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Overtaking Behaviour on Rural Highways under an Heterogeneous Traffic Environment: Evidence from a Developing Country[1]

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Abstract

In the study reported here, the nature of overtaking manoeuver and associated safety risk on a two-lane undivided highway in an heterogeneous traffic environment has been evaluated. Different parameters have been assessed including: overtaking strategies by vehicle types; duration and distance of overtaking; as well as time and distance gaps between involved vehicles. Data from a section of a major highway in Bangladesh has been collected using fixed video cameras and field observers. The findings of this study will also be useful to develop a purpose-specific traffic safety micro-simulation model for further analysis, as well as to take effective countermeasures for improving safety in developing countries.

1. Introduction

Overtaking is very complex and hazardous manoeuver particularly in two-lane two-way highways, where the driver is likely to occupy the opposite lane to overtake slower vehicles facing incoming vehicles (Hegeman et al., 2005, Polus et al., 2000). A significant number of crashes occur due to inappropriate overtaking behaviour. It has been argued that such problems are disproportionately higher and more severe in developing countries (Asaithambi and Shravani, 2017). Firstly, in developing countries like Bangladesh, most of the roads, including national highways, are two-lane two-way with an traffic environment (in Bangladesh, more than 90% of national highways fall under this category). Secondly, due to the heterogeneity of vehicles, the speed differences of different vehicles are very large, (in Bangladesh, it varies between 30 kph to 120 kph, excluding two and three wheelers (Mahmud et al., 2017). This results in the need for frequent overtaking events. In addition, there are wide variations in the static and dynamic characteristics of vehicles, as well as in the degree to which drivers conform to lane discipline.

Therefore, a detailed knowledge of overtaking behaviour is essential to analyze the main safety related issues in developing countries. Very few studies are available in the literature, which addresses the issues of overtaking behaviour in two-lane two-way highways in heterogeneous traffic environments of developing countries. To address this gap, a detailed study has been carried out on overtaking behaviour in one such traffic environment. Data has been collected from a section of a major national highway in Bangladesh (N405). The study section was selected after a detailed analysis of the traffic and crashes in the country.

2. Past Research and Current Study in Context

[1]This is an abridged version of the paper originally presented at ATRF 2018. For further information about this research please contact the authors.

Over the last few decades, several studies have focused on the behaviour of overtaking manoeuver on two-lane roads. Most of those studies used data collected from simulated environments using a driving simulator, such as in Israel (Farah and Toledo, 2010), in US (Jenkins and Rilett, 2005), in Canada (Ghods and Saccomanno, 2016), in Italy (Bella, 2011) in Sweden (Farah, 2013). Some studies used data collected by instrumented vehicle on a selected track, such as in Netherlands (Hegeman, 2008), in Greece (Papakostopoulos et al., 2015), in Spain (Llorca et al., 2013), in Hungary (Mocsári, 2009) etc. Those studies concentrated on gap-acceptance decision-making, as well as passing duration and distance.

Some studies used real-time video observational data. Ghods (2013) developed an overtaking gap acceptance model to analysis the safety risk during overtaking using Time to Collision (TTC) on two-lane highways. Ghods and Saccomanno (2016) developed a microscopic overtaking gap acceptance model for two-lane highways and validated it using video-recoding data.

The above review shows that, the use of real traffic flow data in heterogeneous traffic conditions is very scarce. Therefore, detailed studies are needed to promote safe overtaking manoeuvers in the highways of developing countries.

3. Methodology and Data collection

The study comprises four parts, namely: collection of data on overtaking events; evaluation and analysis of overtaking behaviour characteristics; identification of potential conflicts and safety risk; and recommendation of potential safety countermeasures.

3.1. Data collection

Data was collected in 2017 from the Jamuna Bridge Approach road, a section of a major highway in Bangladesh. The primary data was collected using on-site observers and video, cameras and the floating car method. Cameras were mounted in two pre-selected segments of the road and two ends of the road for six days.

A group of two observers was designated for each camera. Those groups observed and recorded several pre-set attributes mainly related to overtaking behaviour continuously during the entire period of video being captured. Two additional groups were specified to collect some other data such as road geometry, road surface and side friction, traffic composition, spot speeds etc.

3.2. Data extraction: overtaking behaviour

The data extracted from the on-site observation and video observation are divided into two parts, namely: overtaking driving behaviour and drivers' behaviour during overtaking.

Preliminary data extracted included in the driving behaviour dataset are: time of overtaking; vehicular involvement; type of overtaking; duration and distances during overtaking; speed of overtaking and overtaken vehicle; direction of overtaking; and time and distance gap between overtaking and opposite vehicle. Data related to behaviour during overtaking included: use of indicators during lane changing, use of horns during overtaking manoeuver; and the position of different vehicles (before and after overtaking) and risk-taking attitude.

3.3. Types of overtaking strategies

Past studies have defined overtaking types under different strategies. Wilson and Best (1982), defined the overtaking types in three different categories, namely: accelerative, flying and piggybacking. Later, Hegeman (2008) added another strategy with that and termed as 2+ strategies. Some studies categorized overtaking manoeuver in four categories, namely: normal overtaking, aborted overtaking, lane sharing and cutting-in (Kashani et al., 2016). Considering the different scenarios and manoeuver types of overtaking behaviour in the study area, we have clustered nine types of overtaking strategies.

4. Results

The results presented here are based on the analysis of traffic flow for one day (6 hours). There were 535 different types of overtaking strategies recorded within the selected 400 meters segment.

4.1. Distribution of overtaking strategies

Single vehicle overtaking is prevalent, with around 71 percent of total strategies (33% flying and 38% accelerative). The share of those overtaking strategies in the east-west and west-east directions are 72 and 70 percent, respectively. With 9 percent of overall share, 2-vehicle consecutive and 1-vehicle piggy-backing are the second highest number strategies. The analysis observed a significant number of composite overtaking (around 7%), i.e. more than one vehicle overtake more than one vehicle in a single attempt. Very unsafe overtaking attempts were also observed. For example, a maximum of 6 different types of vehicles overtakes 3 vehicles in a single overtaking attempt and in the presence of an opposing vehicle.

4.2. Vehicular involvement

Buses and trucks make up 30% and 39% of the flow, respectively. However, buses are involved in more than 50 percent of all overtaking manoeuvers, whereas its share in overtaken is only 8 percent. Large trucks are being overtaken in 75 percent of all cases. This is mainly due to the very large speed differences between buses and trucks. In the case of light vehicles, microbuses and cars show very similar overtaking patterns. Their overtaking involvement (11%) is higher than their flow rate but overtaken involvement is only 1 percent of the total manoeuvers. Figure 4 shows the proportion of overtaking and overtaken vehicles.

4.3. Speed of the vehicles during overtaking

The study analysed the speed of vehicles during the overtaking manoeuver to quantify the speed behaviour during overtaking manoeuvers. Table 1 represents the minimum, maximum, average speed of major vehicles during overtaking and when being overtaken. Bus poses always the highest speed whether overtaking or being overtaken. However, the average overtaking speed of cars is higher than other vehicles.

Table 1: Speed profile of the overtaking and overtaken vehicles

Type of Vehicle	When overtaking				When overtaken			
	Min	max	Average	St.Dev	Min	max	Average	St.Dev
Bus	50	102	68	11	40	85	64	16
Truck	45	95	62	10	40	75	48	6
Car	55	90	71	11	55	80	68	18

4.4. Overtaking time

In the current study, it was found that the average overtaking time by different types of vehicles is 10.8s and 10.6s for flying and accelerative overtaking, respectively. Heavy vehicles, such as buses and trucks, show longer overtaking times. On average, buses took longer (12.1s) than trucks (11.1s). The maximum overtaking time by buses and trucks is 20.1s and 13.8s, respectively for flying overtaking and 19.9s and 14.5s for accelerative overtaking, respectively. For passenger cars, these values are 10.6s and 8.0s for flying and accelerative overtaking, respectively.

4.5. Overtaking Distance

The current study analysed the distance in flying and accelerative overtaking strategies by different types of vehicles. The average distances for flying overtaking (212 m) is higher than for accelerative overtaking (180m). In flying overtaking, a vehicle does not need to reduce its speed to get gaps in the opposite lane and starts overtaking with higher speed which increases the overtaking distance

On average, buses need longer distances than any other vehicle type, for both flying (244.9m) and accelerative overtaking (196.4m). The standard deviation of required overtaking distance is significantly lower for trucks, compared to buses.

4.6. Driver behaviour during overtaking

Driver behaviour during overtaking was evaluating in terms of the use of indicators, use of horn, position on road before, during and after overtaking and risk-taking attitude during overtaking.

The observations revealed that only few vehicles used indicators during lane changing, including moving to opposite lane (6%) or coming back to own lane (1%). In many overtaking events, the overtaking vehicle did not completely cross the centre-line. To avoid a collision, overtaken vehicles were forced to use the road shoulder, thereby posing serious sideswipe, as well as overturning conflicts. It was found that around 13 percent of overtaken and 8 percent overtaker vehicles cross the lane marking and go on the shoulder during overtaking. Around 40 percent of overtaking vehicles make an estimation error.

4.7. Headway: Prior to and after overtaking

For more than one-third of overtaking manoeuvers, prior headway distance is less than 10m and the corresponding time distance is below one second. The shortest headway distance is 2m, corresponding to 0.13s headway between truck and truck. Around 41 percent of manoeuvers had headway distances at the start of overtaking of between 10 to 20m.

The average headway at the end of overtaking is 22.4 ± 19.4m. Around 27 percent of after overtaking headway distances was less than 10m. In many cases, the overtaken vehicles were forced to decelerate evasively to avoid conflict due to the abrupt cutting into the original lane by the overtaking vehicle.

4.8. The gap with opposing vehicles

Around 16 percent of overtaking was performed when there was no gap between overtaking vehicle and opposite vehicle. Therefore, a significant number overtaking vehicle faces an opposing vehicle in the absence of any gap. In such cases, the lane is shared through evasive action and the use of road shoulder. Such unsafe behaviour produces a very high probability of collision.

The current study further analysed overtaking events with no gap or zero TTC, as shown in Table 2. It was found that, out of 84 such critical events, large-buses were involved in 60 percent events in the presence of large trucks (23%), large buses (15%) and cars (10%).

Table 2: Vehicular involvement in around zero TTC events

Overtaking	Opposing	Frequency	Percent	% of total involved of respective vehicle
Large Bus	Large Bus	13	15	14
	Medium Bus	1	1	
	Large Truck	19	23	
	Small Truck	3	4	
	Microbus	5	6	
	Car	8	10	
	Pickup	1	1	
Subtotal		50	60	
Large Truck	Large Bus	5	6	12

	Medium Bus	2	2	
	Large Truck	4	5	
	Small Truck	2	2	
	Microbus	2	2	
	Car	1	1	
	Tempo	1	1	
Subtotal		17	20	
Small Truck	Large Truck	2	2	8
Subtotal		2	2	
Microbus	Large Bus	1	1	6
	Large Truck	2	2	
	Car	1	1	
	Tempo	1	1	
Subtotal		5	6	
Car	Large Bus	3	4	10
	Large Truck	2	2	
	Small Truck	1	1	
	Microbus	1	1	
	Tempo	1	1	
Subtotal		8	10	
Jeep	Large Truck	2	2	20
Subtotal		2	2	
Total		84	100	100

5. Conclusions

The findings of the analysis of 535 overtaking manoeuvers were presented here. Data was collected from a two-lane two-way highway in an heterogeneous traffic environment in Bangladesh. Nine types of overtaking strategies have been clustered, considering the different scenarios and overtaking characteristics. Different attributes related to overtaking behaviour, such as vehicular involvement, overtaking time and distance have been analyzed. It was found that only very few vehicles used indicators for changing lane or taking overtaking manoeuver. Drivers have a lack of understanding on the use of indicators. Many drivers use the horn to communicate with other drivers. Around 25 percent of vehicles made an estimation error. In around fifty percent of cases, the opposite vehicle had to reduce speed to avoid collision. The study has also found that a significant proportion of overtaking events show very unsafe behaviour in terms of headway gap prior and after of overtaking.

The results obtained from this behavioural analysis have important implications for the selection of specific engineering, education and enforcement measures to reduce the safety risk. Future analysis will focus on the development of a model to investigate the effect of traffic flow and composition, as well as vehicle speeds, on overtaking behaviour using count data modelling approaches. The relationship between overtaking behaviour and probability of conflict will be quantified. The outcome of the study will be used to develop a traffic safety-related micro-simulation model for non-lane base heterogeneous traffic environments, in order to identify safety counter-measures appropriate to developing countries.

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