Accident Analysis and Prevention 72 (2014) 302–308

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Comparison of teen and adult driver crash scenarios in a nationally representative sample of serious crashes

Catherine C. McDonald[a,b,*], Allison E. Curry[b,c], Venk Kandadai[b], Marilyn S. Sommers[a], Flaura K. Winston[b,d,e]

[a] University of Pennsylvania, School of Nursing, Center for Global Women's Health, Center for Health Equity Research, Claire Fagin Hall, 418 Curie Boulevard, Philadelphia, PA 19104-4217, USA
[b] Center for Injury Research and Prevention, The Children's Hospital of Philadelphia, 3535 Market Street, Suite 1150, Philadelphia, PA 19104, USA
[c] Center for Clinical Epidemiology and Biostatistics, Perelman School of Medicine at the University of Pennsylvania, 423 Guardian Drive, Philadelphia, PA 19104, USA
[d] Division of General Pediatrics, Perelman School of Medicine at the University of Pennsylvania, 295 John Morgan Building, 3620 Hamilton Walk, Philadelphia, PA 19104, USA
[e] National Science Foundation Center for Child Injury Prevention Studies, The Children's Hospital of Philadelphia, 3535 Market Street, Suite 1150, Philadelphia, PA 19104, USA

ARTICLE INFO

Article history:
Received 23 December 2013
Received in revised form 29 May 2014
Accepted 17 July 2014
Available online 5 August 2014

Keywords:
Teen drivers
Adult drivers
Crash-contributing factors
Crash scenarios
Risk factors
Traffic safety

ABSTRACT

Motor vehicle crashes are the leading cause of death and acquired disability during the first four decades of life. While teen drivers have the highest crash risk, few studies examine the similarities and differences in teen and adult driver crashes. We aimed to: (1) identify and compare the most frequent crash scenarios—integrated information on a vehicle's movement prior to crash, immediate pre-crash event, and crash configuration—for teen and adult drivers involved in serious crashes, and (2) for the most frequent scenarios, explore whether the distribution of driver critical errors differed for teens and adult drivers. We analyzed data from the National Motor Vehicle Crash Causation Survey, a nationally representative study of serious crashes conducted by the U.S. National Highway Traffic Safety Administration from 2005 to 2007. Our sample included 642 16- to 19-year-old and 1167 35- to 54-year-old crash-involved drivers (weighted n = 296,482 and 439,356, respectively) who made a critical error that led to their crash's critical pre-crash event (i.e., event that made the crash inevitable). We estimated prevalence ratios (PR) and 95% confidence intervals (CI) to compare the relative frequency of crash scenarios and driver critical errors. The top five crash scenarios among teen drivers, accounting for 37.3% of their crashes, included: (1) *going straight, other vehicle stopped, rear end*; (2) *stopped in traffic lane, turning left at intersection, turn into path of other vehicle*; (3) *negotiating curve, off right edge of road, right roadside departure*; (4) *going straight, off right edge of road, right roadside departure;* and (5) *stopped in lane, turning left at intersection, turn across path of other vehicle*. The top five crash scenarios among adult drivers, accounting for 33.9% of their crashes, included the same scenarios as the teen drivers with the exception of scenario (3) and the addition of *going straight, crossing over an intersection, and continuing on a straight path*. For two scenarios ((1) and (3) above), teens were more likely than adults to make a critical decision error (e.g., traveling too fast for conditions). Our findings indicate that among those who make a driver critical error in a serious crash, there are few differences in the scenarios or critical driver errors for teen and adult drivers.

1. Introduction

Motor vehicle crashes (MVCs) are one of the leading causes of death for all ages in the United States, and accounted for almost 2700 deaths of 16- to 19-year-olds and over 19,000 deaths of 20- to 54-year-olds in 2010 (CDC, 2010). Although teen and adult crash fatality rates have declined in recent years, current crash rates still have a serious human and economic cost (Finkelstein et al., 2006; Sommers et al., 2011). Per mile driven, teens are three times more

* Corresponding author at: University of Pennsylvania, School of Nursing, Center for Global Women's Health, Center for Health Equity Research, Claire Fagin Hall, 418 Curie Boulevard, 414, Philadelphia, PA 19104, USA. Tel.: +1 215 746 8355.
E-mail addresses: mcdonalc@nursing.upenn.edu (C.C. McDonald), currya@email.chop.edu (A.E. Curry), kandadaiv@email.chop.edu (V. Kandadai), ssommer@nursing.upenn.edu (M.S. Sommers), flaura@mail.med.upenn.edu (F.K. Winston).

http://dx.doi.org/10.1016/j.aap.2014.07.016
0001-4575/

likely to crash than adults (IIHS, 2013); however among teens and adults who do crash, little is known about the similarities and differences in the types of crashes that occur and factors that contribute to the crashes. Disentangling the complex factors associated with teen and adult MVCs is critical to prevention efforts, policy initiatives, and determining whether teens require interventions and training programs to meet their unique needs.

Several studies have identified proximate crash-contributing factors (i.e., occurring in immediate crash environment) among teen drivers, including: inadequate surveillance (Curry et al., 2011); cell phone use and other technological in-vehicle distractions (Redelmeier and Tibshirani, 1997; Neyens and Boyle, 2008); peer passengers (Chen et al., 2000; Simons-Morton et al., 2005; Curry et al., 2012; Tefft et al., 2012); and risky driving behaviors (Williams, 2003; Ivers et al., 2009). Although adults age out of the developmental challenges related to teen crashes and often have more experience than teens behind the wheel, adults also engage in distracted driving behaviors (NHTSA, 2013) and have additional key risk factors that include alcohol-impaired driving (CDC, 2013) and poor sleep patterns (Thygerson et al., 2011). Recent studies have identified the relative frequency of different types of teen crashes, assessed changes over the first few years of licensure, explored how teen crash types differ from adults, and examined differences in the contributing factors of teens and adults crashes (Braitman et al., 2008; Peek-Asa et al., 2010; Foss et al., 2011; Bingham and Ehsani, 2012; Klauer et al., 2014). Although the literature provides important information on the mechanisms by which crashes occur, few studies have sought to compare teen and adult crashes with integrated information on crash-contributing factors and crash types in a nationally representative sample.

The National Motor Vehicle Crash Causation Survey (NMVCCS), a study of on-site crash investigations conducted by NHTSA, provided data on a nationally representative sample of 5470 serious crashes between 2005 and 2007 (NHTSA, 2008a). The breadth and depth of the NMVCCS data were unique because they included the movement and position of each vehicle immediately prior to and during the crash event and data about the crash-contributing driver, vehicle, and environment (NHTSA, 2008b). Analyses of NMVCCS data allow us to gain a more complete understanding of the immediate environment of MVCs, and how the complex environment of teen crashes may be unique or similar compared with adult crashes.

Our objective was to identify and compare the most frequent crash "scenarios"—or integrated information on a vehicle's movement prior to crash, the critical pre-crash event, and the crash configuration—among teen and adult drivers involved in serious crashes. Further, we aimed to determine whether the relative frequency of crash scenarios differed by gender. Lastly, we conducted exploratory analysis to compare, for the most frequent scenarios, the prevalence of high-level categories of driver critical errors (i.e., an error that led directly to the critical pre-crash event) for teen and adult crash-involved drivers.

2. Methods and materials

2.1. NMVCCS study design and sample

NHTSA conducted data collection for NMVCCS between July 2005 and December 2007. The sampling and data collection methods used in NMVCCS are reported in more detail elsewhere (NHTSA, 2008a; Curry et al., 2011). Briefly, the overall goal of NMVCCS was to identify pre-crash events and contributing vehicular, driver, and environmental factors in order to inform subsequent development of crash avoidance technologies. Data were collected on crashes: in sampling areas that occurred between 6 am and midnight; resulted in injury or property damage; involved response from the Emergency Medical Service (EMS); had police presence at the scene; included a case vehicle that was a towed passenger vehicle; and had an available police crash report. We use the term "serious crashes" to describe crashes in NMVCCS because EMS and police were present at the scene. The overall NMVCCS sample included 10,083 drivers involved in 5470 crashes.

2.2. Variables

Data were collected by trained NMVCCS researchers through surveys and photographs of the scene and vehicles in the crash, and by means of structured interviews with drivers (or their proxy), witnesses, and police (NHTSA, 2008a). The NMVCCS researchers received extensive training in systematic data collection for the crashes and several quality control measures were in place (S.D. Stern, oral communication, June 2010). In order to provide a comprehensive picture of the vehicle's movement just prior to and at the time of the crash—i.e., the crash scenario—we combined three previously-defined variables available in the NMVCCS data using a 3-way cross tabulation: *movement prior to critical crash envelope; critical pre-crash event*; and *first harmful event crash type* (NHTSA, 2008b).

Movement prior to critical crash envelope: the vehicle's movement pattern prior to the critical event. NMVCCS defined 20 possible categories (e.g., going straight, negotiating a curve, and stopped in a traffic lane).

Critical pre-crash event: the event that made the crash imminent and inevitable. We recoded 59 originally specified categories into 17 categories (e.g., turning left at an intersection) in order to group similar critical pre-crash events.

First harmful event crash type: categorized the category and configuration of the crashes. Fourteen categories were defined by NMVCCS (e.g., rear-end, right roadside departure).

NMVCCS researchers used data collected at the crash scene to determine the *critical reason* for the crash, which was defined as "the immediate reason for the critical pre-crash event and is often the last failure in the causal chain" (NHTSA, 2008a, p. 23). NMVCCS researchers assigned only *one* critical reason per crash, either to an environmental factor (e.g., specific roadway factors and atmospheric conditions), a vehicle failure (e.g., tire failure, brake failure), or a driver critical error. We used only *driver critical errors* in our analysis given our aim to focus on driver behavior-related crash factors. NMVCCS defined four high-level categories of driver critical errors:

(1) Non-performance errors (e.g., sleeping, medical conditions).
(2) Recognition errors (e.g., inattention, inadequate surveillance, distraction).
(3) Decision errors (e.g., too fast for road conditions, following too closely, misjudgment of gap/other's speed).
(4) Performance errors (e.g., overcompensation, poor directional control).

Although the critical reason (and therefore driver critical error) was not designated as the cause of the crash or meant to imply fault, it indicated the primary reason for the pre-crash event that made the crash inevitable, thus providing important insight into the primary (driver behavior-related) factors leading up to the crash. As part of quality control measures, the assignment of the critical reason also received a second review by NMVCCS researchers.

2.3. Statistical analysis

For this analysis, we selected two groups of licensed drivers: 16- to 19-year-olds and 35- to 54-year-olds involved in serious crashes while driving a passenger vehicle (Fig. 1). This age range for older