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# Analytic methods in accident research: Methodological frontier and future directions

Fred L. Mannering [a,*], Chandra R. Bhat [b]

[a] School of Civil Engineering, Purdue University, 550 Stadium Mall Drive, West Lafayette, IN 47907-2051, USA
[b] Department of Civil, Architectural and Environmental Engineering, The University of Texas at Austin, 301 E. Dean Keeton St. Stop C1761, Austin, TX 78712, USA

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ABSTRACT

The analysis of highway-crash data has long been used as a basis for influencing highway and vehicle designs, as well as directing and implementing a wide variety of regulatory policies aimed at improving safety. And, over time there has been a steady improvement in statistical methodologies that have enabled safety researchers to extract more information from crash databases to guide a wide array of safety design and policy improvements. In spite of the progress made over the years, important methodological barriers remain in the statistical analysis of crash data and this, along with the availability of many new data sources, present safety researchers with formidable future challenges, but also exciting future opportunities. This paper provides guidance in defining these challenges and opportunities by first reviewing the evolution of methodological applications and available data in highway-accident research. Based on this review, fruitful directions for future methodological developments are identified and the role that new data sources will play in defining these directions is discussed. It is shown that new methodologies that address complex issues relating to unobserved heterogeneity, endogeneity, risk compensation, spatial and temporal correlations, and more, have the potential to significantly expand our understanding of the many factors that affect the likelihood and severity (in terms of personal injury) of highway crashes. This in turn can lead to more effective safety countermeasures that can substantially reduce highway-related injuries and fatalities.



## 1. Introduction

Worldwide, more than 1.2 million people die annually in highway-related crashes and as many as 50 million more are injured and, by 2030, highway-related crashes are projected to be the 5th leading cause of death in the world (World Health Organization, 2009, 2013). In addition to the statistics on death and injuries, highway-related crashes result in immeasurable pain and suffering and many billions of dollars in medical expenses and lost productivity. The enormity of the impact of highway safety on human societies has resulted in massive expenditures on safety-related countermeasures, laws governing highway use, and numerous regulations concerning the manufacturing of highway vehicles. While the success of many of these efforts in reducing the likelihood of highway crashes and mitigating their impact cannot be denied, the toll that highway crashes continue to extract on humanity is clearly unacceptable.

* Corresponding author. Tel.: +1 765 496 7913.
*E-mail addresses:* flm@ecn.purdue.edu, flm@purdue.edu (F.L. Mannering), bhat@mail.utexas.edu (C.R. Bhat).

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Critical to the guidance of ongoing efforts to improve highway safety is research dealing with the statistical analysis of the countless terabytes of highway-crash data that are collected worldwide every year. The statistical analysis of these crash data has historically been used as a basis for developing road-safety policies that have saved lives and reduced the severity of injuries. And, while the quality of data has not always progressed as quickly as many safety researchers would have liked, the continual advance in statistical methodologies has enabled researchers to extract more and more information from existing data sources.

With this said, as in most scientific fields, a dichotomy has evolved between what is used in practice and what is used by front-line safety researchers, with the methodological sophistication of some of the more advanced statistical research on roadway accidents having moved well beyond what can be practically implemented to guide safety policy. However, it is important that the large and growing methodological gap between what is being used in practice and what is being used in front-line research not be used as an excuse to slow the methodological advances being made, because the continued development and use of sophisticated statistical methodologies provides important new inferences and ways of looking at the underlying causes of highway-crashes and their resulting injury severities. Continuing methodological advances, in time, will undoubtedly help guide and improve the practical application of statistical methods that will influence highway-safety policy. Thus, while the intent of this paper is to focus on the current frontier of methodological research (after reviewing current methodological issues), it is important that readers recognize the different objectives between applied and more fundamental research, and the role that sophisticated methodological applications have in ultimately improving safety practice and developing effective safety policies.

The current paper begins by quickly reviewing traditional sources of highway-accident data (Section 2) and the evolution of statistical methods used to analyze these data (Section 3). It then moves on to present some critical methodological issues relating to the analysis of highway-accident data (Section 4). This is followed by a discussion of some emerging sources of crash data that have the potential to significantly change methodological needs in the safety-research field (Section 5). The paper concludes with a discussion of some of the more promising methodological directions in accident research (Section 6), and a summary and insights for the future methodological innovation in accident research (Section 7).

## 2. Traditional highway crash data

Most existing highway-accident studies have extracted their data from police crash reports. These reports are used to establish the frequency of crashes at specific locations and the associated injury-severities of vehicle occupants and others involved in these crashes. In the U.S., common injury severities are assessed by police officers at the scene of the crash such as no injury, possible injury, evident injury, disabling injury, fatality (within 30 days of the crash).[1] Police-reported data also include a great deal of information that can serve as explanatory variables in modeling injury-severity outcomes, including information on time of day, age and gender of vehicle occupants, road-surface conditions, weather conditions, possible contributing factors to the crash, roadway type, roadway lighting, speed limits, basic roadway geometrics (curve, grade, etc.), type of crash (rollover, rear end, etc.) type of object(s) struck, driver sobriety, safety belt usage, airbag deployment, and so on. This information can be quickly expanded further by linking the data with government-provided roadway information (including traffic volumes, pavement friction, detailed roadway geometric characteristics, traffic-signal details) and detailed weather-related data (including temperature ranges, specific precipitation types and accumulations).

While the occurrence of a crash and the severity levels reported by police data have been used in many previous studies to provide insights relating to the factors affect highway safety, the inaccuracies of police-reported data are well documented. For example, it has been well established in the literature that less severe crashes are less likely to be reported to police and thus less likely to appear in police databases (Yamamoto et al., 2008; Ye and Lord, 2011). With regard to the severity of crashes, considerable inaccuracies have been found when comparing police severity reports with the severity assessment made by medical staff at the time of admission to the hospital (Compton, 2005; McDonald et al., 2009; Tsui et al., 2009). Also, with regard to traditional police data, a study by Shin et al. (2009), showed that the medical costs associated with the “no injury” compared to the “evident injury” severity categories were higher due to subsequent hospital admissions (injuries sustained were not reported or observed at the scene). Despite the limitations of traditional crash data (such as police-reported data), these data have supported countless research efforts that have attempted to improve our understanding of the factors that influence the occurrence of crashes and the personal injuries that result. A wide variety of methodological approaches have been used to explore traditional crash data, and these methodologies have become increasingly sophisticated over time as researchers seek to address the many less obvious characteristics of the data in the hope of uncovering important new inferences relating to highway safety.

[1] Other types of injury-severity measurement data that have been used include the Abbreviated Injury Scale (AIS) which was originally developed by the American Association for Automotive Medicine, the Organ Injury Scales (OIS) proposed by the American Association for the Surgery of Trauma and the Injury Severity Score (ISS) used by hospitals.