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A novel approach to study the health consequences of road crashes

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ABSTRACT

Introduction: While an association between road crashes and health impairments is well documented, few studies have analysed impairments in relation to crash parameters. The aim of this paper is to describe a novel approach for studying the full complexity of road crashes which allows an analysis of the relationship between crash factors and longer-term health consequences.

Methods: A multidisciplinary team investigated road crashes sampled in a Swedish region. The course of events, road environment and crash configuration were studied at the scene and telephone interviews were conducted with drivers. Road users were queried about their health status 1, 6, and 12 months after the crash. To illustrate a potential use of the collected data, the relationship between crash factors and impairments for car occupants after one month was explored using multiple logistic regression.

Results: The sampled data included 176 crashes, 310 vehicles and 430 people. The most common crash characteristics were: multiple vehicle crashes (62%); posted speed limit of ≥ 70 km/h (65%); passenger cars (88%); driver age 25–54 years (60%); male drivers/riders (70%). The example analysis of passenger car occupants showed that having an injury with ISS ≥ 1 at the time of crash was a statistically significant predictor for impairment at one month ($p < 0.001$, OR = 25.42, 95% CI: 8.30, 77.81).

Conclusions: The methodology described in this paper provides information about the full spectrum of road crashes and enables novel analyses of unexplored research questions. Based on the data collected so far and the example analysis presented in the paper, recommendations have been made about future data collection. The proposed data collection methodology enables characterisation of crash factors that are associated with long-term health consequences. The ability to timely identify those at risk provides important opportunities for early intervention to reduce long-term health outcomes also from low severity crashes.

1. Introduction

Preventing road crashes with fatal outcomes or serious injury consequences remains the foundation of the Vision Zero system approach to road safety (Larsson et al., 2010). However, with decreasing numbers of fatal crashes in several developed countries (WHO, 2013) it is of increasing importance to understand the emergence and long-term health consequences of less severe crashes. Several studies have shown that even people with low severity injuries, such as those graded at maximum AIS 1 or AIS 2 level on the Abbreviated Injury Scale (AIS) (AAAM, 2008), can experience long-term permanent medical impairment from those injuries (Malm et al., 2008).

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Most previous work related to long-term injury follow-up is based on an individual level rather than crash level. There are three main sources for the selection of cohorts for road crash injury follow-up studies: i) hospital admissions (e.g. Ameratunga et al., 2006; Mayou and Bryant, 2003; Cassidy et al., 2014); ii) injury registries (e.g. Polinder et al., 2015; Tournier et al., 2014); iii) insurance records (e.g. Kenardy et al., 2015; Gustafsson et al., 2014). There is no or little information about crash parameters (e.g. crash configuration, crash severity, vehicle characteristics and crash environment) in these studies. Some of these parameters are known to be strong predictors of major trauma outcome (Buendia et al., 2015), but their relationship with longer-term impairment is less clear.

The aim of this paper is to describe a novel in-depth crash data collection approach and illustrate its potential for the analysis of long-term health consequences of road crashes. In this paper the overall methodology of data collection will be explained and a description of the resulting data outlined. To illustrate how the data collected can be used, an exemplar examination of the relationship of crash related factors and acute injury to health outcomes at one month after the crash is presented for car occupants in low severity crashes.

2. Materials and methods

2.1. Overview of the data collection methodology

The dataset described in this study is referred to as the National In-depth Road Accident Database (INTACT) and originates from in-depth on-scene investigations that are performed at the scene of the crash by trained crash investigators. This dataset is a sample of road crashes in Sweden collected by Chalmers University of Technology. The INTACT methodology was developed in Sweden during 2007 to 2010. The methodology has since been used for crash data collection at a European level in the project Dacota (del Pozo de Dios et al., 2013). A description of the method can be found online (Chalmers University of Technology, 2014). All data was collected by a multidisciplinary team of trained investigators who also performed the case analysis of each case. The process of data collection is described below.

The dataset of road crashes was sampled from crashes in the city of Gothenburg and the six surrounding councils during two years from 1st September 2012 to 31st August 2014. A team of crash investigators were on stand-by to travel directly to the crash scene if notified by the emergency services. The shift schedule was planned with the aim of collecting a random sample of crashes in a two-year period with an expected number of 180 investigated crashes in total. Three shift types: morning (7 a.m. to 2 p.m.), afternoon (2–9 p.m.) and night (9 p.m. to 7 a.m.) were distributed evenly throughout the year and each shift type had the same frequency for each day of the week.

The investigation team received notifications about a crash as soon as an ambulance and the rescue services were called to the scene. Crashes involving at least one passenger car, truck or bus were investigated (therefore, e.g. single motorcycle crashes were excluded). There were no restrictions with respect to injury severity, i.e. all injury severity crashes and non-injury crashes were investigated. Data about the course of events, the road environment and the crash configuration was collected at the scene as well as from witness statements and briefings from the police and the rescue services. The police record of the crash was retrieved and the damaged vehicles were inspected by the team experts. Thorough inspection of passenger cars after the crash were restricted to those of year model 2003 and later as the ECE R94 regulation (UNECE, 2013) requiring an offset barrier test at 56 km/h was enforced to new vehicle registrations from 1 October 2003. Details such as the name and telephone number of involved road users were often obtained directly at the scene or later from the police, to prepare for interviews and injury follow-up. Overall, the collected data includes information from all phases of a crash i.e. pre-crash conditions, in-crash injury outcomes, pre-hospital care and long-term health consequences. These aspects will be described in detail below. The study was approved by the Regional Ethical Review Board in Gothenburg.

2.1.1. Data collection about pre-impact conditions

Data about pre-impact conditions concerning the driver's fitness to drive and the event leading up to the crash were collected after the crash event by telephone interviews with drivers, riders and/or pedestrians. An interview pro-forma (English version available at Chalmers University of Technology, 2012) was used for consistency and the interviews were performed as soon as possible after the crash. Each interview took approximately 30 minutes to conduct. To understand the course of events and the contributing factors to the crash, a computerised reconstruction was performed using the software PC-Crash (DSD, 2010). From this reconstruction, several crash severity measures (such as the impact speed and Delta-V, the change of velocity during the crash) were derived. Identification of the contributing factors to the crash was then performed by trained researchers according to the Driver Reliability Error Analysis Methodology (DREAM) (Ljung Aust et al., 2012). The results from the reconstruction are not reported in this manuscript. Results from the DREAM analysis have been presented previously (Kovaceva et al., 2015).

2.1.2. Data collection of in-crash injury outcomes and pre-hospital care

Once a written consent was obtained from the injured people, the medical records from the ambulance and hospital treatments were gathered. The medical record from the hospital includes injury diagnoses and was used to code in-crash injury outcomes using the Abbreviated Injury Scale (AAAM, 2008). From the AIS codes the Injury Severity Score (ISS) (Baker et al., 1974) was calculated. From the ambulance medical record, the patients' vital signs (systolic blood pressure, pulse rate, respiratory rate and the level of consciousness according to the Glasgow Coma Scale) were recorded. Additional pre-hospital treatment data collected included information about the rescue performed at the crash scene, the treatment during transport and the acute care at the hospital. These details enable further analysis about the pre-hospital treatment. However, such analysis will not be reported in this manuscript.