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Modelling public bus/minibus transport accident severity in Ghana

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ABSTRACT

The current safety concerns with buses/minibuses (public transport) in both developed and developing countries have warranted a renewed interest in bus/minibus safety research. Prior to this, there was a paucity of research in this domain especially in developed countries where the safety associated with buses was deemed adequate. In this study, we examined the factors that influence bus/minibus accident severity in Ghana using bus/minibus accident data from 2011-2015. We estimated the severity of bus/minibus accidents by fitting generalised ordered logit models. Our findings revealed that weekends, the absence of road median, night-time conditions, bad road terrain (curved, wet and rough roads), hit-pedestrian collisions, and drunk driving are associated with more severe bus/minibus accident outcomes. Conversely, minibuses, the absence of road shoulder, accidents in intersections, the presence of traffic control and collision types (except hit-pedestrian) are associated with less severe bus/minibus accidents.

Keywords

Bus/minibus accident severity; generalised ordered logit; accident modelling; Ghana

1. Introduction

Public bus/minibus transport is deemed a relatively safe mode of transport in developed countries, especially in the United States (US) and Europe. In these areas, the safety associated with this mode is considered adequate (Kaplan & Prato, 2012; Barua & Tay, 2010; Berntman, Wretstrand, & Holmberg, 2010). In addition, bus travel is considered the safest per distance travelled. For instance, studies using the number of fatalities per 100 million person-kilometres travelled have revealed that travelling by car entails eight times more risk compared to taking the bus; while walking is associated with 50 times more risk than taking the bus (Albertsson & Falkmer, 2005; Evans, 1994). The safety with public bus transport, especially in the developed countries, explains the paucity of empirical studies on bus accidents as well as the limited public interest in bus accidents relative to other transport modes (Cafiso, Di Graziano, & Pappalardo, 2013; Chimba, Sando, & Kwigizile, 2010). The general perception is that public transport use reduces traffic congestion and pollution, and improves road safety (Brenac & Clabaux, 2005).

Conversely, the situation in developing countries is quite different, where public bus/minibus transport has serious safety concerns as a result of frequent involvement in severe accidents (Barua & Tay, 2010; Iles, 2005; Hamed, Jaradat, & Easa, 1998). In these countries, bus/minibus accidents are rampant with alarming consequences (Kaplan & Prato, 2012; Chimba et al., 2010).

In the book "*Public transport in developing countries*", Iles (2005) observed that public transport vehicles (buses and minibuses) in developing countries are frequently involved in fatal accidents. Iles maintains that speed is the underlying cause of most of the accidents in these countries.

Based on recent developments in both developed and developing countries, research interest in bus and bus passengers' safety has emerged strongly. A couple of studies and interventions have been implemented in the bid to identify and tackle emerging challenges, and thus improve bus safety. Kaplan and Prato (2012) for example, reports that in the United States (US) the renewed interest in bus safety resulted in the new Motorcoach Enhanced Safety Act of 2011 and the prioritisation of research on bus safety, and the subsequent creation of a new training curriculum for bus operators.

2. Magnitude and severity of public bus/minibus accidents in Ghana

Public bus/minibus transport form the backbone of mobility in Ghana, as in other low- and middle-income countries (Mohan, 2016). Unfortunately, bus/minibus passengers are a significant road user group at risk of road traffic accidents (Odero, Khayesi, & Heda, 2003). In Ghana, bus/minibus occupants are the third road users with the highest fatality risk (National Road Safety Commission, NRSC, 2014). For the period 1991-2014, public buses/minibuses constituted 23.9% (n=90,206) of the total number of vehicles involved in accidents in Ghana producing 35.7% of the total recorded casualties (n= 327,994).

Generally, road traffic accidents cost 1.6% of Ghana's gross domestic product (GDP) (Ackaah, Afukaar, Agyemang, & Debrah, 2008). Intuitively, the contribution of public buses/minibuses (as a higher occupancy mode) to the total cost of road traffic accidents in Ghana is expected to be higher (exact figures are not available). Addressing the public bus/minibus safety concerns through evidence-based interventions will increase PT passengers' confidence and patronage and hence promote sustainable PT use (Khoo & Ahmed, 2018). In Ghana, PT has a positive impact on road space occupancy; buses/minibuses utilise about 30% of road space but convey over 70% of person-trips (Amoo-Gottfried, 2012).

The government through the Metropolitan, Municipal and District Assemblies (MMDAs) regulate public transportation in their areas of jurisdiction. However, public transportation operations are deregulated (with both government, quasi-government, and private ownership and operations) (Sam & Abane, 2017; Yobo, 2013; Salifu, 2004).

2.1. Study objective

In this study, we examine the factors that influence public bus/minibus accident severity in Ghana using the national bus/minibus accident data from 2011 to 2015. Unlike previous studies, this study considers both bus and minibus accidents for this reason: minibuses are also important transport modes in developing countries and are associated with a relatively higher accident risk (see Hamed et al., 1998). As Kaplan and Prato (2012) argue, examining the factors that are associated with bus accident severity can alert PT operators of the circumstances that are associated with injury risk for bus accidents. This knowledge can serve as the basis for bus safety improvement strategies.

In this study, we applied the following definition to a public bus and minibus transport: a commercial vehicle with a seating capacity of more than 25, and 10-25 seating capacity respectively. To the best of our knowledge, this study is the first work to examine the factors that bear injury risk for buses/minibuses (public transport) in Ghana. This is regardless of their enormous safety concerns in the country. Obviously, addressing the safety concerns of the buses and minibuses in the country needs a "local context" for it to be sustainable. At best previously established significant bus/minibus accident severity predictors can be used for probing purposes and a benchmark in the search for, and explanation of significant local factors.

3. Descriptive statistics

Public bus/minibus accidents in Ghana are basically high and severe. But for the period 2011-2015, the situation followed a downward trend specifically from the year 2012. The 2012 figure constituted 23% of the total bus/minibus accidents for this period (N=33,694). Perhaps, the downward trend is an indication of the effectiveness of the road safety interventions, particularly those targeting buses/minibuses, in the country. This period under investigation witnessed the launch of the UN Decade of Action for Road Safety 2011-2020, and subsequently Ghana's adoption of this global action plan. In accordance with this global action plan, a number of traffic safety interventions have been implemented nationwide especially targeting the road users with high fatality risks. Towards bus/minibus safety, the measures include increased educational campaigns and training for bus/minibus drivers, safety audits of the transport operators' operations, and traffic police highway visibility (especially on accident-prone roads). In a recent study, Sam and Abane (2017) observed that the bus operators have equally adopted a number of measures to enhance bus/minibus safety: strict adherence to routine bus maintenance schedules, periodic driver training and retraining, and medical screening. In addition, the following have also been implemented: mandatory rest stops for drivers on long distance journeys, driver awards schemes (awarding drivers who record no road accident for a specified period), driver behaviour tracking in real time, and surcharging of at-fault drivers with the cost of repairs on damaged buses and property.

The data revealed that there were more male bus/minibus drivers (99.7%) than their female counterparts involved in road accidents over the period. This may be explained by the male dominance in the industry (commercial bus/minibus driving) and also driving in general in Ghana. The majority (64.8%) of these drivers could be classified as young (≤35 years), fully licensed to drive (94.8%), even though 5.2% of them were either unlicensed or at best partially licensed. Nearly 83% of the drivers involved in the accidents were uninjured. Interestingly, about 70% of the accidents could be attributed to driver errors in the form of lapses and errors (inexperience and inattention), and traffic violations (improper overtaking, improper turning, over-speeding, fatigued driving and tailgating). On this phenomena, the national road safety commission (NRSC, 2014) revealed that driver indiscretion and poor judgement is a major cause of road fatalities among public transport users in the country. We admit that this should be prioritised for training and remedial action by the public transport operators and the other relevant road safety stakeholders. Addressing these issues will help improve public bus/minibus safety in the country. We further observed that in many of the instances, the buses/minibuses were going ahead (84%) than otherwise (turning, reversing etc) at the time of their accidents.

Table 1 details the explanatory variables used in estimating bus/minibus accident severity. For the 5-year period, there were more buses (72.1%) than minibuses (27.9%) involved in accidents, resulting in more property-damage-only (33.2%) accident outcomes. Fatal accidents constituted 15.6% of the accident outcomes. Nearly 70% of the accidents occurred on weekdays with its huge traffic and thus increasing the exposure to risk.

Furthermore, Table 1 reveals that nearly 70% of the accidents occurred during the day, and on straight and flat roads (89.4%) without median (69.4%). The vast majority of the accidents occurred on dry (84.4%), and good (92.4%) road surfaces, with good shoulder conditions (45.8%), though in some instances, there were no shoulders (42.0%). Furthermore, 74.5% of these accidents happened on road sections than on intersections (25.5%), with no form of traffic control (58.6%) resulting in an almost equal number of hit pedestrian (25.7%) and rear end (22.8%) collisions. Only 1.9% of the cases involved drunk driving. We found some correlations among these explanatory variables. For example, we observed a weak correlation between the location of the accident and the type of traffic control ($r=.17$, $p<.001$). Table 4 in the appendix presents the intercorrelations among the explanatory variables. It should be noted that none of the variables was "highly correlated" (i.e. none of the correlations was above the threshold of .80 to depict the existence of multicollinearity problems), thus our decision to retain them in the model (see Pallant, 2016; Field, 2013).

Table 1 Explanatory variables used in the model (N= 33,694).

Variable	Categories	N	%
Accident severity	Fatal	5250	15.6
	Hospitalised	8748	26.0
	Injured not hospitalised	8497	25.2
	Damage only	11199	33.2
Day of week	Weekdays	23447	69.6
	Weekends	10247	30.4
Road separation	Median	10295	30.6
	No median	23399	69.4
Vehicle type	Bus	24296	72.1
	Minibus	9398	27.9
Light condition	Day	22563	67.0
	Night (no light or light off)	7056	20.9
	Night (light on)	4075	12.1
Road description	Straight and flat	30106	89.4
	Curved/ inclined/ bridge	3588	10.6
Road surface	Dry	28430	84.4
	Slippery	5264	15.6
Shoulder condition	Good	15441	45.8
	Poor	4088	12.1
	No shoulder	14165	42.0
Location	Section	25117	74.5
	Intersection	8577	25.5
Traffic control	None	19733	58.6
	Present (Signals, stop sign, give way, pedestrian-X)	4519	13.4
	Others (e.g. speed hump/ rumble strips)	9442	28.0
Collision type	Head-on	3242	9.6
	Rear end	7692	22.8
	Right angle	2408	7.1
	Sideswipe	4777	14.2
	Overturn	4302	12.8
	Hit object	2621	7.8
	Hit pedestrian	8652	25.7
Drunk driving	Tested negative	33064	98.1
	Tested positive	630	1.9
Surface repair	Good	31139	92.4
	Rough with potholes	2555	7.6

4. Factors influencing bus/minibus accident severity

The available literature on bus accident injury severity is rather limited relative to the other transport modes; even though it is important for remedial action to promote sustainable bus use. However, the previous studies presented below bears greater significance to our current work. Fortunately, a couple of these studies (Barua & Tay, 2010; Hamed et al., 1998) were conducted in developing countries. This is important because of the peculiar mobility context and traffic risk of developing countries (Machado-León, de Oña, Baouni, & de Oña, 2017).

In the literature, accident severity has been attributed to a number of factors relating to the road user characteristics, prevailing traffic and road environment. These factors include vehicle types involved, the speed of travel, manner of the vehicle collision, the road environment and road user characteristics (see Prato & Kaplan, 2014; Barua & Tay, 2010; Elvik, Vaa, Høye, & Sorensen, 2009; Hamed et al., 1998). In addition, some studies have also estimated accident severity using the characteristics of the transport operators (see Hamed et al., 1998; Chang & Yeh, 2005).

Regarding bus/minibus accident severity, Table 2 presents some explanatory variables used in previous models. These include some proven significant predictors (*in italics*) with both positive and negative effects. For instance, Prato and Kaplan (2014) using generalised ordered logit models observed that bus accident severity increased with the presence of vulnerable road users, high speed, night hours, elderly third-party vehicle drivers, and bus drivers and other drivers crossing in the yellow or red light. They found age effects of bus accident severity as well.

In an earlier study, Kaplan and Prato (2012) revealed that (bus) driver gender and age also influence accident severity. They contend that male drivers reduce the probability of both severe injuries and fatalities, but are associated with an increase in property-damage-only accidents. Further, they demonstrate that both young and old age is associated with aggravated accident severity probability.

On their part, Barua and Tay (2010) fitted an ordered probit model and revealed that bus accident severity increases when the collisions occur in weekends, off-peak periods, on twoway lanes and is a single vehicle accident (involving pedestrians and other vulnerable road users). On the contrary, they observed that the presence of a median, sideswipe collisions, collisions with a parked vehicle and fixed objects, and the presence of signalised traffic controls with police presence are associated with lower severity risks.

Moreover, Hamed et al. (1998) studied commercial minibus accident severity in Jordan using a Poisson regression model. They found that the accident severity (in this case the number of injuries) is influenced by the driver's age, accident type, accident location, surface pavement conditions, the cause of the accident, time of day, daily distance travelled (indicative of the level of exposure) and time since the previous accident. Specifically, they revealed that accidents caused by younger drivers, single-vehicle accidents, resulting in vehicle rollover or head-on collisions, involving higher speed as well as accidents occurring on intercity rural roads are severe. However, they noted that dry road surface conditions, relative to wet surfaces, are related to less severe injuries.

Table 2 Explanatory variables used in previous bus accident severity studies.

Publication	Explanatory variables used
Prato and Kaplan (2014)	*Bus driver's age*; driver gender; driver's intoxication; *driver manoeuvre*; *driver manoeuvre at intersection*; bus type; accident type; *third party involved*; *third party's age*; third party's gender; *third party's intoxication*; third party's seat belt use; *third-party driver's manoeuvre*; *third-party driver's manoeuvre at intersection*; accident location; *speed limit*; number of lanes; light conditions; surface conditions; weather conditions; *year*; season; day; *time of day*; *land use* and *area*.
Kaplan and Prato (2012)	*Driver gender*; *driver age*; *driver behaviour*; *bus service type*; *bus type*; *other road users involved*; *other driver's age*; *other driver's behaviour*; *section type*; *number of lanes*; *road type*; *road alignment*; *road profile*; *road surface conditions*; *light conditions*;

	speed limits; *region*; and *year*
Barua and Tay (2010)	*Time trend; day of the week; time of the day; the number of vehicles involved; traffic control and operation; type of collision, and median availability*
Hamed et al. (1998)	*Driver age; type of accident; accident location, pavement surface condition; cause of the accident; time of accident occurrence; time of the previous accident; and distance travelled per day*.

5. Methods and data

We utilised econometric discrete choice modelling as a technique to model the severity of bus/minibus accidents in Ghana given a number of predictors or conditions.

5.1. Data

The bus/minibus accident data from 2011 to 2015 were extracted from the national accident database. This data comprised all bus/minibus accidents in both urban and rural environments over the period. This database is managed by the Building and Road Research Institute (BRRI) of the Council for Scientific and Industrial Research (CSIR), Kumasi, Ghana. The database is comprised of a police-compiled road traffic accidents occurring on Ghanaian roads, using a standard road accident report form. This report contains information obtained from surviving traffic accident casualties, witnesses, detailed accident sketches, hospital post-mortem reports in the event of fatal accidents, and detailed reports from accident investigators and vehicle examiners (NRSC, 2014). The data is stored in computers using the Transport Research Laboratory, UK (TRL)-developed Microcomputer Accident Analysis Package (MAAP, Windows version) software.

The database provides information on the driver, traffic elements, and road environment conditions at the time of the accidents. The driver information includes the name, sex, age, injury sustained, license number and status, a declaration of whether drunk-driving was involved and the driver errors associated with the accident (if any). Information related to the traffic elements and road environment include the vehicle types involved, vehicle manoeuvre, vehicle ownership and usage, the extent of damage, vehicle defects suspected and direction of travel at the time of the incident. In addition, the road type and description, surface type, shoulder type and condition, weather and light conditions, the presence of road separation, surface condition, accident location, traffic control, collision type and surface repair are also specified. Furthermore, the data also indicates the day and time of the accident, the number of vehicles involved, the number of casualties killed and injured, and the accident severity, measured on a four-point scale. The data provide important information on the nature and extent of bus/minibus accidents in the country. Notwithstanding, the data is subject to some under-reporting (basically as a result of shortfalls in recovery). According to the NRSC, the data recovery rate is currently over 80%. Regarding the degree of under-reporting in Ghana's official accident database, Salifu and Ackaah (2012) maintain that the level of non-reporting varies significantly with the severity of the accident (from 57% for property damage only accidents, 8% for serious injury accidents to 0% for fatal accidents). These levels of underreporting are not exceptional in an international context but must be taken into account when interpreting the results. Moreover, bus accidents are less likely to go unnoticed, and hence the risk of under-reporting is reduced (Prato & Kaplan, 2014).

5.2. Model estimation

We fitted generalised ordered logit models to estimate the severity of bus/minibus accidents in Ghana (dependent variable). Previous models we fitted using the ordered logit failed the test of parallel lines (proportional odds assumption) and thus our decision to use the generalised ordered logit where the proportional odds assumption (i.e. equal coefficient across thresholds, in this case, accident severity) is relaxed. Williams (2016) maintains that "the use of an ordered logit model when its assumptions are violated creates a misleading impression of how the outcome and explanatory variables are related" (p.11). The test of parallel lines in IBM SPSS (Polytomous Universal Model- PLUM) indicates whether the proportional odds assumption have been violated or not. It is important to note that a significant value (0.05 or less) for this test indicates a violation of the proportional odds assumption for which the use of the ordered logit is not advisable.

We utilised a two-stage procedure in selecting the most important predictors (variables with the strongest impact) of bus/minibus accident severity in the country. In the first stage, we fitted a full model. The full model included 25 bus/minibus accident-related variables captured in the database and associated with the driver (6 variables), traffic environment (7 variables) and road environment (12 variables). Although the vehicle type (i.e. bus or minibus) was not significant in the full model, we included it in the final model given its established importance to accident severity outcomes (see Elvik et al., 2009; Wood, 1997). The final model presented in this study comprised of the significant variables from the initial full model. Fortunately, these variables have been established in previous studies to be significant predictors of bus/minibus accident severity.

According to the traffic injury literature, the severity of an accident is determined by the road user with the most severe injury outcome. Accordingly, we defined bus/minibus accident severity as the most severe injury suffered by a bus/minibus occupant, or a road user where a bus/minibus is involved (Prato & Kaplan, 2014; Barua & Tay, 2010).

In the police report, accident outcomes are captured in a categorical ordinal format (*fatal*, *hospitalised*, *injured but not hospitalised* and *damage only*) defined as follows (NRSC, 2014):

- fatal accident: an accident where at least one casualty dies of injuries sustained within 30 days of occurrence;
- hospitalised or serious injury accident: at least one person is detained in hospital as an in-patient for more than 24 hours;
- injured, but not hospitalised or minor injury accident: accident in which the most severe injury sustained by a casualty is only minor, requiring at most first-aid attention, and
- damage-only accident: an accident which results only in a vehicle or other material damage.

Given the ordinal nature of accident severity outcomes (i.e. fatal, severe injury, slight injury and damage only), an ordered logit model can be specified in terms of the probability of injury severity *j* for a given accident *i* as (see Long, 1997; Prato & Kaplan, 2014):

$$P(y_i > j) = \frac{exp(X_i\beta - \phi_j)}{1 + exp(X_i\beta - \phi_j)} \qquad j = 1, 2, ..., M - 1 \qquad (1)$$

where X_i is a vector of explanatory variables of accident *i*, β is a vector of parameters to be estimated, ϕ_j are cut-off points for the thresholds of the ordered model to be estimated, and *M* is the number of categories of the ordered-response variable.

However, the generalised ordered logit model expresses the probability of injury severity *j* for a given accident *i* as (see Long, 1997; Williams, 2006; Prato & Kaplan, 2014):

$$P(y_i > j) = \frac{exp(X_{1i}\beta_1 + X_{2i}\beta_{2j} - \phi_j)}{1 + exp(X_{1i}\beta_1 + X_{2i}\beta_{2j} - \phi_j)} \qquad j = 1, 2, ..., M - 1 \quad (2)$$

where β_1 is a vector of parameters associated to a subset X_{1i} of explanatory variables that do not violate the proportional odds assumption (i.e. parallel lines), and β_{2j} is a vector of parameters associated with a subset X_{2i} of explanatory variables that vary according to the cut-off points of the ordered model. Positive coefficients on the explanatory variables imply a likelihood of a more severe outcome on the dependent variable (i.e. more severe bus/minibus accident outcome); the reverse is also true. The probability of injury severity has a closed-form expression and the parameters $\beta_{1,}$ β_{2j} and ϕ_j are estimated through the maximisation of the log-likelihood function *LL*:

$$LL = \sum_{n=1}^{N} \sum_{j=1}^{J} d_{nj} lnP(y_i > j) \qquad (3)$$

where N is the number of accidents,
and

$$d_{nj} = \begin{cases} 1, & \text{if accident n results in severity category j} \\ 0, & \text{Otherwise} \end{cases}$$

We fitted the model using the GENLIN procedure in IBM SPSS Statistics version 24. The dataset used in estimating the model contained 33,694 complete cases. All variables with incomplete cases were excluded from the model estimation not to introduce inconsistencies.

6. Results and discussion

6.1. Model estimation results

The goodness-of-fit of the model was established by a non-significant deviance value of 1.185 (χ^2 = 16801.16, df = 14173) indicating that the data is a good fit for the model. Table 3 presents the parameter estimates of the model. The Exp (B) stated in Table 3 indicates the change in the odds resulting from a unit change in the predictor. If the value is greater than 1, it suggests that as the predictor changes (in this case increases), the odds of the outcome occurring equally increases (positive correlation). Equally, a value less than 1 shows that as the predictor increases, the odds of the outcome occurring decrease (negative correlation) (Field, 2013).

From the model outcome (as illustrated in Table 3), we found the following variables to be correlated with the severity of bus/minibus accidents in Ghana: day of week, road separation, vehicle type, weather conditions, light conditions, road description, road surface, surface repair, and shoulder conditions, accident location, traffic control type, collision type, and the incident of drunk driving. Of this 13-factor model, we realised that 10 were road environment related (road separation, weather condition, light condition, road description, road surface condition, surface repair condition, shoulder conditions, accident location, collision type and traffic control type), 2 traffic related (day of the week and vehicle type), and 1 driver related (incident of drunk driving). However, we excluded the weather variable from the model to address inconsistencies with the road surface condition variable.

Table 3 Parameter estimates of the model.

Variable	*B*	Std. Error	Exp(B)
Threshold			
Damage only	-1.510	.0456	0.221*
Injured (not hospitalised)	-.135	.0447	0.874***
Hospitalised	1.519	.0458	4.569*
Day of week (Reference category: Weekdays)			
Weekends	.090	.0223	1.095*
Road separation (Reference: Median)			
No median	.259	.0253	1.295*
Vehicle type (Reference: Bus)			
Minibus	-.079	.0231	0.924***
Light condition (Reference: Day)			
Night (Light ON)	.168	.0324	1.183*
Night (Light OFF)	.224	.0258	1.251*

Road description (Reference: Straight and flat)			
Curved/inclined	.388	.0341	1.475*
Road surface (Reference: Dry)			
Wet	.097	.0374	1.102***
Shoulder condition (Reference: Good)			
No shoulder	-.458	.0227	0.633*
Poor	-.031	.0373	0.969
Location (Reference: Section)			
Intersection	-.193	.0280	0.824*
Traffic control (Reference: None)			
Speed humps/ rumble strips	-.205	.0240	0.815*
Present	-.399	.0378	0.671*
Collision type (Reference: Head on)			
Hit pedestrian	.902	.0383	2.465*
Hit object	-1.267	.0509	0.282*
Overturn	-.655	.0433	0.519*
Sideswipe	-1.523	.0440	0.218*
Right angle	-.862	.0522	0.422*
Rear end	-1.626	.0414	0.197*
Drunk driving (Reference: Tested negative)			
Tested positive	.215	.0753	1.240***
Surface repair (Reference: Good)			
Rough with potholes	.109	.0469	1.115**

Note. *p<.001; **p<.05; ***p<.01; N=33694

Firstly, we observed that the severity of public bus/minibus accident is related to the day of the week. With reference to weekdays, we observed that bus/minibus accidents occurring on weekends are significantly associated with an increase of 9.5% in the severity of the accidents. Thus, public bus/minibus accidents during weekends in Ghana are more severe consistent with both our expectation and previous findings including Barua and Tay (2010) and Michalaki, Quddus, Pitfield, and Huetson (2015). For instance, Barua and Tay (2010) found that more severe bus accident outcomes are associated with weekends during which time vehicle driving speed is relatively high as a result of the reduced traffic volumes. According to the Ghana national road accident reports, weekends (especially Saturdays and Sundays) record the most road traffic fatalities (NRSC, 2014). For example, of the 1,836 traffic deaths recorded in 2014, the highest number (323 or 17.6%) occurred on Sundays, with the lowest occurring on Wednesday (178 or 9.7%). For the previous year (2013), most traffic deaths (334 out of 1,898) occurred on Saturdays. This may be explained by the greater tendency for unlicensed (as noted earlier, 5.2% of the drivers were unlicensed) and inexperienced drivers (mostly minibus drivers) to drive on weekends given the low traffic volume, and police enforcement and surveillance. Hence, there is the heightened tendency for reduced concentration and reckless driving with severe accident consequences on weekends.

We also noted that the absence of a median (relative to the presence of a median) is associated with an increase of 29.5% in the severity of bus/minibus accidents. Even though there have been some mixed results on the impact of road medians on traffic safety, most studies (including Barua & Tay, 2010; Polders, Daniels, Hermans, Brijs, & Wets, 2015; Kaplan & Prato, 2012) have reported of positive safety impacts. From these studies, the implication is that road medians are associated with lower accident severity (Barua & Tay, 2010); reduce fatalities (Kaplan & Prato, 2012) and prevents head-on collisions (Polders et al., 2015) consistent with our present findings.

Surprisingly, we found that minibuses (relative to buses) are significantly associated with a lower accident severity risk by 7.6%. This is contrary to the supposed safety benefits of vehicle size and mass (see Evans, 1994; Wood, 1997; Elvik et al., 2009). For instance, Elvik et al. (2009) claim that "small cars do not give as good protection against injury in an accident as large cars" (p.64) and that "the greater the mass, the more protection people have against being injured in accidents" (p.67). However, it is also important to note that a vehicle's travelling speed is correlated with both the risk of accident involvement and also its severity; and hence the greater the travelling speed, the greater the impact and the impact outcomes (Kloeden, Ponte, & McLean, 1997; Michalaki et al., 2015; Peden et al., 2004). In this regard, Kloeden et al. (1997) contend that the risk of severe accident outcomes (i.e. risk of involvement in a casualty accident) doubles with each 5 km/h increase in vehicle speed above 60 km/h. Therefore, in the event of an accident, the faster-travelling vehicle is expected to be more severely impacted. By comparison, buses have a higher speed capacity than minibuses and thus are more inclined to travel at a much higher speed. This is a plausible reason behind the finding that minibuses are associated with a lower accident severity. the Another reason for this finding is that, in Ghana, most long-distance bus journeys (unlike minibuses) are scheduled for the night as it is presumed to be conducive to the buses' ease of movement. However, as we will establish later in this study, night-time conditions presents a lot of driving hazards including perceptual errors which impede safe driving. Further, this period is associated with increased driver speeding and recklessness given the "almost" absent traffic.

Similarly, relative to daytime, we observed that night-time conditions increase the severity of bus/minibus accidents from 16% (i.e. during night-time with the artificial light on) to 18.7% (night-time with the artificial light off (darkness)). Night conditions (whether there is artificial light on or off) impede safe driving in view of the difficulty with visibility, and hazard perception and response, potentially reducing the ability of the driver to avoid an impact (Abdel-Aty, Ekram, & Huang, 2011). Jägerbrand and Sjöbergh (2016) further argue that the correlation between road accidents and night conditions (darkness or low light conditions) could be explained by drivers' failure to adjust their speed to the reduced visibility. There is also an elevated tendency for perceptual/visual errors, drowsiness and drunk driving during the night (Boyce 2003). In their study, Assum, Bjørnskau, Fosser, and Sagberg (1999) observed that the introduction of road lighting increased vehicle driving speed by nearly 3% compared with unlit road sections. In support of this finding, Bassani and Mutani (2012) and Jägerbrand and Sjöbergh (2016) also found higher driver speed at night time; attributable to the tendency for faster drivers to drive at night as the proportion of slower drivers and vulnerable road users are reduced at that time. In accordance with this reasoning, and for ease of movement (given the vehicle mass), most long-distance bus departures in Ghana are scheduled for the night-time. However, it has also been argued that night-time conditions influence drivers' perception of their travelling speed and the most appropriate speed for the road environment (Edquist, Rudin-Brown, & Lenné, 2009). Taken together, weather and light conditions and road lighting are believed to have an interaction effect on vehicle speed (Jägerbrand & Sjöbergh, 2016).

In a similar vein, the road description (straight or curved), surface condition (dry or wet) and surface repair (good or rough) have significant effects on the severity of bus/minibus accidents. We observed that curved/inclined ($p<.001$), wet ($p<.01$) and rough ($p<.05$) road surfaces are associated with increased bus/minibus accident severity by 47.5% on curved/inclined roads, 10.2% on wet road surfaces, and 11.5% on rough roads with potholes. Intuitively, it makes a lot of sense that these road conditions are associated with the fatal accidents. Fortunately, earlier studies have confirmed this finding. For example, Prato and Kaplan (2014) also found that slippery (wet) roads increase the probability of severe accidents. Further, although curved and rough roads engender careful driving, these conditions, notwithstanding, constitute driving hazards and thus risk factors for road accidents. This explains the finding that more severe road accidents occur on curved roads than straight roads (Chen, 2010; Rakotonirainy, Chen, Scott-Parker, Loke, & Krishnaswamy, 2015). This is in view of the fact that curved and rough roads make vehicle control difficult (Elliott, McColl, & Kennedy, 2003) and are particularly associated with off-road/roll-over collisions (Rakotonirainy et al., 2015).

In addition, we observed that the absence of road shoulder (no shoulder) and poor road shoulder are associated respectively with 36.7% and 2.6% reduced bus/minibus accident severity. Martens, Comte and Kaptein (1997) reasoned that drivers may perceive the presence of a road shoulder as an extension of the road and thus compensate for the wider road surface by speeding. It is thus not surprising that the absence of a road shoulder (which implies a narrower road) is associated with reduced accident severity than a poor road shoulder (which may also be perceived as an extended driving space).

Similarly, bus/minibus accidents on road intersections (i.e. crossroads, T junctions, staggered crossroads, Y junctions, roundabouts, railway crossing) relative to road sections reduce accident severity risk by 17.6%. This finding is inconsistent with the previous finding that more severe accidents occur in road intersections (see Kaplan & Prato, 2012). A probable reason for this finding is the possible impact of the presence of traffic controls in intersections. Traffic controls regulate driver speeding and thus presents the possibility of having less severe accident outcomes in intersections. This notwithstanding, further research is needed to demonstrate this.

Further, we observed that the presence of traffic controls and speed calming measures are related to a reduced bus/minibus accident severity by between 18.5%-32.9% relative to where none exist, consistent with previous studies. In an earlier study, Zein, Geddes, Hemsing, and Johnson (1997) found that traffic calming accounted for a reduction in collision frequency, severity and the annual collision claim costs in the Greater Vancouver area, Canada. Similarly, Barua and Tay (2010) observed the same accident-severity reduction effect of traffic controls, particularly with police enforcement in Bangladesh. This is thus contrary to the claim that traffic control systems are installed on roads mainly to regulate vehicle traffic rather than improve safety (Kennedy & Sexton, 2009).

We also found the collision types to be related to the severity of bus/minibus accidents. Consistent with previous studies (Barua & Tay, 2010; Prato & Kaplan, 2014; Michalaki e al., 2015), we observed that "hit-pedestrian" collisions are associated with an increase in bus/minibus accident severity by 146.5% relative to head-on collisions. The other collision types specified (see Table 3) are also associated with reduced bus/minibus accident outcomes

($p<.001$). It is common knowledge that pedestrians are the most vulnerable of all road users and as such, any collision involving them is expected to result in a higher than usual severity outcome, relative to the other collision types.

Lastly, we observed that the probability of more severe bus/minibus accident is more likely where the drivers tested positive for alcohol (drunk driving) relative to where drunk driving was not involved ($p<.01$). This is expected given the effect of alcohol on driver performance, and both accident frequency and severity. For instance, Peden et al. (2004) maintain that drunk driving is related both to a higher accident risk and severity. This is because alcohol hinders driver performance in respect of coordination, judgement and vehicle control (Ogden & Moskowitz, 2004). Alcohol consumption has also been linked to increased aggression in general (Bushman & Cooper, 1990); implying that a drunk driver will drive more aggressively with serious accident outcomes.

7. Conclusion and recommendations

Our findings suggest that weekends, the absence of road median, night-time conditions, bad road terrain (curved, wet and rough roads), hit-pedestrian collisions, and drunk driving are associated with a higher bus/minibus accident severity. Conversely, the minibuses, the absence of road shoulder, accidents in intersections, the presence of traffic control and collision types (except hit-pedestrian) are associated with less severe accident outcome. Obviously, these results have research, policy, and practice implications for road safety stakeholders (e.g. road safety researchers, public transport operators, the police, road and traffic engineers and administrators) in view of implementing workable countermeasures and strategies to reduce bus/minibus accident fatalities.

Our estimated model suggests that bus/minibus accidents occurring during weekends, night-time conditions and on bad road terrain have worse outcomes. This finding implicates the driving behaviour (driver speeding and risk-taking) exhibited in these conditions. It should be noted that these conditions in themselves do not cause accidents (Iles, 2005), but drivers' failure to adjust their behaviour to these conditions is the problem. Based on our model outcome the following traffic safety strategies, which have the potential to reduce bus/minibus accident severity in the country, are recommended:

Firstly, given that weekends are associated with more severe bus/minibus accidents in Ghana, we recommend increased police enforcement and surveillance during these periods. Previous studies (e.g. Barua & Tay, 2010) have found a positive effect of police presence and enforcement on driver compliance and behaviour.

Secondly, as the absence of road median increases the severity bus/minibus accidents, we recommend the implementation of road medians on major roads (especially accident-prone roads) in the country. This should be extended to both current and future road infrastructural developments in the country. Further, owing to the fatalities associated with vehicle-pedestrian collisions and the fact that the road space in developing countries (particularly in Ghana) is a shared space for all road users (especially in the urban environment), the provision of road median and adequate pedestrian facilities will help separate pedestrians and other vulnerable road users from the road environment and thus reduce their exposure levels, and future vehicle-pedestrian collisions. In addition, we recommend that bus/minibus drivers be trained to be very vigilant and expectant of pedestrians and other vulnerable road users in the course of their travels, especially in the urban environment.

Thirdly, we also established that traffic controls and other speed calming measures have safety benefits. Accordingly, we recommend that traffic control and speed calming measures be implemented on major roads nationwide, especially within the urban environment.

On the finding that night-time conditions and bad road terrain increase the severity of bus/minibus accidents, we recommend that public transport operators should invest much effort in training and retraining their drivers to appropriately recognise, manage and respond to the potential risks associated with driving in these conditions. This is important given the findings that about 70% of the reported bus/minibus accidents were attributable to driver errors (mainly traffic violations and lapses). The data also revealed that in most of the cases, the drivers were not attentive (29.8%) and as such exhibited poor judgements. We recommend that public transport operators adopt high standard internal safety policies, monitor driver behaviour in real time and enforce strict compliance with road traffic rules. Likewise, we recommend driver licensing and re-licensing procedures to test (practically or otherwise) for bus/minibus drivers' ability to detect and manage road hazards with severe injury consequences.

8. Study limitation

As we indicated earlier, our data is subject to some under-reporting resulting from the shortfalls in data recovery. Even though the current accident data recovery rate of over 80% is good, we admit some information may have been lost by way of under-reporting or discrepancies in data reporting and capturing.

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Appendix

Table 4: Intercorrelations between explanatory variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
Day of week	1												
Road separation	.02**	1											
Vehicle type	.002	-.02**	1										
Light condition	.04**	-.04**	.03**	.36**	1								
Road description	.02**	.16**	-.04**	.02**	-.02**	1							
Road surface	.01*	.25**	-.04**	.03**	-.03**	.17**	1						
Shoulder condition	-.01	.03**	.05**	-.05**	.01	.02**	.17**	1					
Location	-.001	-.25**	.02**	-.07**	.00	-.11**	-.15**	.07**	1				
Traffic control	-.003	-.15**	.06**	-.04**	.02**	-.05**	-.16**	-.08**	.18**	1			
Collision type	-.003	.09**	-.003	.01*	.01	.003	.05**	.03**	-.16**	-.05**	1		
Drunk driving	.01**	-.02**	.03**	.004	.01*	-.003	-.001	.01**	.006	.005	.005	1	
Surface repair	.002	.18**	-.03**	.03**	-.03**	.13**	.56**	.14**	-.11**	-.15**	.03**	-.005	1

NB: * p<.05; ** p<.001