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Road Safety Issues on Two Major Intercity Highways in Sri Lanka (A001 and A004) - Preliminary Analysis

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1. Introduction

According to the World Health Organization's 2015 global status report [1] on road safety, nearly 1.25 million people are killed in road accidents each year, and millions more suffer serious injuries with long-term adverse health consequences. In Sri Lanka, after 2010 there was a noticeable decline in road traffic fatality rates, yet in 2013 Sri Lanka remained above the WHO projected Southeast Asia regional average of 17 deaths per million population per year [1]. In this study, we carried out a micro-level analysis of accidents occurred on two major intercity highways (A001 and A004) in Sri Lanka.

2. Related Studies

This study focuses on analysing crash-frequency and crash-injury severities. Traditional Poisson and negative binomial/Poisson-gamma regression processes are the most commonly used models in crash frequency analysis [2] in relating that parameter to explanatory variables. However, in recent years some researchers have derived more enhanced models such as Poisson-lognormal, zero-inflated Poisson and negative binomial and gamma models to address the drawbacks of the earliest Poisson process models [2]. Binary outcome regression models, such as bivariate binary-probit and ordered-probit, and the unordered multinomial discrete outcome models, such as multinomial logit and nested logit, can be stated as the most commonly used models in crash-injury severity studies [3].

3. Data

The study was conducted using 2010 to 2012 records of accidents that occurred within an approximately 50-km length on the each A001(Peliyagoda to Ambepussa) and A004 (Vilasitha Niwasa to Avissawella) highway segments. The main source of accident data for this study was from the Sri Lanka Police Central Crash Record Database.

4. Methodology

In this study, the negative binomial (NB) regression model was used to predict the frequency of crashes of a specific severity level, as a function of explanatory variables. Since the dependent variable (accident frequency) was a non-negative integer and also on the basis of past research [2] Poisson regression model was the natural first choice. However, due to drawbacks such as over-dispersion [2], negative binomial regression was chosen as the most suitable tool to be used in this study. Multinomial logistic regression (MLR) was used to analyse the factors that prevailed in a specific crash leading to a certain crash severity, including site-specific factors on sections of both highways A001 and A004. This regression model was mainly chosen based on the dependent variable characteristic, which was a nominal variable with four outcome severity categories. In addition, past research [3] and the convenience of understanding and interpreting the results contributed to the selection. Additionally, descriptive statistics of all accident severity types and their explanatory variables were obtained. All accidents were normalized according to segment length and traffic volume, and the accident rates were given in units of accidents per million vehicle kilometres.

5. Results

5.1. Descriptive statistics

Table 5.1 shows the descriptions used for each severity type considered in the analysis**.**

Table 5.1: Description of the severity types

Severity	Description
Fatal	Person(s) Deceased
Grievous	Injury to head or permanent damage to any body part
Non-grievous	Small injuries such as abrasion
Damage only	Only property damage

The total number of accidents reported along A001 and A004 for the selected segments during the period from 2010 to 2012 were 3,855 and 3,006 accidents respectively; among these accidents, approximately 16% were fatal and grievous, 24% non-grievous, and 60% were damage-only accidents. Among all severity types, approximately 80% of the victims were male and 20% were female. Three-quarters of the victims were less than 50 years of age; among them, 25% were younger than 27 years. 77.4% of the total accidents resulting in death or major injuries occurred on stretches of road more than 10 m away from an intersection, followed by 12.2% at four-way intersections, and 4.7% at three-way intersections.

Further, 75% of the fatal accidents occurred during off-peak traffic hours. About 20% of drivers who suffered fatal accidents did not have a valid driver's license. On both highways, motorbikes were the leading vehicle type involved in fatal or grievous accidents, accounting for around 25% of the total in each highway and followed by dual purpose vehicles (15 %), three-wheelers (14 %), cars (13 %) and buses (13%). Pedestrian, head-on, rear-end and sideswipe accidents were the top four collation categories among major injury accidents on each highway, accounting for 80% of total accidents. Further, 70% of the fatalities were due to head-on collisions and pedestrian accidents.

5.2. Analysis of crash-frequencies

For the crash-frequency analysis, log counts of crash rates were regressed against average daily traffic (ADT), number of lanes, and highway segment lengths on highways A001 and A004. The omnibus test results of both highway models were significant (<0.05) and therefore both estimated models were a significant improvement over a model without any predictors. As shown in Table 5.2, all dependent variables were significant (P-value < 0.05), and the estimated models without intercept could be expressed as the following NB model linear equations (i) and (ii) for highways A001 and A004 respectively.

$$\log(\text{crash rates: A001}) = 0.45(\text{ADT}) + 0.44\,(\text{number of lanes}) + 5.87\,(\text{length}) \quad \text{(i)}$$

$$\log(\text{crash rate: A004}) = 0.75(\text{ADT}) + 0.36\,(\text{number of lanes}) + 1.56\,(\text{length}) \quad \text{(ii)}$$

Since all of the estimated coefficients were positive, the crash rates for both highways tend to increase with an increase in any of these dependent variables. According to Table 5.2, compared to lower ADT values (< 25,000 veh/day), the total accident rate on the A001 was 2.55 times higher when the ADT values were greater than 25,000 veh/day, and it was 1.64 times higher on the A004. With an increase of one in the number of lanes, the total accident rate tended to increase by 69% on the A001, and by 13% on the A004. Further, with an increase in length of 1 km along the highways, the total accident rate tended to increase by approximately 355.19 times on the A001, and 4.76 times on the A004 highway, respectively.

Table 5.2: Negative binomial estimation results

Variables	A001			A004		
	Estimated coefficient (B)	**Sig.**	**Exp(B)**	**Estimated coefficient (B)**	**Sig.**	**Exp(B)**
ADT **	0.45	0.00	2.55	0.75	0.00	1.64
Number of lanes	0.44	0.00	1.69	0.36	0.00	1.13
Length (in Km)	5.87	0.01	355.189	1.56	0.02	4.763

**1 if ATD ≥ 25,000 veh /day, 2 otherwise

5.3. Analysis of highway crash-injury severities

Table 5.3 illustrates the estimated coefficients and significance of each explanatory variable for different severity outcomes under the multinomial logistic regression. However, statistically insignificant (p-value > 0.05) variables and categories under any severity type were excluded from Table 5.3. Non-grievous crashes were considered as the base injury-severity type, and both fatal and grievous injury crashes were compared with the base type to infer results. The variables with positive coefficients indicate an increase in the probability of occurrence of a specific crash category with the severity level compared to the base, and vice versa. For example, the coefficient related to the variable "Urbanicity" (urban/rural) is negative for both fatal and grievous injury severity levels, which suggests that driving in an urban area along these highways reduces the probability of fatal and grievous injury crashes, compared with non-grievous crashes. In contrast, driving without safety precautions (seat belts) indicates a higher propensity for involvement in a fatal crash compared to non-grievous injury crashes. Further, the odd ratio (computed as the exponential of the coefficient of the variable 'protection = safety precautions not taken') of a crash being fatal compared with non-grievous crashes was 4.04 ($e^{1.397}$). A surprising fact found was that, drivers tested for alcohol level after the crash and had over the legal limit (blood alcohol content > 0.08%) were tended to be involved in fewer fatal crashes compared to non-grievous injury crashes. 2,954 crash records were included in fitting the MLR model and the model was found to be statistically significant*. In addition, the Pearson goodness-of-fit test p-value was 0.11(> 0.05), which indicated that the estimated crash-injury severity model fits the data well. Moreover, sixteen dependent variables were selected for this crash-injury severity analysis and variables such as weather condition, intersection type, traffic condition, driver age and gender and experience were excluded due to lack of statistical significance.

Table 5.3: Multinomial logistic regression model for the crash injury severities.

		Fatal		Grievous	
Variables	**Categories**	Coef.	Sig.	Coef.	Sig.
	Intercept	-0.901	0.541	0.960	0.288
Urbanicity	Urban	-0.348	0.013	-0.292	0.003
	Rural	0[a]		0[a]	
Collision type	Other	-0.674	0.014	-0.313	0.061
	Rear-end	-0.991	0.000	-0.574	0.000
	Sideswipe	-0.998	0.019	-0.617	0.006
	Single Vehicle	0.161	0.589	-0.761	0.008
	Pedestrian	0.400	0.034	0.163	0.236
	Cyclist	-0.637	0.084	0.074	0.754
	Head-on	0[a]		0[a]	
Light condition	Proper lighting (day or night)	-0.419	0.002	-0.044	0.654
	Improper lighting (day or night)	0[a]		0[a]	
Traffic control	Controlled by traffic lights or Police	0.145	0.354	0.260	0.013
	No Control	0[a]		0[a]	
Casualty gender	Male	0.331	0.055	0.267	0.028
	Female	0[a]		0[a]	
Casualty age	26 and younger	-1.491	0.000	-0.559	0.007
	26-65	-1.266	0.000	-0.269	0.154
	65 and over	0[a]		0[a]	
Protection	Safety precautions not taken	1.397	0.000	-0.328	0.402
	Safety precautions taken	0[a]		0[a]	
Element type	Bus	0.955	0.000	0.623	0.000
	Lorry	0.525	0.045	0.351	0.053
	Car	0[a]		0[a]	
Validity of the license	Without Valid license for the vehicle type	0.917	0.000	0.175	0.218
	Valid license for the vehicle type	0[a]		0[a]	
Alcohol level	Over Legal limit	-1.031	0.027	-0.387	0.194
	No alcohol or below legal limit	0[a]		0[a]	

a. Set to zero because this parameter is redundant (base category).

*Note: -2 × Log-likelihood (final model): 6285.876; -2 × Log-likelihood (constant-only), 4708.131; P-value: 0.000: - indicates that the fitted model is significant over an intercept only model.

6. Conclusion

This study provides an empirical and methodological analysis of accident frequency and injury severity reported from A001 and A004 highways segments. According to the general statistics we found that, many of the victims who suffered fatal or major injury severity accidents were male, those without a valid driving license, who were younger than 50 years of age, were motorbike users, or were pedestrians. Further, most of these accidents occurred during off-peak hours and were more than 10 m away from an intersection. The crash-frequency model results of both A001 and A004 highways suggested a strong relationship between traffic volume (ADT) and the number of lanes with accident rates. Accident rates tended to increase significantly as traffic volume and the number of lanes increased. According to the crash-injury severity analysis, we found that human factors such as age, gender and protection; road and environmental factors such as light conditions, urbanicity and traffic control; and vehicle factors such as element type (mode of transport), have a significant and direct impact on the severity level of the accidents that occurred on both highway segments. However, driving under the influence of alcohol showed contradicting results to the norm. The findings of this study are suggestive but limited in that they are based only on A001 and A004 highway segments. For future research, it is recommended that the highway crash history of Sri Lanka be examined.

7. References

[1] Global status report on road safety 2015. (2015). Geneva: World Health Organization (WHO).

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