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A multinomial logit analysis of risk factors influencing road traffic injury severities in the Erzurum and Kars Provinces of Turkey☆

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ABSTRACT

A retrospective cross-sectional study is conducted analysing 11,771 traffic accidents reported by the police between January 2008 and December 2013 which are classified into three injury severity categories: fatal, injury, and no injury. Based on this classification, a multinomial logit analysis is performed to determine the risk factors affecting the severity of traffic injuries. The estimation results reveal that the following factors increase the probability of fatal injuries: drivers over the age of 65; primary-educated drivers; single-vehicle accidents; accidents occurring on state routes, highways or provincial roads; and the presence of pedestrian crosswalks. The results also indicate that accidents involving cars or private vehicles or those occurring during the evening peak, under clear weather conditions, on local city streets or in the presence of traffic lights decrease the probability of fatal injuries. This study comprises the most comprehensive database ever created for a Turkish sample. This study is also the first attempt to use an unordered response model to determine risk factors influencing the severity of traffic injuries in Turkey.

1. Introduction

As *Global Health Estimates 2013* reports, traffic injuries are the eight leading cause of mortality and disability (World Health Organization; WHO, 2013a). Approximately 1.24 million people die each year as a result of traffic accidents, and between 20 and 50 million people suffer from non-fatal injuries. Moreover, traffic accidents are predicted to cause the deaths of nearly 1.9 million people annually by 2020 (WHO, 2013b). Traffic injuries and fatalities are overwhelmingly increasing in low- and middle-income countries; current trends suggest that they will become the fifth leading cause of death by 2030. Overall, 80% of traffic mortalities occur in middle-income countries; this percentage corresponds to 72% of the world's population. Half the world's traffic deaths occur among vulnerable road users, and a higher proportion of these users are citizens of low- or middle-income countries (WHO, 2013c,d). Between 2008 and 2013,[1] around 6 million traffic injuries were reported in Turkey; more than 22,000 people were killed and almost 1.4 million people suffered from a variety of injury severities. Despite the implementation of numerous road safety policies, the number of traffic accidents and severe injuries in Turkey has increased over the past 10 years (Turkish Statistical Institute, 2013; Turkish National Police, 2013).

This paper seeks to provide some empirical evidence to the existing literature by conducting a disaggregate-level statistical analysis of driver injury severities in the Erzurum and Kars Provinces of Turkey for the period of 2008–2013. Particularly, the present study explores possible risk factors affecting road traffic injury severities in the corresponding provinces of Turkey. Using a multinomial discrete-probability analysis this paper allows to determine possible risk factors affecting road traffic injury severity in terms of several characteristics. Furthermore, the estimation results of this study may shed light for future traffic safety policy of relatively least-developed territories. The rest of this paper is organized as follows. Section 2 involves an extensive literature review of several factors considered in the estimated model. Section 3 gives detailed information about the methodological approach. Section 4 describes data used in the model estimation. Section 5 presents the model estimation results, discussion of these results and relevance to the previous work, while Section 6 gives a brief discussion of model specification issues. The paper concludes with implications of estimation results for road accident severity analysis, limitations of the present study and recommendations for further research.

☆ This paper is based upon the first author's master's thesis research.
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[1] The numbers for 2013 only include police-reported traffic accidents.

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2. Literature review

Many risk factors can contribute to the severity levels of injuries after an accident; these include drivers, vehicle, temporal, environmental and geometry characteristics. Laapotti et al. (2006) showed that leisure driving and driving at night were more typical for young drivers than middle-aged drivers, whereas middle-aged drivers' most typical driving involved driving to and from work. Clarke et al. (2006) suggested that losing control in the dark is an important problem for younger drivers, which might also lead to the decreased ability to show a quick improvement. A recent study (Møller and Haustein, 2014) revealed that perceptions of friends' speeding were strongly associated with speeding behaviours in male drivers between the ages of 18 and 28. Particularly, older drivers tend to drive faster relative to drivers in younger age groups. As a result, many other researchers found strong evidence that younger drivers have a higher proportion of increasing injury severity levels (Laapotti et al., 2001; Islam and Mannering, 2006; Yau et al., 2006; Haque, 2011; Martensen and Dupont, 2013; Curry et al., 2014; Weiss et al., 2014). These results may be somewhat associated with the amount of driving experience in terms of traffic accident involvement (Al Reesi et al., 2013; Borowsky and Oron-Gilad, 2013; Elvik, 2013; Scott-Parker et al., 2013; Glendon et al., 2014). Systematic and structured driver education can be an effective way of increasing new drivers' experience and decreasing their accident involvement (Cartensen, 2002). In contrast, older drivers' significant impact on injury severity levels was also highlighted (Carson and Mannering, 2001; Dissanayake and Lu, 2002; Yan et al., 2005; Boufous et al., 2008; Chen and Chen, 2011; Kim et al., 2013; Thompson et al., 2013; Yasmin et al., 2014). In addition, research studies suggested that inexperienced drivers tend to have a higher risk for traffic violations, such as speeding, drunk driving (Shankar and Mannering, 1996; Khorashadi et al., 2005; Yan et al., 2005; Jung et al., 2013; Chiou et al., 2013; Zhang et al., 2013, 2014) and not using seatbelts (Valent et al., 2002) or helmets (Shankar and Mannering, 1996; Kim et al., 2007; Shaheed et al., 2013). Accordingly, previous studies found that a majority of accidents leading to serious injuries were a result of driver inattention, which is an important traffic violation (Shankar and Mannering, 1996; Beanland et al., 2013).

The influence of gender as a potential risk factor affecting accident injury severity levels was frequently reported on traffic research. Male drivers generally tend to be less cautious than females about the risks of dangerous driving behaviours (Zhang et al., 2014; Shinar and Compton, 2004). Some previous research found that male drivers have a higher risk of being involved in more serious accidents than female drivers (Valent et al., 2002; Yau, 2004; Yan et al., 2005; Yau et al., 2006; Factor et al., 2008; Kim et al., 2013). However, other control variables may decrease this risk, such as age group (Santamariña-Rubio et al., 2014; Morgan and Mannering, 2011), driver characteristics (Obeng, 2011), heavy traffic volume (Abdel-Aty and Radwan, 2000) and accident type (Ulfarsson and Mannering, 2004; Santamariña-Rubio et al., 2014).

Vehicle characteristics such as the vehicle type and the number of vehicles involved in the accident can be associated with the injury severity levels of traffic accidents as potential risk factors. Carson and Mannering (2001) found that the probabilities of injuries and fatalities increase when the number of vehicles in the accident increases. Their results also showed that semi-trailers increase the probability of fatal injuries. Previous research also found that the involvement of multiple trucks (Abdel-Aty and Abdelwahab, 2004; Yan et al., 2005; Chen and Chen, 2011; Kim et al., 2013; Jung et al., 2013; Khorashadi et al., 2005) buses, cars (Valent et al., 2002; Yau et al., 2006; Martensen and Dupont, 2013; Chiou et al., 2013) or motorcycles (Valent et al., 2002; Yau et al., 2006; Chiou et al., 2013; Shaheed et al., 2013) increased fatal accident injuries. Uçar and Tatlıdil (2007) indicated that two-vehicle accidents led to increased probabilities of no severe injuries.

Temporal and environmental characteristics can also be considered risk factors affecting injury severity levels. Several research studies highlighted the occurrence of accidents on weekends (Valent et al., 2002; Yau, 2004; Martensen and Dupont, 2013; Zhang et al., 2013). Weekdays (Carson and Mannering, 2001; Rifaat et al., 2011) and a variety of time periods (Valent et al., 2002; Yau, 2004; Khorashadi et al., 2005; Yau et al., 2006) were also prominent as increasing or decreasing risk factors. Some research studies found that inclement weather conditions, such as fog, rain or snow, led to increased driving hazards (Keay and Simmonds, 2006; Kim et al., 2007; Brijs et al., 2008), However, Edwards (1998) suggested that rain-related accidents showed a consistent decrease in injury severities relative to optimal weather conditions. One recent study suggested that drivers' perceptions and reactions generally change in very different ways in relation to different surface conditions; male drivers under 45 years old had a higher probability for minor injuries on wet road surfaces (Morgan and Mannering, 2011). Laapotti et al. (2006) also indicated that slippery road conditions tend to increase the probability of fatal accidents for young females. Darkness or twilight generally increases the probability of severe injuries (Yau, 2004; Yau et al., 2006; Kim et al., 2007; Wanvik, 2009; Rifaat et al., 2011; Martensen and Dupont, 2013). Shaheed et al. (2013) revealed that motorcyclists have a higher risk of injury accidents in the summer months and that riding during daylight decreases the probability of severe injuries.

The possible effect of road geography on accident injury severity levels was extensively studied in the literature. Kim et al.'s (2007) results indicated that curved roads increase the probability of fatal injuries. Hosseinpour et al. (2014) suggested that several geometry characteristics, such as horizontal curvatures, paved shoulder width, terrain type and side friction, are associated with more severe injuries. Rifaat et al. (2011) suggested that the probability of a severe injury increases if the accident occurs on a divided road with barriers. Li et al. (2013) found that injury severity increases when accidents occur on jointed concrete pavement compared to asphalt or continuously reinforced concrete pavement. Their results also showed that poor pavement conditions lead to more severe accidents compared to fair pavement conditions. These effects on accident severity are evident when examining injuries resulting from accidents occurring on dry pavement and in daylight. Eluru et al. (2013) highlighted the significant roles of sidewalks, parking, vertical grades and bicycle routes for local and arterial roads on the severity of injuries.

3. Methodology

3.1. Statistical approach

The potential uncertainty and bias of univariate analyses has emphasized the need for multivariate analyses that consider the effects of all risk factors influencing injury severity (Shankar and Mannering, 1996). The main objective of this paper is to analyze possible risk factors affecting the severity levels of injuries resulting from traffic accidents. In contrast with accident frequency data, accident severity data are discrete data (Carson and Mannering, 2001). The database used in the current study has three discrete injury severity categories: no injury, possible/evident injury and fatality. The injury classification is based only on drivers' injuries; passengers' injuries are not considered. Fatalities are classified as an injured driver who dies at the scene of the traffic accident (Turkish Statistical Institute, 2013). Since the three possible discrete outcomes have a natural ordering, from a lower severity to a higher severity, an ordered probability model might be most