(s).

Table 3. Overview of the thesis organization

Article/ Study	Research questions	Observation unit	Outcome	Main focus/ definition
I	What is the frequency of occurrence of young driver fatal crashes that involve YUDs? What are the driver characteristics and crash circumstances involving YUDs? Are there age and sex differences in fatal crashes involving YUDs?	Fatal crash	RTC fatality	WHO: Age /Sex WHERE: Region
II	Does material deprivation and urbanicity play a role in the county-level occurrence of unlicensed car driving fatal crashes among the young?	County	Fatal RTC	WHERE: Urbanicity/ Material Deprivation
III	What is the scope and age distribution of YUD crashes? What are the individual characteristics of YUDs involved in car crashes compared to licensed drivers? What are the RTI and crash circumstances of YUDs involved in car crashes?	Individual	RTI RTC	WHO: Age/Sex WHERE: SES/ Urbanicity
IV	Do health risk behaviors distinguish drivers by driving practice group among high school students? Do unlicensed and licensed drivers differ in their practice in car driving health risk behaviors among high school students?	Individual	Health risk behaviors	WHO: Age/ Driving status

Aspects and concepts central to the thesis are clarified and defined below.

Study designs. All three studies from the US are cross-sectional and the Swedish one has a cohort design. In Study I, a focus on the crashes involving YUDs, the question of “who” and “where” of fatal crashes are described with driver characteristics and crash circumstances. Study II, area-based, looks at the “where” crashes occurred in relation to county-level material deprivation and urbanicity. Study III in Sweden looks at the “who” and “where” of the YUDs involved in fatal and non-fatal crashes and the circumstances of their RTIs. Study IV considers “who” with self-reported health risk behaviors based on driving practices and licensing.

The focus of the studies included driver characteristics (who) such as age (Studies I, III) described below, sex which is self-explanatory (Studies I, III, IV), and socioeconomic position (Study III) described under the study. “Where” is the location of the residence of the young person (Study I, II) or the site of the crash (Study III) described below.

Age. The studies altogether cover a range of ages, from pre- to post eligibility for a license that allows for investigation in two contexts – age ineligible at 14-15 and age-eligible at 16+ in the US and two years later in Sweden. The two US national crash studies considered young drivers up to the age of 18 years. In the US, the age of driver licensing varies from 14 years in a few states to 16 years in most states (Williams, 2009). In Study I, the lower age limit was not restricted (and turned out to be 8 years). In Study II, the lower limit was set at 11 years due to the very low number of cases under that age. In Sweden, 18 years is the age of driver licensing. Given the design of the Swedish study (Study III; see below), no age limit was set; age at time of crash ranged between 11 to 27 years of the cohort. The study on health risk behaviors (Study IV), focused on high school students, included a limited age range from 16 (corresponding to the age of eligibility to be licensed in the state) to 19 years (typical age of high school completion).

Unlicensed driving. In the three crash studies, unlicensed driving means operating a motor vehicle on a road when one does not have a driving license and to the best of our knowledge has never been licensed to drive. It excludes those driving with a learner’s permit or a provisional license as well as those who have their driving privileges suspended or revoked. In the health risk behavior study, unlicensed driving also deals with “never been licensed” youth and is defined by the survey question about driving practice and license (Study IV). The scope of the problem is described as the overall frequency of occurrence and circumstances of crashes or behaviors of unlicensed driving/drivers.

Area. In the three studies that examine area, the first two are area-based on the residence of the YUD (US) and the third study is individual-based on the location of the crash. Each crash study examines various geographic area configurations and attributes described as “where.” In Study I, crashes were assigned to one of the US four

Census regions (see Figure 2). In Study II, the unit of observation was the county with each assigned an urbanicity designation based on the Rural Urban Continuum Codes (USDA, 2003) and material deprivation score based on the county. Counties were also grouped into nine US Census divisions (see Figure 2). In Study III, an individual- based study, the place of occurrence of a crash was classified in one of five area levels of urbanicity based on population and distance from city center derived from the Swedish Population Register information.

Crash. In Studies I, II, III the term crash includes the event and circumstances where at least one car is driven by a YUD as the outcome measure. In all studies, the crash information is extracted from official registers based on police reports. Crashes were also restricted to those involving four-wheeled passenger motor vehicle(s). Farm machinery, off-road recreational vehicles, and three- or fewer-wheeled vehicles were excluded. Differences exist in recording the crash events between the US and Swedish registers. The US register includes only crashes that result in a fatality on a public road without individual identifiers. As such, the observation unit is the crash in Study I. There are no national registers of non-fatal crashes in the US. The Swedish register includes all crashes on private and public roads regardless of injury outcomes identified to the individual as the observation unit. Both registers update the records for a fatality that occurs 30 days after the crash event.

Study Settings

US motor vehicle transportation. Motor vehicle transportation includes a network of over 3.9 million miles (6,237,290 kilometers) of roads. Vehicles that include cars, trucks, vans, and motorcycles account for 86% of passenger-miles traveled on roads. In 2003, there were 759 automobiles per 1,000 US inhabitants compared to 472 per 1,000 inhabitants of the European Union. In the US there are an estimated 205.7 million licensed drivers, 6.4% (13.2 million) are young people between 15 and 20 years old. In the US, there were 43,443 fatalities in 2005. Source: <http://www.nationalatlas.gov/transportation.html>

The US has a relatively low age of licensure, less restrictive laws governing issuance of driving license, and availability of cars. Obtaining a license upon becoming age-eligible is relatively easy and inexpensive by global standards (Patel et al., 2000). Each state establishes their own licensing regulations. To obtain driving privileges some states allow provisional driving/learner's permits for 14 year-olds; most allow drivers to begin learning at age 15, and in all but one state 16 years is the minimum age to obtain a driver's license (age 17 in New Jersey). All states have some form of a graduated drivers licensing system (GDL) that modulates the risk with increasing driving privileges for novice drivers through to age 18 (cite). In other motorized countries, the minimum licensing age is 18 or a learner/practice license can be obtained license at age of 16 but this involves great cost and extensive training.

Sweden motor vehicle transportation. The Swedish National Road Administration manages the country's road network and safety. The road network totals about 420,000 km (261,000 miles) with two-thirds that are primarily private, unpaved forestry roads open to the public. The distance of State-owned roads is 98,000 km (61,000 miles), while municipal road and street networks total about 40,000 km (25,000 miles). Much of Sweden is also covered by a well-organized, reliable, and efficient public transport network connected to most of the country. In Sweden, there were approximately 3.9 million registered cars among 8.9 million inhabitants (44 cars per 100 inhabitants) in 2000. The current basic speed limit is between 30 mph (19 mph) in built up areas and on highways the typical speed limit is 90 kph (56 mph) and freeways (motorways) it is usually 110 kph (68 mph). Already with the lowest number of traffic fatalities in relation to its population among motorized countries, Sweden has a long-term commitment to road safety goal of no road traffic fatalities or serious injuries. The 2005 Swedish road traffic fatality count was 440. Source: Swedish Institute- www.sweden.se

In Sweden, there is no GDL system but young people may start to learn at the age of 16 with a learner's permit. Driver education for learner-drivers can choose professional education at a driving school and/or private education by a lay instructor who is at least 24 years-old and who has held a driving license for a minimum of five years. There is a three-stage process of driver training and education for 18 year-olds to obtain a license. The first stage is the human factor and knowledge of other dangers in traffic. Secondly, a practice driving course to learn how to control a car during a spin. Finally, to determine if the student has gained competence of the curriculum, a driving-license test that consists of practical and theory components is taken. Upon passing, the driving test allows a temporary driver's license (valid for a year) is issued (Henriksson et al., 2004). Approximately 27% of Swedish youth have a driving license at the age of 18 with 31% among males and 22% for females (Hasselberg et al., 2005).

US fatal crash studies

Both US crash studies (I and II), presented first, drew their respective crash and population data from the same national register.

Fatal Analysis Reporting System (crash data). Crash data for 1998-2002 (Study I) (NHTSA, 1998-2002) and 2000-2006 (Study II) (NHTSA, 2000-2006) were extracted from the Fatal Analysis Reporting System (FARS) that is administered by the National Highway Traffic Safety Administration (NHTSA) in the US Department of Transportation (DOT). The NHTSA is charged with reducing deaths, injuries, and economic losses resulting from motor vehicle crashes. The FARS provides crash data circumstances on all motor vehicle fatalities occurring on a road normally open to the public. Those data are collected on over 185 coded elements organized into linkable crash, vehicle, and person files. NHTSA has a cooperative agreement with an agency in each state government to provide information in a standard format on fatal crashes.

Quality Control is a vital system feature with a series of consistency checks for timeliness, completeness, and accuracy from the states. Crash data are restricted to the subjective assessment of the police at the scene. To protect individual privacy, no personal information, such as names, addresses, or specific crash locations are entered in the system. For more information about FARS:

<http://www.nhtsa.dot.gov/people/crash/Index.html>

US Census (population data) The Census Bureau in the US Department of Commerce provides an estimated count of US residents every ten years. The data include individual demographics (e.g., age, sex, race, Hispanic or Latino origin), employment (e.g., employment status and characteristics and poverty), and housing conditions (e.g., household type, group quarters population, housing occupancy, and housing tenure). Data are subjected to a set of checks to insure accuracy and overall reliability. Data are available at different geographic levels within states and across multi-state boundaries including regions and divisions. For more information about the US Census:

<http://www.census.gov/>

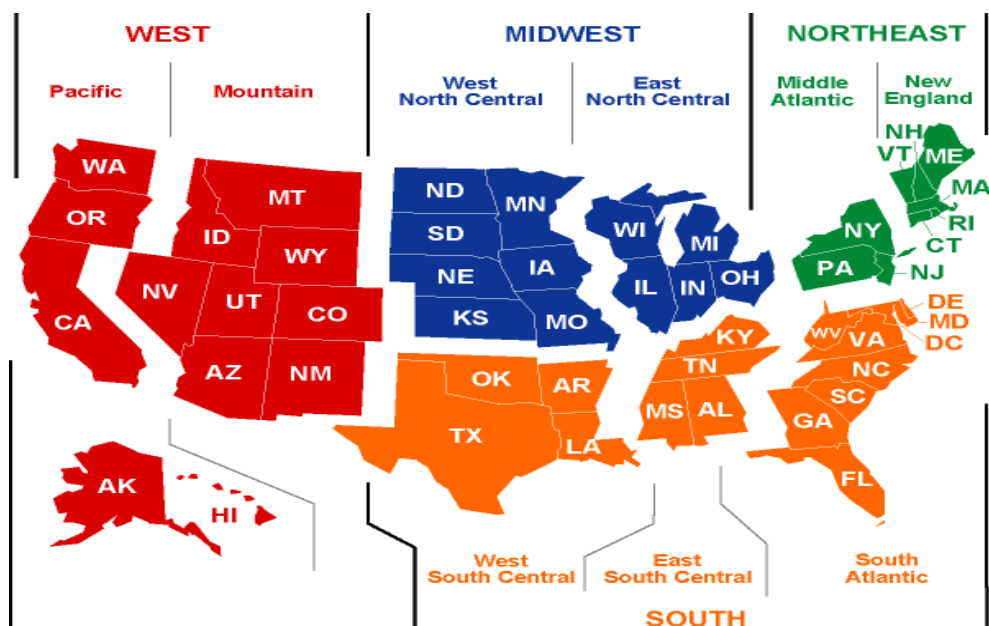


Figure 2. US Census regions, divisions, and states

Study I Young unlicensed drivers involved in fatal crashes in the US

Study questions

- What is the frequency of occurrence of young driver fatal crashes that involve unlicensed drivers?
- What are the driver characteristics and crash circumstances involving YUDs?
- Are there age and sex differences in fatal crashes involving YUDs?

Observation unit. The observation unit in this study was a fatal crash. In FARS, during the period 1998-2002, 2,457 YUDs were involved in 2,452 fatal crashes. For a crash to be included in FARS there must be a fatality.

Driver characteristics. Young people under the age of 19 who were involved in a fatal crash were included. The youngest driver in the crash that was 8 years-old defining the lower age limit. In the age-based analysis, the YUDs aged 8 to 13 years were aggregated. Crash circumstances were stratified by age and sex further clarifying the “who.”

Where. Crashes were assigned to one of four regions (west, midwest, south, or northeast) based on the residence of the YUD and the licensed driver (n=20,780) crash for geographic distribution.

Crash circumstances. Temporal descriptors included time of the crash in three-hour increments (8 categories), 7 days of the week, 12 months of the year, and year (5 years of observation). Additional crash variable circumstances are described in Table 4.

Table 4. Study variables and definitions

Crash variable circumstances	FARS definition
<u>Speed limit zone of crash</u> (aggregated into four different miles per hours speed groups)	Actual posted or statutory miles per hour speed limit. Acceptable speed limits are in 5 mph increments.
<u>Number of vehicles in crash</u> (crashes with four plus vehicles are combined)	Only motor vehicles in transport when they are on the traffic way or on the roadway (whether in motion or not).
<u>Number of occupants in YUD vehicle at crash</u> (six or more occupants are combined)	Vehicle and total number of occupants in the motor vehicle.
<u>Restraint use by YUD</u> (only lap/shoulder belt considered proper use)	Coded regardless of whether the vehicle is equipped with manual systems, automatic belts or harnesses, air bags, or any combination.
<u>Owner of the vehicle driven by the YUD</u> (not the registered owner; registered owner; other private owner; stolen; driverless; or business/ government/ rental combined)	Type of registered owner of the vehicle.
<u>Injury severity to YUD</u>	Fatality injury; incapacitating injury; non-incapacitating evident injury; possible injury; injured-severity unknown; no injury; died prior to accident, and unknown.

Data treatment. Univariate analyses were conducted to describe the distribution of the fatal crashes involving YUDs. Also, Pearson chi-square tests were used to measure the association between driver characteristics (age and sex) and crash circumstance

variables. The proportion and total of crashes of unlicensed drivers by region and involving young licensed and unlicensed driver crashes were compared.

Study II Fatal crash involvement of unlicensed young drivers: County level differences in the US

Study question

- Does material deprivation and urbanicity play a role in the county-level occurrence of unlicensed car driving fatal crashes among the young?

Observation unit. County was used as the observation unit of analysis. In the US, counties (n =3141) are administrative units of government that sub-divide each state (n=50). In the study, all independent cities (n =43) were considered as county equivalent as was the District of Columbia. County populations and area sizes vary widely in each state as described in the article II (US Census, 2000). County material deprivation and urbanicity differences for “where” were examined using the nine US Census divisions independently and collectively as seen in Figure 2.

Outcome: The outcome of this study was a fatal crash. In FARS, during the period 2000 to 2004, a total of 3059 YUD crashes were recorded for unlicensed drivers between the ages of 11-18.

Material deprivation. County level material deprivation was measured with a directory constructed from the Townsend Index of Relative Material Deprivation as a general measure of the availability and access to local goods, services, resources, and amenities. The Index includes four area attributes to measure small area deprivation (Townsend, 1967; Townsend et al., 1988). For the present study, the area attributes were derived at the county-level from the 2000 US Census data variables aligned to the Townsend definitions as described in Table 5.

Table 5. Census material deprivation and Townsend index variables and definitions

US Census Variables	Townsend Index of Material Deprivation Definitions	US Census Definitions
Occupants per room	Percentage of households with more than one person per room	Percent of people in each occupied housing unit divided by the number of unit rooms. More than 2.01 persons per room
Unemployed	Percentage of economically active people unemployed	Percent of 16 years-old and over classified as unemployed by not working but available and looking for work during the previous four weeks.
Vehicles per household	Percentage of households with no car	Percent of the aggregate number of vehicles available by the number of occupied housing units.
Renter occupied housing	Percentage of households not owner-occupied	Percent of all occupied housing units that are not owner occupied, and occupied with payment of cash rent.

Urbanicity. Urbanicity was based on the US Department of Agriculture (USDA) Rural-Urban Continuum Codes (RUCC) (cite). The RUCC provides a county-level classification scheme that considers population and proximity to a metropolitan area or areas status in June 2003. In the RUCC all US counties are codified into nine levels, either one of three metropolitan or six non-metropolitan groupings. The county distribution of crashes occurring in less than half of the counties necessitated the construction of nine levels to one metropolitan and two nonmetropolitan county groups as described in Table 6. For more information about RUCC: <http://www.ers.usda.gov/Data/RuralUrbanContinuumCodes/>

Table 6. Constructed urbanicity levels, RUCC 2003

Urbanicity Level	RUCC Category	RUCC Description	Number of counties/population
Urban	1,2,3	Counties in metro areas with a population of 250,000 to 1 million or more	1089/232,579,940
Suburban	4,5,6	Counties with populations of 20,000 or more adjacent to or not to metro county	932/ 20,015,434
Rural	7,8,9	Counties of 19,999 to less than 2500 adjacent or not to a metro county	1120/13,692,175

Data treatment. The outcome was dichotomized by counties with at least one fatal crash and those without a crash. The distribution of fatal crashes across counties was highly skewed, with many counties having none or two or fewer crashes. A single material deprivation score was derived and calculated and urbanicity level were assigned at the county level. The first of two steps used an unconditional model to test the main effects and interactions of census division, urbanicity, and material deprivation to assess the necessity of the use of the conditional model on census division. No significant interactions with census division would indicate that the main effects and interaction were uniform across census divisions and no need for further analysis. A significant interaction with census division would indicate the need to test conditionally to account for variations across divisions. The conditional logistic model was used to test the main effects and interactions of urbanicity and material deprivation conditional on census division. Both models used logistic regression with odds ratios calculated with 95% confidence intervals (CI).

SWEDISH CRASH STUDY

Study III Road traffic crash circumstances and consequences among young unlicensed drivers: A Swedish cohort study on socioeconomic disparities

Study Questions

- What is the scope and age distribution of YUD crashes?
- What are the individual characteristics of YUDs involved in car crashes?
- What are the RTI and crash circumstances of YUDs involved in car crashes?

Observation Unit: The study was conducted at the individual level and used a population-based cohort that includes individuals born between 1977 and 1991 (n= 1,616,621) who were in the Swedish Population Register on 31 December 1997. This register contains individual information about place/date of birth of the subjects, sex, immigration and emigration, citizen and civil status, housing, parish/municipality, and

family relationships of each resident. Record linkage with the various registers summarized in Table 7 was made using the Swedish personal identification number.

Table 7. Summary of crash and population data

Agency	Registers	Variable
Swedish National Road Administration	Swedish National Road Registry (1998-2002)	Car crash morbidity and mortality
	Swedish Traffic Accident Data Acquisition 2003-2004	
	National Driver's License Registry	License status
	Swedish Motor Vehicle Registry	Parental car ownership
Statistics Sweden	Population and Housing Census 1990	Urbanicity of living area Parent's social position
	Swedish Total Enumeration Income Survey	Social welfare recipient Family disposable income
Swedish Population Registry		Population cohort

Individual socio-demographic characteristics. Individual socio-demographic characteristics are gathered countrywide on individuals every five years by Statistics Sweden (1990). The Population and Housing Census information on the family social position, welfare recipients, family disposable income, and urbanicity of living area of the cohort was presented. The family social position was constructed based on a classification scheme of the dominant parent's occupation. The scheme divides occupations into six socioeconomic groups based on production, type of production, and education required for their occupation. These include intermediate and high-level salaried employees; farmer (small-scale and medium-scale farmers); self-employed (self-employed without employees or small-scale entrepreneurs); assistant non-manual employees; manual workers (skilled and unskilled); and others (such as students, persons on sickness leave and disability pensions, and the long-term unemployed). The quality of the information is regarded as good as missing cases are less than one percent.

Statistics Sweden also includes social welfare recipients and family disposable income derived from the Swedish Total Enumeration Income Survey. Social welfare benefits include for example temporary economic support, sickness pension, and permanent disability. Disposable income is calculated from total income, after tax and transfers divided by the weight of consumption taking into consideration the number of children and adults in the household.

Where: Urbanicity of living area categories was derived from the Swedish Population Register (1998) defined by five levels based on population density and proximity to the city center (see Table 8).

Table 8. Urbanicity of Living Areas-Sweden, 1998

Urbanicity of living area	Population (kilometers [km] from city center)
Metropolitan	>300,000 persons
Large urban	>90,000 persons (30 km)
Medium-sized urban	27,000- 90,000 persons (30 km) and >300,000 persons (100 km)
Small urban	27,000-90,000 people (30km) and <300,000 of the same city center(100 km)
Rural	<27,000 people (30km)

**Figure 3. Map of Sweden**

<http://www.wordtravels.com/Travelguide/Countries/Sweden/Map>

Licensed and unlicensed drivers. In calculating person-time at risk, those without a date of issue for a full driver's license at the time of crash were defined as unlicensed drivers. Drivers were regarded as licensed drivers from the date the license was issued. Information was obtained from the National Driver's License Register.

Outcomes: RTC and RTI severity both serve as outcome measures provided by the Swedish National Road Registry database. The database also provided information on people, vehicle, and circumstances on crashes from police-reports from 1998 to 2004. Crash circumstances age and sex, suspicion of impaired driving due to alcohol/drugs; type and severity of injury to the driver and most serious injury to all others in the crash separately; driving conditions including speed restriction; weather and road conditions; time of crash, and urbanization level of crash site were stratified by license status. Crashes were restricted to first time car crashes (n=21,386). Road traffic injuries to unlicensed drivers and other were classified into four categories of injury outcomes: (1)

no physical injury; (2) minor injuries not requiring hospital care; (3) serious injuries requiring hospital care; and (4) fatalities. A severe RTC injury includes hospital care (3) and a fatality (4).

Data treatment. The seven-year cumulative incidence of RTC per 1,000 person years with 95% confidence intervals were calculated as the ratio of the number of RTCs per year at each age by the person-time at risk by age (13-27 years) for licensed and unlicensed drivers. The crash circumstances assigned to each unlicensed and licensed driver were described as proportions by category of variables compared using p-values for chi-square test. Accuracy and completeness of crash data are restricted to the reporting and subjective assessment of the police at the scene. The hazard ratios were among unlicensed drivers with corresponding 95% confidence intervals (CIs) as measured by relative risks (RR) using Cox regression in assessing the effect of socioeconomic positions and level of urbanicity on the risk of a YUD crash. Relative risks are presented as crude and as adjusted for sex and age as a continuous variable (by stratification allowing the baseline hazard function to vary for the different age cohorts).

Health Risk Behavior Study

Study IV Unlicensed driving and other related health risk behaviors: A study of Montana high school students

Research Questions

- Do health risk behaviors distinguish students by driving practice groups?
- Do unlicensed and licensed drivers differ in their involvement in car driving health risk behaviors?

Observation unit: The study is based on the individuals who were age-eligible to be licensed drawn from participants in the Montana YRBSS in 2003, 2005, and 2007 (n=5895). Students were stratified by driving status and sex.



Figure 4. Location of the State of Montana, US
http://www.nationsonline.org/oneworld/usa_map.htm

Data source. The Youth Risk Behavioral Surveillance System (YRBSS) is a biennially (odd years) state-based epidemiologic surveillance conducted in selected states by the US Centers for Disease Control and Prevention (CDC) (Brener et al., 2004). CDC developed the YRBSS to monitor priority health-risk behaviors that contribute to the leading causes of death, disability, and social problems among youth in the US. The YRBSS uses clusters to construct samples proportional to each state's school enrolment in grades 9–12. State data are weighted to adjust for students' grade, sex, and race/ethnicity. CDC is committed to ensuring that the data are of the highest quality beginning with questionnaire items subjected to reliability and validity testing. Surveys are self-reported and administered by using standardized procedures in each state (Brenner et al., 2004). The survey measures 90+ individual demographic and self-assessed health characteristics and risk behaviors.

Data treatment: Nine topical questions were selected based on the frequency and overall health and safety risks of high school students. The question topics included: behaviors related to car driving/riding (4 questions) and non-traffic behaviors that include alcohol use (2 questions), tobacco use (1 question), use of marijuana (1 question), and violent behavior (2 questions). For more information about the YRBSS: <http://www.cdc.gov/yrbs/>

Outcome: The outcome is health risk behaviors that are considered differently across the analysis. The responses car driving/riding related health risk behaviors, use of marijuana and violent behavior were dichotomized into non-risk and risk behavior. For alcohol use and cigarette smoking, further use of categorization was made into “occasional” and “often” use. See Table 9 below.

Table 9. Description of specific health risk behaviors and categorizations

Health Risk Behavior/ “YRBSS Question”	Non-risk	Risk
Seat belt use as a passenger: “How often do you wear a seat belt when riding in a car driven by someone else?”	always	never, rarely, sometimes and most of the time
Seat belt use as a driver: “How often do you wear a seat belt when driving a car?”	always	never, rarely, sometimes and most of the time
Drinking as a driver: “During the past 30 days, how many times did you drive a car or other vehicle when you had been drinking alcohol?”	0 times	1 time, 2 or 3 times, 4 or 5 times, 6 or more times
Riding with a drinking driver: “During the past 30 days, how many times did you ride in a car or other vehicle driven by someone who had been drinking alcohol?”	0 times	1 time, 2 or 3 times, 4 or 5 times, and 6 or more
Alcohol drinking: “During the past 30 days, on how many days did you have at least one drink of alcohol?”	Never: 0 days	Occasionally: 1 or 2 days, 3 to 5 days, 6 to 9 days, 10 to 19 days Often: 20 to 29 days, all 30 days
Alcohol binge drinking: “During the past 30 days, on how many days did you have 5 or more drinks of alcohol in a row, that is, within a couple of hours?”	Never: 0 days	Occasionally: 1 day, 2 days, 3 to 5 days, 6 to 9 days, 10 to 19 days, Often: 20 or more days
Cigarette smoking: “During the past 30 days, on how many days did you smoke cigarettes?”	Never: 0 days	Occasionally: 1 or 2 days, 3 to 5 days, 6 to 9 days, 10 to 19 days, Every day: 20 to 29 days, all 30 days
Use of marijuana: “During the past 30 days, how many times did you use marijuana?”	0 times	1 or 2 times, 3 to 9 times, 10 to 19 times, 20 to 39 times, 40 or more times
Weapon carrying: “During the past 30 days, on how many days did you carry a weapon such as a gun, knife, or club?”	0 days	1 day, 2 or 3 days, 4 or 5 days, 6 or more days
Involved in physical fighting: “During the past 12 months, how many times were you in a physical fight?”	0 times	1 time, 2 or 3 times, 4 or 5 times, 6 or 7 times, 8 or 9 times, 10 or 11 times, 12 or more times

Driving practice. Since 2003, Montana has included a question to monitor voluntary participation in driver's training, licensing status, and driving practice. Driving practice was defined based on the responses to the question: "Do you drive, and did you complete driver education (classroom and behind-the-wheel)?" Based on four response alternatives three categories of driving practice were developed in identifying "who": unlicensed non-driver, licensed driver, and unlicensed driver (MOPS, 2003). Driving status was stratified by sex.

Data treatment. The sex-specific prevalence of each health risk behavior was assessed by driving practice and differences were tested by chi-square test. Further, the sex-specific association between licensed and non-licensed driving practice and motor vehicle-related health risk behaviors was estimated using logistic regression. The sex-specific associations between the three different driving practices and car driving and non-traffic related health risk behaviors were estimated using multinomial logistic regression. All multivariate analyses were weighted to adjust for the non-randomized sampling technique and results presented as odds ratios (ORs) with 95% confidence intervals (CIs). Licensed drivers were used as a comparison group. All independent variables were entered as categorical variables. Adjustments were made for age and race/ethnicity. Partially missing answers, for driving and license status (2.4%), were excluded from the analyses.

RESULTS

FATAL CRASH STUDIES FROM THE US

The results for the fatal crash studies in the US will be presented first. Study I looked at the scope of the problem and crash circumstances, who involved in the crash stratified by age and sex, and geographically (where) by the residence of the YUD. Results of study II are presented on where YUD in the crash resides according to county-level material deprivation and urbanicity.

What is the frequency of occurrence of young driver fatal crashes that involve YUDs?

In the US, during the period 1998-2004, 10.8% of all fatal crashes involving young drivers (n= 20,799) under the age of 19 years involved a YUD (n=2452) (Figure 5). The annual frequency of occurrence was steady through the study period.

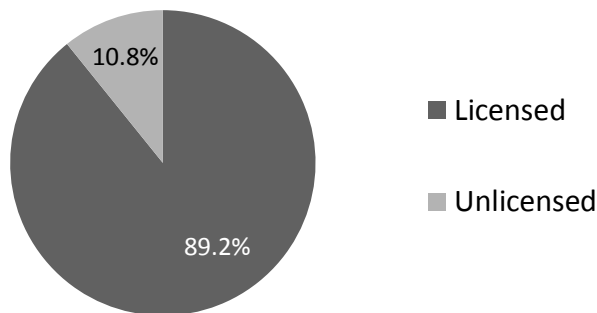


Figure 5. Fatal crashes involving young drivers under the age of 19 by license status, US, 1998-2004

What is the scope of driving circumstances of crashes involving YUDs?

Crashes involving YUDs occur in high-speed zones, in the form of single vehicle crashes, during the evening/morning hours, and on the weekends. Often, no restraint is in use by the YUD, there were up to three occupants in the vehicles, and in less than half the crashes, the fatality was not the YUD.

Table 10. Variable categories and crash circumstances of fatal crashes involving YUDs

Variables	Crash circumstances	%
Speed limit zone of crash	>55+ speed zones	85.0
Day of week	Friday-Sunday	72.5
Number of vehicles in the crash	Single vehicle	63.1
Time of day (Hour)	18.00-05.59	58.8
Car restraint use by the YUD	None	53.9
Occupants in the YUD vehicles	<4 occupants	79.8
Injury severity of YUD	Fatal	44.1

Who is involved and what were the crash circumstances in unlicensed fatal crashes stratified by age and sex?

A closer look at the age and sex distributions of YUDs reveals that more males are involved in fatal crashes at each age, with the numbers reaching a plateau at age 15 among females and 16 among males.

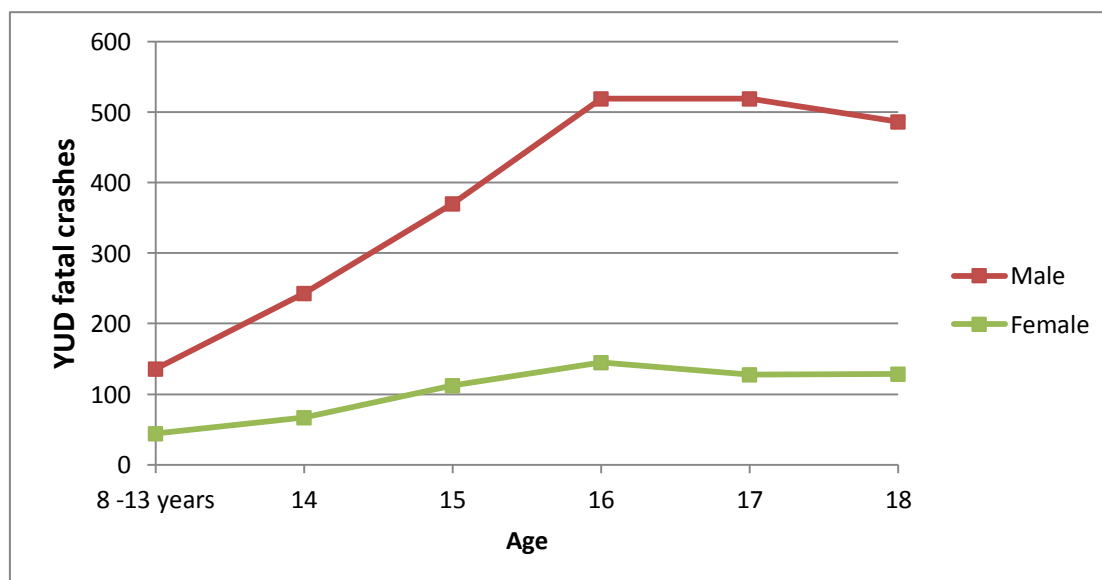


Figure 6. Number of fatal crashes involving unlicensed drivers by age and sex, US, 1998-2002

Significant associations between the sex and age of the YUDs and circumstances were found summarized in Tables 11 and 12. Table 11 considers the risk for males compared to females. Crash circumstances for males were significantly more likely to include late at night, single occupant, stolen vehicle, no restraint use, and more often a fatality.

Table 11. Crash circumstance variable associated with sex differences in YUDs

Variables	Male crash circumstances
Hour	late at night (00.00-02.59) ****
Occupant(s) in YUD vehicle(s)	in vehicles with only one occupant****
Vehicle owner	in stolen vehicle****
Restraint use by YUD	None ***
Injury severity of YUD	Fatal *

* p < 0.05; *** p < 0.001; **** p < 0.0001

Table 12 examines age differences in crash circumstances. Considering age, significant associations were found with crash circumstances for the younger YUDs – often prior to age of licensing – displaying dangerous and illegal driving practices (Table 12).

Table 12. Categories and crash circumstances by age of YUDs

Variables	Age of YUD and crash circumstances
Number of vehicles in crash	8-13, 14, 15, 16 year-olds were more likely to be in a single vehicle crash****
Speed limit zone of crash	8-13 year-olds were more likely to be driving in 55+ mph zones***
Restraint use	8-13, 14 year-olds were less likely to be restrained**
Vehicle owner	14-16 year-olds more likely to driving a stolen vehicle **

** p < 0.01; *** p < 0.001; **** p < 0.0001

Where do YUD fatal crashes occur according to the region?

Fatal crashes involving both unlicensed and licensed drivers are not evenly distributed across US Census regions (see Table 13). In both groups, about half of all fatal crashes occur in the southern region with a higher percent of YUD crashes in the west considering all young driver crashes. In the Midwest region YUD fatal crashes represent a higher percent of all YUD crashes. The northeast is similar for percent of all YUD crashes and for all young driver crashes.

Table 13. Number and percent of YUD fatal crashes and young driver fatal crashes involving a YUD by region, 1998-2002

<i>Region</i>	<i>YUD fatal crashes (n)</i>	<i>% of YUD fatal crashes</i>	<i>% of YUD crashes to all young driver crashes</i>
Northeast	155	6.4	6.4
Midwest	411	16.8	7.2
South	1,217	49.9	12.0
West	656	26.9	15.3
Total	2,452	100.0	10.8

Is county material deprivation and urbanicity associated with the occurrence of an unlicensed car driving fatal crash involving a YUD?

Using the unconditional model, the main effects of census division, urbanicity, and material deprivation were highly significant. The interaction of census division and urbanicity was nearly significant (0.050), and the interaction of census division and material deprivation, as well as the three-way interaction of the variables, were highly significant for a lack of uniformity in predicting a county-level fatal crash of a YUD—prompting the use of the conditional model. The results are shown in Table 14.

Table 14. Unconditional model predicting an association between a YUD fatal crash occurrence by county urbanicity, material deprivation, and interaction

<i>Effect</i>	<i>Wald Chi-Square</i>
Census Division	32.07***
Urbanicity	60.10***
Material deprivation	18.84***
Census Division	
Census Division by Urbanicity	26.28
Census Division by Material Deprivation	27.00***
Urbanicity by Material Deprivation	0.11
Census Division by Urbanicity by Material Deprivation	33.52***

** $p < 0.01$; *** $p < 0.001$

When using the conditional model that considers all divisions together, a positive association was revealed between county material deprivation and the occurrence of fatal crashes involving a YUD (OR = 1.19, 95% CI 1.17, 1.21). The findings of YUD fatal crashes were less likely to occur in rural counties relative to urban is likely a function of population and traffic density. It cannot be concluded that rural counties are less risky where YUDs are concerned. No additional observed associations were found for urbanicity and fatal crashes. Further, considering material deprivation by county urbanicity, a weak negative association between material deprivation and fatal crashes in suburban counties (OR = 0.92, 95% CI 0.90, 0.95) was found (See Table 15).

Table 15. Conditional model predicting an association between a YUD fatal crash occurrence by county urbanicity, material deprivation, and interaction

Parameter	Odds ratio	95% CI	
		Lower	Upper
Material deprivation	1.19***	1.17	1.21
Material deprivation			
Rural	1.00	0.98	1.03
Suburban	0.92**	0.90	0.95
Urbanicity			
Rural	0.55	0.52	0.58
Suburban	1.03	0.97	1.09

** p< 0.01; *** p< 0.001

SWEDISH CRASH STUDY

The crash study results are presented by scope with circumstances, who is involved in crashes stratified by sex and socioeconomic position for RTI outcomes and crash circumstances, and where by urbanicity stratified for RTI outcomes.

What is the scope of unlicensed driving crashes among young people?

First time crashes of the cohort included 21,386 of which 1,522 (7.7%) were crashes involving an unlicensed driver.

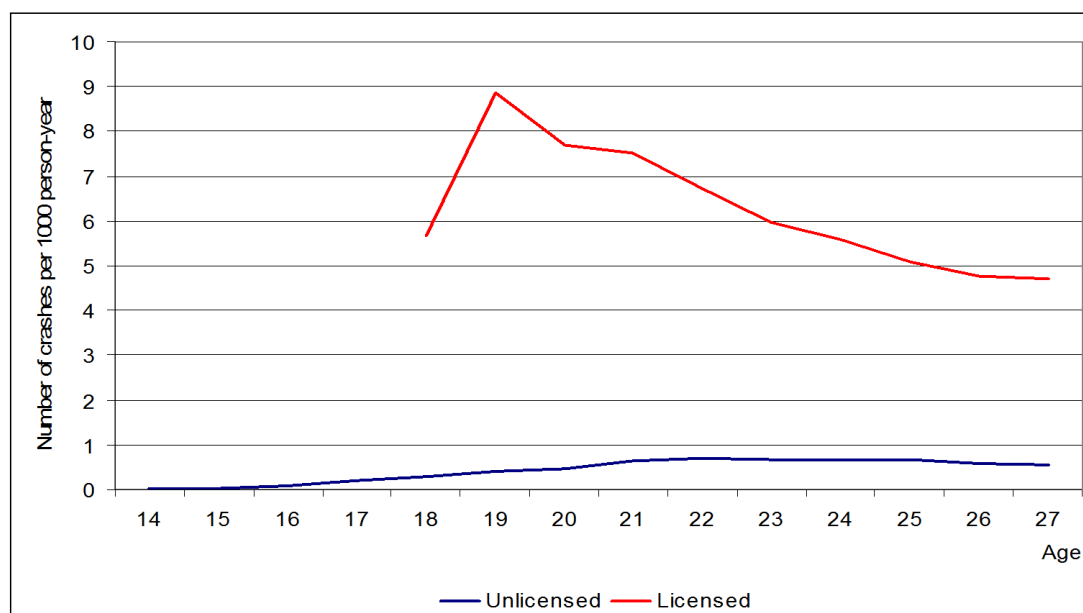


Figure 7. Age-specific cumulative incidence of first car crash during 1998-2004 per 1000 person years, with 95% confidence intervals

Who are the YUDs involved in crashes?

The cumulative incidence of first crash per 1000 person years increases at the age of 18 years for both licensed and unlicensed drivers. For YUDs the incidence remains steady through age 27 while it decreases for licensed drivers (see Figure 7).

Unlicensed drivers involved in car crashes are most often males (85.1%) who have a 6.57 (95% CI 5.24-8.25) risk of being in a RTC with severe injuries compared to females.

What is the scope of circumstances of severe crashes involving YUDs compared to all crashes?

Car crashes involving unlicensed drivers compared to licensed drivers found excess risk for crashes with suspected impaired driving, late night/early morning hours, higher speed limit zones, injury to YUD, and a fatality (Table 16).

Table 16. Variables and association with YUD RTC circumstances and percent compared to licensed RTC

Variables	YUD crash circumstances	%
Suspected impaired driving	Yes*	43.7
Time of day	2300-0559*	36.9
Speed limit zone of crash	>90km/hr.*	30.1
Injury outcome of YUD	Fatal*	19.0
Injury outcome for other persons	Fatal*	20.8

*p < 0.001

Who are the YUD involved in RTCs compared to all YUD crashes?

Compared to all unlicensed drivers involved in RTCs, unlicensed drivers from families with a lower socioeconomic position showed relative risks for a severe RTC in the range of 1.75 (assistant non-manual employees) to 3.25 (others) compared to those in higher socioeconomic positions (high/intermediate salaried employees). Unlicensed drivers in a crash from families receiving social welfare benefits showed twice the risk for a RTC (RR=2.21 95% CI 1.99-2.44) compared to those from families not receiving such benefits.

Where do the crashes of YUDs occur and what are the circumstances?

Compared to all crashes there was excess likelihood of a YUD crash occurring in a rural area compared to urban areas. The risk for severe RTIs increased for unlicensed drivers living in areas with low population density (and less access to city center) in all areas compared to metropolitan areas. Those living in rural areas involved in a YUD crash had an increased risk for a severe RTC of 3.29 (95% CI 2.47 - 4.39).

HEALTH RISK BEHAVIOR STUDY

The behavior study provided the scope of unlicensed driving stratified by sex and non-traffic health risk behaviors and risky driving stratified by driving status and sex.

What is the scope of unlicensed driving among high school students?

- Overall 5.1% of the students responded affirmatively when questioned about driving regularly on public roads without a valid license or permit. By sex, 5.0% of the females and 5.2% of the males reported unlicensed driving.

Who are the students by driving practice group and sex reporting non-traffic health risk behaviors?

Driving status: The prevalence of non-traffic, health risk behaviors is high between both groups of drivers, but systematically higher among the unlicensed. The odds of all health risk behaviors are systematically higher among unlicensed drivers than among their licensed peers. When considering non-drivers, the patterns are not unidirectional and consistent.

Sex: Male unlicensed drivers more often report health risk behaviors than female unlicensed drivers do. Licensed drivers reported a similar prevalence of health risk behaviors between the sexes, except for being involved in a physical fight and weapon carrying which was slightly higher among males. The odds of all health risk behaviors are systematically higher among both male and female unlicensed drivers than among their licensed peers. The odds ratios are comparable for male and female unlicensed drivers with the exception of lower involvement in physical fighting among females. Drinking alcohol is reported less among male and female unlicensed non-drivers (although not statistically significant for “often” for females) and everyday cigarette smoking is more commonly reported among non-drivers compared to licensed drivers.

Who are the students by driving practice group and sex reporting risky driving practices?

The differences in all car driving-related health risk behaviors among both male and female unlicensed drivers have higher odds except for riding with a drinking driver compared to licensed drivers.

Ethical considerations

All studies used data registers where individual identifiers were not available to the researchers. Each study was reviewed for ethical considerations and approved by various institutions. Study I was approved by the Marshfield Clinic Research Foundation Institutional Review Board in Marshfield, Wisconsin (US). Study II and IV was approved by the University of Michigan Institutional Review Board in Ann Arbor, Michigan (US). Study III was approved by the Regional Ethical Review Board in Stockholm (Diary number 2005/1084-31) in Sweden.

WHAT THE STUDIES SHOW

What is the scope of going unlicensed driving among the young?

- YUDs are found in one of nine fatal crashes among all young drivers (<19 years) (US).
- YUDs are found in 7.7% of the crashes involving 11-27 year-olds in (Sweden).
- Montana students report 5.2% have driven as an unlicensed driver.

What is the scope of crash circumstances of crashes involving YUDs?

- Fatal crash circumstances involving YUDs occur in high-speed zones, in the form of single vehicle crashes, during the evening/morning hours, and on the weekends. Often, no safety restraint is use by the YUD, up to three occupants are in the vehicles, and in less than half the crashes, the fatality was not the YUD.
- Car crashes involving unlicensed drivers compared to licensed drivers were found to have excess risk for crashes with suspected impaired driving, late night/early morning hours, higher speed limit zones, injury to YUD, and a fatality.

Who are the YUDs and what are the age, sex, and, socioeconomic specific crash circumstances?

Age

- Most of the YUDs involved in a crash are age-eligible to be licensed (US and Sweden).
- Younger YUDs (<17 years) while in fewer crashes were more likely to be in single vehicle crashes, driving alone, be driving in high speed zones, not be using a safety restraint, and be in a stolen vehicle compared to older YUDs (17-19 years).
- Among those, age-eligible to be licensed alcohol use appears as a common crash circumstance compared to underage YUDs.
- The cumulative involvement of first crash of unlicensed drivers increases at age 15 in the US. In Sweden the increase is at age 18 and remains steady through age 27 for unlicensed drivers.

Sex

- Most of the YUDs involved in a crash are male (US and Sweden).
- YUD males in a crash are more likely to involve dangerous driving circumstances (US and Sweden).
- YUD males in a crash experience more severe injuries including fatalities than YUD females (US and Sweden).
- Male YUDs in a fatal crash are more likely to be driving during late night/early morning hours, have three or more passengers in the vehicle, be driving a stolen vehicle, less likely to be wearing safety restraints, and have more severe RTI compared to females.

Socioeconomic

- YUDs from families in lower socio-economic positions have greater risks for a severe RTC compared to YUDs in families from higher socioeconomic positions (Sweden).
- YUDs from families with a history of receiving welfare benefits ran twice the risk of a RTC compared to families not receiving benefits.

Where do crashes involving YUDs occur?**Geographic location (crash and area level)**

- In the US, fatal crashes involving YUDs are more frequent in the southern and western states located in their respective regions and divisions.

Urbanicity (individual and area level)

- An unlicensed driver is more likely to be in a crash in a rural area compared to crashes of licensed drivers (Sweden).
- YUDs from everywhere other than metropolitan areas have an increased risk for severe RTI related to decreasing urbanicity.
- Rural areas have the highest risk of severe RTI compared to unlicensed drivers in crashes compared to those living in metropolitan areas (Sweden).
- At the division level, the association with YUD fatal crashes with urbanicity varies according to geographic division.

Material deprivation (area level)

- There is a positive association between county-level material deprivation and a fatal crash involving a YUD (US).
- At the division level, the association with YUD fatal crashes with material deprivation and urbanicity vary according to geographic division.

Who are the students by driving status who exhibit car driving health risk behaviors between licensed and unlicensed drivers among high school students?

- Unlicensed drivers tend to disclose risky car driving behaviors to a greater extent than their licensed peers for both male and females do.

What is the difference of non-traffic health risk behaviors that distinguish young drivers by driving practice group (who) among high school students?

- The odds of all health risk behaviors studied are systematically higher among both male and female unlicensed drivers than among their licensed peers. Non-drivers, the patterns are not unidirectional and not as consistent.
- In general, male students reported more health risk behaviors than females with little effect between the sexes on driving practice.

DISCUSSION

MAIN FINDINGS

As a whole, the results provide new insights into “going” unlicensed among young people from studies on both traffic crashes and self-reported driving practice.

Unlicensed driving is also considered in two different national contexts where motorization is high but where, among other things, the age of eligibility for licensing differs. Across the studies, attempts are made to clarify the *scope* of the phenomenon, an illegal behavior, and a threat to population health and safety; *who* those young people are that drive unlicensed, including their socio-demographic attributes and the health risk behaviors in and outside cars; and *where* the crash involving an unlicensed driver is most likely to occur. Those different aspects are discussed in turn below.

Scope of unlicensed driving

Two studies documented the frequency of occurrence of unlicensed driving based on data from crashes. They considered both those under age and those age-eligible using different age ranges (13-19 and 11-27 years), contexts (US vs. Sweden), and outcomes. Articles I and III indicate that respectively 10.8% and 7.7% of the crashes involved a YUD.

Those findings echo earlier American and Swedish studies. One US study, with a broad age range (16-24 year-olds) and considering fatal crashes found that 7.3% involved an unlicensed driver (Tsai et al., 2008). In Sweden, looking at the crash involvement of 18-20 year-olds, a study found that 7.5% of those involved in fatal and non-fatal crashes were unlicensed (Hasselberg & Laflamme, 2008). Similar level of fatal RTC involving unlicensed driving in the US is also reflected in regional and state-based studies that consider limited age ranges and the driving status is sometimes defined differently, which make comparisons difficult (Williams et al., 1995; Williams et al., 1997; Huber, 2006; Males, 2006; Frisch et al., 2007; Frisch & Plessinger, 2007; Males, 2009a; Williams & Tison, 2012).

Article IV for its part gives an indication on how prevalent unlicensed driving can be in that age group. The study was carried out in a region where the involvement of YUDs in fatal crashes is one of the highest in the country (as shown in Article I). The number of students reporting unlicensed driving was 5.2% a figure that otherwise is in line with the previous studies from two different locations (Elliott et al., 2008; Heck et al., 2008) in spite of variations in definition, difference in settings, and restricting to only those who were age-eligible.

Unlicensed driving remains a heterogeneous concept. It may occur on a more or less regular basis, from a one-time supervised driving session with a parent (which can be considered to be the least risky) (Berg et al., 2004) to repeated unsupervised episodes which may involve very dangerous driving practices such as a police chase (Rivara & Mack, 2004). Unlicensed driving is illegal and occurs often with unauthorized use of the family car or to a lesser extent with a stolen car as seen in Article I. Further, driving unlicensed and unsupervised among young people provides no future crash protection benefit (Stevenson & Palamara, 2001; McDowell et al., 2009; Scott-Parker et al., 2011) and endangers all road users (Kallail et al., 2008; Winston et al., 2008).

Who are the young unlicensed drivers (socio-demographic)

Age. Across the studies, age was defined in different groups – and periods of adolescence and youth. Yet, in Articles I (US) and III (Sweden) show that a majority of the crashes occur when young people are age eligible to be licensed and thereafter. Article IV supports this notion with self-reports on driving practice of high school students showing that unlicensed driving practices were stable beginning at age 16 (age of eligibility in Montana) through age 19. The increase in crashes in each country occurs within the designated transition age to driving as described in the TTT model. A similar pattern for unlicensed driving was also found in the US with states that allow younger people (14-15 years) to be licensed also reported unlicensed driving commenced at earlier ages compared to states who licensed at older ages (Ferguson et al., 1996; Frisch et al., 2003).

Age influences not only the frequency of unlicensed driving, but also driving practices. In general, the younger the unlicensed driver the more common driving practices such as speeding, single vehicle crashes, and no restraint use. Older YUDs also drive dangerously as shown from the crash circumstances of Article I that are contingent on weekends, late at night, and drinking and driving. Although age can be incrementally associated with unlicensed driving, it is just one of the individual influences. Additional influences reflected in the TTT model include biology, attitudes and personality, and demographic attributes (Shope et al., 2003; Allen & Brown, 2008), lifestyle (Gregersen & Berg, 1994; Bina et al., 2006), and academic achievement (Murray, 1998; Elliott et al., 2008). It was beyond the scope of the studies to consider those factors.

Sex. As could be expected, the majority of YUDs involved in RTCs were male (across the studies). These differences are also reflected in crash circumstances of male YUDs who are more likely to be involved in more dangerous driving practices (i.e., stolen car), late night driving, driving alone, no restraint use, and to die as the result of the crash in Articles I and III. In contrast, self-reported unlicensed driving practices such as how frequently they drive and driving practices such as neglect to wear a seat belt as a passenger and a driver and drinking and driving were similar between the sexes in Montana in Article IV.

In light of the TTT model one could attribute sex differences in unlicensed driving practices to developmental and external influences. Promotion of driving to males begins at earlier ages, to drive more often, and to do so recklessly as a way of obtaining manhood (Suitor & Reavis, 1995; Marshall et al., 1996; Knight et al., 2004; Bingham & Shope, 2004b; Steg, 2005). Developmentally, young males possess a greater propensity for sensation seeking, aggression and risk taking that is biological and externally driven (Dejoy, 1992; Jonah, 1997; Turner & McClure, 2003). The sex differences in male unlicensed drivers are not unique to license status (NHTSA, 2004; Twisk & Stacey, 2007; Zhang et al., 2010).

When it comes to self-reported unlicensed driving the weak differences between the sexes observed in Article IV concur with recent studies (Elliott et al., 2008; Heck et al., 2008; Scott-Parker et al., 2011). It could be part of a wider proliferation of unlicensed driving by females. Alternatively, it could reflect imprecision or priorities in the survey tools from the lack of driving practice measures. Many studies of unlicensed drivers do not consider driving practices and supervision levels that could help highlight differences in the sexes (i.e., same age passengers, late at night). The few studies that do cover driving practices found that YUD males do indeed spend more time driving, drive greater distances, and more often drive alone or with peers as YUDs compared to females (Williams et al., 1985; Heck et al., 2008; Begg et al., 2011; Scott-Parker et al., 2012).

Socioeconomic position. The results from Article III indicate that YUDs from families with lower socioeconomic position are more at risk of severe RTI compared to those from families in the highest socioeconomic positions.

Social and economic disadvantage can establish barriers to licensing, perceived or real, contributing to unlicensed driving in different groups and context. Barriers could include the costs of training and driving, access to training programs, (Williams, 2006) and the geographical and social isolation in remote areas (Zwerling et al., 2005; Scott-Parker et al., 2012). In some areas where segments of the population are proportionately unbalanced by sex, age, or disadvantage can be prone to escalate licensing barriers and accumulate more unlicensed driving (Stamatiadis & Puccini, 2000; Braver, 2001; Williams & Collins, 2001; Campos-Outcalt et al., 1997; Murray et al., 2006; MMWR, 2009; Laflamme et al., 2010).

The risk of severe RTI for YUDs from lower socioeconomic groups is echoed in earlier Swedish studies of all young drivers (Hasselberg & Laflamme, 2003; Hasselberg et al., 2005; Hasselberg & Laflamme, 2005; Hasselberg & Laflamme, 2008). Several factors can partially explain the differences in risk from the physical and social contexts that young people from different socioeconomic positions travel and live in. Risk may be moderated by how much a young person needs and values a license or a car for transport (Berg et al., 1999) or the availability of public transport in their particular area

(Elliott, 2008). When involved in a crash, lower socioeconomic groups may also be driving less crashworthy vehicles and travel under more dangerous conditions resulting in the severity of RTI (Williams et al., 2006; Hellinga et al., 2007; Laflamme & Vaez, 2007).

As the TTT model suggests, parents play a pivotal role in supervising and facilitating young people during the transition to independent driving. The age range (children to young adults) in the cohort in Article III represents various socioeconomic relationships with their families. As they grow older, the more likely young people are to be more independent where their driving practices would not be monitored as closely by parents when they were younger (Hasselberg, 2003). As well, for some groups, driving before a license is essential to support their families for farmworkers (Stiles & Grieshop, 1999; Heck et al., 2008; Knight et al., 2012) and the self-employed (Hasselberg & Laflamme, 2005). This could account for the continued and steady unlicensed driving crashes by young adults after the age of eligibility.

Who are the young unlicensed drivers (behavioral)

The self-reported findings in Article IV demonstrate the clustering of non-traffic health risk behaviors of YUD among both sexes. Health risk behaviors are a normative part of the developmental process during the transition. However, the students in Montana who identified as unlicensed drivers (Article IV) exceeded the normative limits of health risk behaviors compared to state (MOPS, 2010) and national findings (Eaton et al., 2008). The TTT model would offer that their behaviors were overly-influenced by external factors such as peer influences tending to more deviance (Voas & Kelley-Baker, 2008). Unlicensed driving is not an isolated problem and appears to be part of an interrelated profile of health risk behaviors (Jessor, 1991; Petridou et al., 1997; Shope & Bingham, 2008). At least among unlicensed drivers, health risk behaviors are not discriminated by sex (Elliott et al., 2008; Heck et al., 2008) as across the general public (Begg & Gulliver, 2008; Eaton et al., 2012). Health risk behaviors tend to cluster with YUD as they have established themselves as risk takers (Jessor, 1991). Whether unlicensed driving serves to initiate, proliferate, or compound health risk behaviors or if the behaviors have the opposite effect on unlicensed driving needs to be better understood (Chliaoutakis et al., 1999).

Alcohol use and the lack of safety restraints among unlicensed drivers were common across age, sex, and socioeconomic groups studied. The TTT model suggests that these behaviors can proliferate in the absence of parental and community influence as part of a broader risk profile influenced by peers. This is not unique to unlicensed drivers as other studies of young licensed drivers have found similar findings (García-España et al., 2012; Voas et al., 2012). Both behaviors associated with dangerous driving practices can be influential in the severity of RTI (Jones & Shults, 2000; Shope et al., 2003; Williams, 2003; Vaez & Laflamme, 2005). Alcohol can play a dual role in

unlicensed driving: both as a motivation to join peers in unregulated environments and lowering of inhibitions to drive unlicensed (Bingham et al., 2008; Fell et al., 2009). The use of restraints is well documented as proven safety measure for reducing RTI in vehicles (Phebo & Dellinger, 1998; García-España et al., 2012). Addressing these two specific health risk behaviors individually and together among young people can serve to minimize the risk of RTI for all youth (Waylen & McKenna, 2008).

Where do crashes involving YUDs occur

Geographic distribution. Across the studies, the geographic distribution of crashes has been measured on the individual (Article III) and area levels (Articles I and II). In Sweden, crashes clustered in individuals living in rural areas. As well, crashes with severe RTI involving YUDs in rural were more common in all areas below metropolitan designations. In the US on the area level, a concentration of crashes involving YUDs were found in regions (Article I) and divisions (Article II) in those sections of the country that tend to be least densely populated, more youthful population, without public transport, more poverty, and similar geographic patterns to all driver crashes (Baker et al., 1987; Clark & Cushing, 1999; Gonzales et al., 2005). The individual findings from Sweden and those on the area level in the US suggest a pivotal but preliminary role in unlicensed driving on geographical differences.

The more complicated task is to identify the specific area influences that differentiate outcomes beyond the geographic designations, as crashes involving YUDs are relatively infrequent. To study crashes of unlicensed drivers would require a large area to incorporate enough events to assess risks. The size of the area also needs to be sensitive to encompass both the daily living and travel zones of young people without being too large (Noland & Quddus, 2004; Imai & Mansfield, 2008). It was necessary in the studies to aggregate smaller somewhat more meaningful areas into larger units, sacrificing some specific daily patterns. Examples include individual states were aggregated into four regions (Article I), rural counties were aggregated into nine divisions (Article II), and multiple urbanicity levels were aggregated into five levels (Article III).

Material Deprivation. In considering all counties together, there was a positive association between material deprivation and a county-level fatal crash involving a YUD. Material deprivation possibly contributes to a void in community and parent support (Voas & Kelley-Baker, 2008), opening opportunities for unlicensed driving and other health risk behaviors from enhanced peer influence (Abdalla et al., 1997; Voas & Kelley-Baker, 2008). Material deprivation can contribute obstacles to safe driving that include driving conditions (Fleury et al., 2010) and less crashworthy vehicles (Laflamme & Vaez, 2007) as well barriers to licensing that include demographic profiles (Braver, 2001) and reduced opportunities to practice driving and obtain a timely license (Berg et al., 1999).

To a lesser degree in Article II, the interaction of material deprivation and urbanicity were associated with reduced odds for a fatal crash only in suburban counties compared to urban counties. A partial explanation is that outlying suburban counties where public transport is limited and services are spread out over greater distances, enough so young people are more likely to obtain a timely license and affluent enough to have access to a car (Trowbridge & McDonald, 2008; McDonald & Trowbridge, 2009).

Anecdotally rural youth have a greater need and opportunity to drive with or without a license as compared to urban youth (Blatt & Furman, 1998; Peek-Asa et al., 2010). Whether or not this is true, highlights one of the challenges in examining area differences in identifying area-specific driving practices. The evidence is clear that there are differences in unlicensed driving and severity of RTI at differing levels of urbanicity lacking specific determinants at this time. Some settings face special challenges such as those with high deprivation and rural remote areas for unlicensed driving (Blackman et al., 2008; Males, 2009). This will be important for consideration for future resource allocation and developing area-specific countermeasures (McDowell et al., 2009).

STRENGTHS AND LIMITATIONS

Strengths. The thesis was able to provide insights into unlicensed driving from the context of the three national crash studies in the US and Sweden. Fatal crashes derived from national registers are generally inclusive of all events providing comprehensive coverage of the studies. The ability to link multiple Swedish databases provided insights into the distribution of individual unlicensed drivers across socioeconomic groups as a valuable dimension. The studies included a variety of levels of area measures from counties, state, divisions, regions, to nationwide offering multiple perspectives and increasing the confidence in our findings. The studies also included a wide span of ages including prior to the age of eligibility to be licensed through early adulthood adding multiple developmental perspectives to the findings. Finally, the self-report came from an on-going CDC national surveillance, deemed a valid and reliable tool that protects anonymity assuring the best possible responses (Eaton et al., 2012).

Limitations. It was unclear whether the reported unlicensed driving practices and crashes were part of an incidental or a routine act that can change within, or across studies further limiting presumptions about individual practices. The studies are silent regarding area affect from traffic density and driving behaviors. The findings are further restricted to the absolute number of crashes due to the inability to identify unlicensed drivers in the general population. Both these may contribute to underestimating both crashes and driving of YUDs.

Reliance on self-identified health risk behaviors can succumb to social desirability bias in reporting of illegal activities, leading to underestimation of unlicensed driving (Af

Wählberg, 2010). In Article IV, the responsibility of assigning driving group relied on one question. Any misinterpretation of that question could alter the allocation to driving groups of unlicensed drivers and ultimately raising or lowering the odds ratios depending on the response (Article IV).

Crash data are limited by the accuracy and completeness of information collected by the reporting law enforcement (McDonald et al., 2009). Crash data in Sweden is not exhaustive for crashes without serious injuries. Minor injuries were not a primary focus of Article III, not influencing the main findings. In the case of young and unlicensed drivers, the police may unintentionally assign greater crash culpability to YUDs, overestimating the assignment of crash circumstances (Williams & Shabanova, 2003). Both in the US and Sweden crash databases are limited in their capacity to assess alcohol and other drug use, underestimating the involvement on crashes of YUD (Hubicka et al., 2007). The crash studies sought an indication of the “who” and “where” of unlicensed driving that similar behaviors/groups/areas might benefit from the findings of young drivers. A focus on passenger cars, young people without a driving license, and in car dependent countries with formal licensing systems limiting the global generalizability.

IMPLICATIONS FOR RESEARCH, POLICY AND PRACTICE

The current level of research, policy, and practice is not in proportion to the scope and public health impact of unlicensed driving. Unlicensed driving is a complex behavior requiring contributions from youth development, engineering, insurance, law enforcement, education, policy development, health care, traffic safety, and public health toward solutions. Emphasis in the short term should be placed on addressing crosscutting issues as license access, mobility, and health risk behaviors. Careful consideration should be applied that any solutions do not impact unequally on more disadvantaged youth. Below is an overview of what seems most important to prioritize in the near future.

Research

Finding measures to prevent young people from driving unlicensed should remain an important priority of research.

- Promote a better understanding of the individual determinants of unlicensed driving, using both qualitative and quantitative approaches.
- Gain a better understanding of the regional, geographical, and area differences in unlicensed driving and crashes.
- Increase knowledge about the role that driving education and the licensing process plays in unlicensed driving on different segments of the population.

Policy

Unlicensed driving is not only an illegal practice but also calls for broader policies that address lifestyle and mobility options for young people.

- Policies that are credible and relevant should encourage compliance with existing licensing practices to deter young people from driving unlicensed.
- Develop and promote transportation options in areas where the availability of opportunities are limited.
- Promote policies inclusive of multiple funding streams that involve traffic safety and other youth health and safety efforts addressing fundamental developmental and mobility issues.
- Encourage car owners not to give permission to drive unlicensed and monitor the unauthorized use of their vehicles.

Practice

During the transition to driving support needs to be provided where risk for unlicensed driving is highest not only to eliminate unlicensed driving, but to bolster opportunities for independence by addressing the fundamental mobility issues.

- Social marketing campaigns and influential adults in schools, athletics, government, and health care should provide pre-driving anticipatory guidance for safe and responsible attitudes and behaviors. Guidance should include both driving and riding unlicensed.
- Broaden the availability of driver training to public venues such as schools that provide equal access to all youth.
- Encourage data gathering practices in the US for a national registry for non-fatal crashes (similar to FARS) and reliable state licensing data to assess scope and risk of unlicensed driving.
- Work to implement overall road safety improvements that address young driver risk including rigorous enforcement of existing licensing and driving practices, focusing on areas where unlicensed driving risk is high.

CONCLUSIONS

In both countries, crashes involving a YUD are an objective measure of unlicensed driver characteristics and circumstances demonstrating conclusively a measurable proportion of crash involvement. Studies on RTC and self-reported health risk behaviors suggest that driving unlicensed among the young is a common health risk behavior, even past the age of eligibility of licensing. It is more frequent among males and some socio-demographic groups of young people. It is accompanied with other health risk behaviors and can be more prevalent in some area types. To address the issue will require multi-disciplinary targeted efforts to both discourage unlicensed driving and promote developmental opportunities with safe youth mobility options.

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