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Road Safety Modelling: Macroscopic and Microscopic Approach

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Abstract

As budgets for road safety measures, policies and interventions are limited, road safety stakeholders worldwide have to decide about the most effective use of available funds. Policy makers need prediction tools and decision support systems, developed through the utilization of quantitative road safety modelling research, allowing them to analyze potential safety issues, identify appropriate safety improvements and estimate their potential effect in terms of crash reduction. Two distinct approaches can be defined in road safety modelling research, as far as the nature of the developed models and results is concerned: the microscopic (i.e. accident prediction at specific sites) and the macroscopic approach (accidents and casualty forecasts over larger geographic regions). The paper aims to present a systematic review of existing knowledge and international pertinent research on both microscopic and macroscopic road safety modelling, pointing out how they actually complement each other to the benefit of road safety practitioners.

Keywords: safety, injuries, fatalities.

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1. Introduction

Despite the efforts of policy makers, road safety practitioners and transportation researchers to reduce the number of people killed and injured on the roads, road traffic crashes constitute a major global societal problem with more than 1.35 million fatalities per year (WHO, 2018). Road traffic injuries are the eighth leading cause of death for all age groups and the first mortality cause for children and young adults aged 5-29 years (WHO, 2018).

As budgets for road safety measures, policies and interventions are limited, decision makers and road safety stakeholders worldwide have to decide about the most effective use of available funds. Critically, the justification of investments in a field such as road safety, where large investments can potentially bring little or no results (and on rare occasions even negative results), is more than necessary. However, only in very few countries globally is the evaluation of the effectiveness of road safety measures, policies and interventions part of the culture and a routine within road safety programs. And even when this actually is true, the evaluation is usually limited to infrastructure and enforcement measures while the evaluation of entire road safety programs is even more rare.

In order to effectively improve road safety, policy makers need prediction tools and decision support systems, developed through the utilization of quantitative road safety modelling research, allowing them to analyze the potential safety issues, identify appropriate safety improvements and estimate the potential effect of these improvements in terms of crash reduction. Two distinct approaches can be defined in road safety modelling research, as far as the nature of the developed models and results is concerned: the microscopic and the macroscopic approach. Microscopic modelling is primarily infrastructure related and focuses on the development and implementation of specific Accident Prediction Models (APMs) that predict accident frequency in specific road elements (segments, intersections, interchanges, etc.) based on the values of infrastructure geometric characteristics (e.g. curve radius, lane width, shoulder width etc.) or traffic attributes (e.g. AADT). On the other hand, the focus of macroscopic modelling is on the prediction of values for key road safety performance indicators for larger geographic areas (e.g. city, region, country) using a broader and more generalized approach.

Within the aforementioned context, the objective of the paper is a systematic review of existing knowledge and pertinent research on road safety modelling, crash prediction tools and road safety decision support systems available worldwide. The review is performed within the research project i-safemodels: International Comparative Analyses of Road Traffic Safety Statistics and Safety Modelling, aiming to provide supportive evidence worldwide to improve national safety management strategies, geometric design guidelines, and hazardous locations identification and improvement.

2. Methodology

Databases such as Scopus, TRID and ScienceDirect are exploited in order to identify relevant literature, and a large number of international relevant data sources is investigated, including research papers, handbooks, meta-analysis studies, guidelines and web-based toolkits and decision support systems. Different modelling efforts (microscopic and macroscopic) and statistical techniques are reviewed and assessed in terms of theoretical approaches, methodologies for data collection, characteristics of models in use, implementation conditions, data requirements, modelling complexity and modelling transferability.

3. Results

3.1. Microscopic Road Safety Modelling

The analysis of crashes at microscopic level, usually referred to as accident prediction modelling (APM) aims at identifying the relation between with road crashes and injuries, and road infrastructure characteristics and traffic. This is usually achieved through appropriate statistical modelling, the type of which mostly depends on data availability. The release of the Highway Safety Manual (AASHTO, 2010; AASHTO, 2014) was an important milestone in accident prediction research, as it enables the practical implementation of an extensive predictive method for estimating the expected average crash frequency (by total crashes, crash severity or collision type) of a road network, facility or individual site, covering many types of roadway elements.

Other **indicative** references on microscopic road safety modelling to be included in the final paper and conference presentation include several pertinent research projects such as RIPCORD (2005, 2007 & 2008), RISMET (2011a & 2011b), PRACT (2015a, 2015b & 2015c; La Torre et al., 2016), existing online toolkits, as well as a very large number of related papers in journals and conferences (indicatively: Cafiso et al., 2012; Cafiso & D' Agostino, 2012; Caliendo, 2013; Chengye & Ranjitkar, 2013; Haleem et al., 2013; Kang et al., 2013; La Torre et al., 2014; Maier et al., 2013; Montella & Imbriani, 2013, etc.).

3.2. Macroscopic Road Safety Modelling

Microscopic or in-depth models and factors are very useful for estimating the safety effects of a specific infrastructure treatment applied in a specific location of the road network (e.g. increasing shoulder width, improving road alignment in a specific horizontal curve by increasing curve radius etc.), but cannot be used to summarize the broad picture of expected overall improvement in road casualties after the implementation of interventions of greater scale.

Macroscopic safety analysis on the other hand is related to traffic crashes at aggregate spatial levels (e.g. traffic analysis zone, county or region) with demographic, socio-economic, built environment, traffic attributes and roadway characteristics varying at the geographic-unit of analysis level. While microscopic level analysis is more focused on road infrastructure, the macroscopic analysis provides a broader spectrum for long-term policy-based measures such as enactments of traffic laws, police enforcement, education and area-wide road-design solutions In this task, advanced statistical analyses will be conducted to identify the feasible macroscopic safety analyses unit (e.g., TAZ or census block etc.).

Indicative references on macroscopic road safety modelling to be included in the final paper and conference presentation include the UNECE SafeFITS model and decision support tool (Yannis et al., 2018; Yannis et al., 2017), as well as other forecasting models on traffic casualty numbers (Broughton, 2011; Lassarre et al., 2012; Mitchell & Allsop, 2014; SWOV, 2010) or road safety indexes (Al Haji, 2015).

4. Discussion

(*to be completed in the final paper*) Quantitative road safety models are a valuable tool for more effective measures, interventions and policies, aiming to reduce the number of fatalities and injuries in road traffic crashes. Microscopic and macroscopic models complement each other according to the nature of the examined road safety polices and decision support tools based on both types of models should be available in the arsenal of transport decision makers.

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