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Predicting casualty-accident count by highway design standards compliance

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ABSTRACT

Compliance to standard has been the main doctrine in highway design, but its relationship with accident count has not been widely scrutinized. One of the key programs in road safety in Indonesia is road-worthiness test which assesses the compliance of a road to national design specifications and criteria. In light of current improvements in the crash data system in Indonesia, this study is carried out to develop a model to predict the accident count per type of crashes and to identify significant road features based on their compliance to a national standard. 272,200 km of arterial road in East Java North Corridor (EJNC) is selected as case study and 2012–2014 crash data is analyzed. Zero-Inflated Negative Binomial (ZINB) Model is preferred to develop crash prediction model with significant variables.

This study has several findings. First, the constant values of the prediction model are relatively close to the average number of accident which implies that the mere compliance to current standard cannot warrant the safeness of Indoensian highways. Second, the number of median opening per unit length and disturbance level to pedestrian and road reserve area are the features that having positive relationships with total accident count. Meanwhile, the ROW disturbance, conformance of intersection and of road marking also show significant value but negative relationship with total accident count. Third, significant variables for each type of crash may have different sign. For example, in right angle crash, median width has positive relation with the number of accident, while in run off and rear end crash, median width compliance is shown to have negative relation.

Introduction

Many road designers believe that when a road is built to meet standards, it should be safe. Thus, adherence to standards has been the main doctrine in highway design practice. However, the level of safety cannot be measured only by the standards. Hauer (2000) points out that many highway standards are limit standards. They do not govern the safest design, rather, they control the permissible limit for each element of a road.

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The relationship between highway standards and the real measure of safety (i.e., accident rate and accident severity) is conjectural (Hauer, 2000). Standards are set to avert failures. On the other hand, the concept of failure in highway design is defined by surrogates, such as a shortfall in lane width, or deficient centripetal force. Accordingly, a road built only to standards is built without a premeditated level of safety. Yet, there has not been many efforts to understand the relationship between governed standard with the accident count.

At the national level, understanding the relationship between standards and the real accident count can be important to indicate the effect of regulating one standard to the safety level of the road. Furthermore, it can serve as a guidance to a national road improvement program, especially for developing countries that are struggling to build roads in compliance with their national standard. By identifying which elements of highway standards contribute to the real number of accidents, the authority can effectively target highway expenditure to the improvement of deficient roads. On the other hand, while the crash database system is being improved in national level, the development of crash prediction model can help the other region with weak accident database.

This study embarks on the brink of crash data improvement of Indonesian arterial road. While reliable crash data was unavailable, Bina Marga, Indonesian highway authority, was under heavy pressure to increase the level of safety on its national roads. In 2011, the road-worthiness program was introduced to rectify safety deficiencies based on nominal safety. The main goal of the program is to provide a sound level of safety for all road users. Since then, every existing road has been thoroughly assessed to meet the current Indonesian highway standard, starting with national roads on Java Island. A new problem was then raised when the road-worthiness assessment found that almost all of our national roads in Java were unable to meet the minimum standard. A limited budget has made it difficult for Bina Marga to implement their safety program. Priority needs to be put on the national scale to gradually improve national roads.

Literature review

Road accidents and contributing factors

A road accident is a chain of events which results in one or more road users causing damage or injury to himself or others. There are three main factors that influence the number of people killed or injured: exposure, accident rate and injury severity (Elvik and Vaa, 2005). Exposure relates to the extent to which road users are exposed to risk factors. This is usually represented by the traffic volume in average annual daily traffic which is the average number of vehicles on a section of road per day throughout the year, regardless of the variation of traffic or the different type of vehicles on that road. Accident rate refers to the risk of accident per unit of exposure. Traditionally, it has been accepted as the safety measurement of a given road. Whereas injury severity refers to the result of accidents which is often measured in discrete value (fatal, seriously injured, injured and material damage only).

The most significant variable influencing the number of crashes is the traffic volume (Shankar et al., 1995; Caliendo et al., 2007; Haynes et al. 2008; Lord et al., 2008). Yet different ways of travelling involve different levels of accident risk. Based on the cross-sectional studies in five countries, the motorcyclist, for example, has over 10 times the risk injury than that of a car on average (Elvik and Vaa, 2005). Given a substantial variation in the means of transportation, the accident rates may also differ.

Most roads carry different types of traffic. The involvement of non-motorized road users in accidents has been modelled in many studies, such as Hall (1986), who studied 177 four-arm intersections in UK and used generalized regression techniques to produce the model with vehicles inflow and pedestrian flows as variables. Brüde and Larsson (1993) developed a model using the coefficient of determination, R2, based on accident data at 377 junctions in Sweden to develop model to predict number of pedestrian accidents using number of motor vehicles, number of pedestrians, and number of cyclists as predictors. Similarly, studies by Jackett (1992), Turner (1996), Summersgill and Layfield (1996), and Shankar et al. (2003), have also modelled the relationship between exposures of different types of road users and the accident rate. Interestingly, Leden (2002) finds that the risk involving pedestrians decreases with increasing pedestrian flow. The more pedestrians, the safer they are.

Road geometric also plays important part as contributing factors in accident occurrence. Milton and Mannering's (1998) work, using 2 years of crash data on 4386 km of Washington State highways and negative binomial regression to predict the number of accidents, showed the positive sign of a relationship between accident frequency and section length, vertical grade, AADT per lane, number of lanes, narrow right shoulder, narrow left shoulder, horizontal curve and central angle. Showing a negative relationship however were the peak hour percentages, percentage of single-unit trucks, percentage of trucks, posted speed, narrow lanes, sharp horizontal curves, horizontal curve radius, and tangent length.

Prediction models for accident occurrence

Many researchers have developed models for accident prediction. The generalized linear models have been favored by recent studies due to the limitations of linear models. Violation of the homoscedasticity assumption of linear regression and their unrestrained to negative accident frequency are some of the limitations found by Jovanis and Chang (1986). Furthermore, work by Lord and Mannering (2010) provides detailed review and assessment of the current statistical analysis of