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Analysis of factors associated with injury severity in crashes involving young New Zealand drivers

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ABSTRACT

Young people are a risk to themselves and other road users, as motor vehicle crashes are the leading cause of their death. A thorough understanding of the most important factors associated with injury severity in crashes involving young drivers is important for designing well-targeted restrictive measures within youth-oriented road safety programs. The current study estimates discrete choice models of injury severity of crashes involving young drivers conditional on these crashes having occurred. The analysis examined a comprehensive set of single-vehicle and two-vehicle crashes involving at least one 15–24 year-old driver in New Zealand between 2002 and 2011 that resulted in minor, serious or fatal injuries. A mixed logit model accounting for heterogeneity and heteroscedasticity in the propensity to injury severity outcomes and for correlation between serious and fatal injuries proved a better fit than a binary and a generalized ordered logit. Results show that the young drivers' behavior, the presence of passengers and the involvement of vulnerable road users were the most relevant factors associated with higher injury severity in both single-vehicle and two-vehicle crashes. Seatbelt non-use, inexperience and alcohol use were the deadliest behavioral factors in single-vehicle crashes, while fatigue, reckless driving and seatbelt non-use were the deadliest factors in two-vehicle crashes. The presence of passengers in the young drivers' vehicle, and in particular a combination of males and females, dramatically increased the probability of serious and fatal injuries. The involvement of vulnerable road users, in particular on rural highways and open roads, considerably amplified the probability of higher crash injury severity.

1. Introduction

The continued over-representation of young drivers in road crashes and fatal crash injuries is a global public health concern (see, e.g., Williams, 2003; Twisk and Stacey, 2007; Scott-Parker et al., 2013; Zhu et al., 2013). Across the OECD countries, motor vehicle crashes are the leading cause of death, with approximately 25,000 young people between the age of 15 and 24 killed every year. These 25,000 crash fatalities account for 35% of all deaths in this age group. Across the same countries, young drivers represent 28–30% of all driver fatalities, while constituting only 9–13% of the population (OECD, 2006). Young drivers are a disproportionate danger to other road users as well. U.S. data show that about 30% of the fatalities in crashes involving young drivers are their passengers, 24% are other vehicle occupants and 7% are non-motorists (AAA, 2009). OECD estimates indicate that for each young driver killed, 1.3 other road users are likely to die in the same crash (OECD, 2006). The societal costs of crashes involving young drivers have been estimated at 20 billion Euros across OECD countries in 2004 (OECD, 2006).

An ample body of research has been dedicated to studying the problem of high risk of crash involvement among young drivers, the factors that are associated with risk taking behavior of young drivers and the effectiveness of graduated driver licensing (GDL) programs (e.g., Hedlund and Compton, 2005; Williams and Shults, 2010; Williams et al., 2012; Prato and Kaplan, 2013). Understanding the factors associated with crash injury severity of young drivers is also important because of its potential to help designing well-targeted and restrictive measures related to youth-oriented road safety programs. Notably, only a handful of studies has been dedicated to understanding the underlying factors associated with injury severity in young driver crashes, and these studies have often concentrated on specific aspects rather than on the spectrum of factors possibly related with injury severity. Yannis et al. (2005) and Zambon and Hasselberg (2006) focused on young motorcyclist crashes due to the popularity of two-wheelers among young adults. Specifically, Yannis et al. (2005) analyzed the effect of engine size and young rider's age on crash severity and the at-fault young rider's risk in Greece, while Zambon and Hasselberg (2006) looked at the socioeconomic differences in road traffic injuries of young

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riders. Gray et al. (2008) investigated the factors underlying injury severity of motor vehicle crashes involving male young drivers from 1991 to 2003 in London and the whole of Great Britain. Factors related to the driver, infrastructure and environmental characteristics were analyzed, although the data did not capture behavioral factors such as the number of passengers, driver distraction, speeding or reckless driving, license type and driving experience (Gray et al., 2008). Paleti et al. (2010) concentrated on the correlation of injury severity with aggressive driving style and low driving experience among young drivers. Orsi et al. (2013) focused on the association of higher injury severity with the presence of young passengers.

The current study extends this line of research by developing a conditional model of crash injury severity (i.e., conditional on the fact that a crash has occurred) and thus exploring the entire spectrum of underlying factors associated with the injury severity of crashes involving young drivers in New Zealand. The analysis was conducted on a comprehensive dataset of 43,008 crashes that involved at least one 15–24 year-old driver in New Zealand between 2002 and 2011 and resulted in any minor, serious or fatal injuries to the young drivers, their accompanying passengers, other vehicle occupants and vulnerable road users. The dataset was compiled from police reports collected by the Land Transport Safety Authority (LTSA) that contained detailed information about young drivers' characteristics and behavior, other road users' characteristics and behavior, vehicles' characteristics, crash location, roadway characteristics, and environmental and temporal conditions. The analysis was conducted by means of discrete choice models. A binary logit model, a generalized ordered logit model and a mixed logit model were estimated and their performance comparison illustrated the latter being the best model. The mixed logit model accounted for heterogeneity and heteroscedasticity in the propensity that determines the probability of injury severity outcomes, as well as correlation between serious and fatal injuries.

The paper is organized as follows. The next section provides a general background for the case study context. Then, the data source and estimation sample are described, and the employed methodology is detailed. Last, model estimation results are presented and discussed, and concluding remarks are offered.

2. Case study context

New Zealand considered youth-oriented driver policies in the mid-80s to counter unfavorable crash rate trends among young New Zealander drivers 15–24 years old. In 1985, their road crash fatality rate was nearly 48 per 100,000 person years, compared to 40 in Australia, 35 in the U.S., 34 in Canada, and 18 in the U.K. and Sweden (Begg and Stephenson, 2003). In 1986, their road crash fatality proportion reached 39%, while their population proportion was only 18%. In light of this, the New Zealand Parliamentary Select Committee on Road Safety proposed a GDL system in 1987 (Begg and Stephenson, 2003).

The GDL system initially was designed as a three-stage licensing process that applied to all novice 15–24 year-old driver applicants. In the first stage, a learner license imposed supervised driving and enforced a more restrictive blood alcohol limit (0.03 mg%) than other drivers (0.08 mg%). In the second stage, a restricted license imposed nighttime restrictions and young passenger limitations in addition to the restrictive blood alcohol limit. In the third stage, a full license without restrictions was awarded. A written test, an oral theory test, and an eyesight test were required to obtain the learner license, a practical driving test was necessary to obtain the restricted license, and no final test was needed for the full license. The GDL system was modified in 1999 following a review by the LTSA. Changes included (i) the application of the process for all novice New Zealander drivers regardless of age, (ii) the extension of the learner period without the possibility of reductions after taking driving courses, (iii) the design of a new driving test based on driving skills and hazard recognition and the introduction of a new test for obtaining the full license, and (iv) the imposition of heavier fines for violations of the GDL restrictions and license suspensions for repeated offenders.

Numerous studies have evaluated the effectiveness of the GDL system in New Zealand. Initially, the focus was on the attitudes and experiences of young drivers entering the GDL system (Begg et al., 1995). Later, the attention moved toward the analysis of crash rates to examine the effectiveness in reducing road crashes among young drivers, verify the hypothesis that reduced exposure caused the reduced crash involvement, and examine violations of GDL restrictions (Langley et al., 1996; Begg et al., 2001). Although the period between 1987 and 1996 saw a 50% reduction in the rate of fatally or seriously injured motor vehicle occupants between 15 and 24 years of age (Begg and Stephenson, 2003), road crashes remained the leading cause of death among 15–19 years old with 42.6 fatalities per 100,000 person years (Kypri et al., 2002).

Various efforts have been directed toward understanding factors contributing to the high crash risk of young New Zealander drivers. From the individual perspective, the focus has included gender (e.g., Reeder et al., 1998; Lewis-Evans, 2010), substance abuse (e.g., Begg et al., 2003, 2009; Kypri et al., 2006), cellphone use (Begg et al., 2009; Hallett et al., 2011), and risk-taking behavior (Blows et al., 2005; Ivers et al., 2009). From the social perspective, the attention has been on parental influence (Brookland et al., 2010; Brookland and Begg, 2011), peer pressure (Lam et al., 2003; Keall et al., 2004), and night-time driving (Keall et al., 2004). These studies addressed the crash risk of young drivers by analyzing data from self-report questionnaires regarding driving habits, attitudes and crash involvement by young New Zealander drivers.

3. Data

The dataset for model estimation was derived from police reports of crashes between 2002 and 2011 where at least one 15–24 year-old driver was involved. LTSA collected the police reports that contained one record for each road user who was involved in a crash and suffered a minor, serious, or fatal injury. An injury was considered minor if no medical treatment was required, serious if medical treatment or a period in hospital was necessary, and fatal if death occurred within 30 days of the crash as a result of injuries sustained from this crash. The police reports also contained one record for each driver who was not injured but was involved in a crash resulting in at least a minor injury to one road user.

Given the focus of the present study on injury severity of crashes involving young drivers, only crashes involving a young New Zealander driver between 15 and 24 years old that resulted in a minor, serious or fatal injury to the young driver or other road user(s) were analyzed. The unit of analysis was the crash injury severity, defined as the worst injury severity sustained by any road user involved in the crash. Accordingly, the dataset for model estimation was constructed by individuating the road users involved in the same crash through a crash identifier. Also, the dataset was compiled by distinguishing the young driver from the (possibly present) other driver and the other road user in the attempt to discern possible differences in the underlying factors associated with injury severity for the young drivers and the other road users.

The dataset for model estimation contained details about young driver's characteristics (i.e., age and gender), young driver's behavior (i.e., alcohol use, seatbelt use, fatigue, distraction, inexperience, speeding, reckless driving), young driver's maneuvers before the crash occurrence, number of passengers and their gender and age,