Hazard-Driven Drivers’ Behaviours towards Vehicle-to-Median Safe Distances

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Abstract

A median is required for a two-way road to separate traffic from opposing lanes and to prevent head-on collisions. However, studies indicate that medians are also perceived as hazards which need to be avoided during driving. This hazard perception is manifested in drivers’ changing behavior towards various types of medians along the driving lanes inform of their tendency to allow various safe distances to the medians. The Indonesian Highway Capacity Manual (IHCM) does not differentiate between types of medians and the influence on the drivers’ choice of safe margin to the medians. Therefore, this study looks into how the existence and types of medians influence the safety distances of different categories of vehicles from different types of medians as the manifestation of their perception of hazard potentials of medians. Traffic recordings on different categories of vehicles are used to obtain movement margins of vehicles along various medians during near-saturated traffic. Using the smallest values of 10 and 90 percentile of distances, the results show that drivers shy from 0.27 m to 0.82 m from medians. The result of this study will contribute to the change of applied assumptions used in determining the effective lane capacity to road safety-based assumptions.

Keywords: effective lane width, hazard perception, road medians, road safety, safety distance

1. Introduction

A median functions to separate opposing lanes, providing recovery for out-of-control vehicles, reducing head-on collisions, providing an area for emergency parking, allowing space for left-turn lanes, minimizing headlight glare, allowing for future widening, and controlling access [1]. A median is mandatory for a two-way road to separate the opposite traffic lanes to prevent head-on collisions.

Previous studies [2-4] have been undertaken in an attempt to quantify the relationship between safety and roadway design elements as well as the qualitative concept of risk reduction in traffic accidents [5]. Various Studies have also indicate that the presence and
types of barrier in medians have shown counterbalancing potential to improve safety and that median width influences multilane roadways safety [6-9]. Elvik [10] suggests that there is an effect due to the type of median used—their presence of a median guardrail, for example, has the potential to increase crashes. Hong, D. and LEE, Y [11] conducted a research on the correlation between accidents and the number of junctions per km by comparing roads with and without medians. The results show that the constant and the coefficient of independent variable of number of intersections with median barriers are higher compare to those without median barriers. This indicates that the existence of medians does not only function as a safety measures as prescribed in road designing but also susceptible to generate adverse effects.

Therefore the issue that needs to be critically assessed here is whether the placement of a median barrier will act positively or negatively on the safety of the roadway segment under study. These hazard perceptions are manifested in drivers’ changing behavior towards various types of medians along the driving lanes which informs their tendencies in allowing various safe distances to the medians. The effective lane width, which is the width section with the lowest perceived risk, can therefore be affected by the existence, types and dimensions of the medians. This is in line with Hauer [6] who noted that the effectiveness of the presence of medians on safety cannot be conclusively identified but nevertheless noted that there is potential for the median to impact safety. Another study [12] also indicated that there is a relative effect of different median widths on accident types and accident severity.

The Indonesian Highway Capacity Manual (IHCM) [13] incorporates the existence of medians in the calculation of lane capacity, but does not differentiate between the types of medians. The manual also applies carriageway adjustment factors based solely on the carriageway width. The effective road width factor in the manual does not take into account the influence of changing distance of the vehicles to the medians despite the variety of medians types, shapes and dimensions. In the manual, effective lane widths are influenced only by the roadside activities like on-street parking, whilst the median factor is only related to U-turns existence. The perceived hazard of medians which influences the drivers’ choice of safe distance to medians, however, is rarely taken into account. This study is aimed at looking at the impact of hazard perception of drivers, influenced by the median shapes and dimension, on the drivers’ behaviors when driving along various medians and the impact on the effective lane widths.

2. Methods

Primary data were obtained from video recording of traffic along the survey locations for 2 hours on each location in non-congested traffic conditions and V/C ratio around 0.5 to 0.65 to ensure that the traffic condition provides the drivers with free-choice of lane positioning. The surveys were conducted along straight and flat sections of 12 m 4/2D urban roads with 4 types of medians: wide medians: more than 1.50 m wide, medians with fence, raised medians: medians with curbs only, and line medians: non-physical medians.

Analysis was performed on the recorded data to obtain the safety margins of the running vehicles to the medians based on the vehicles categories of motorcycles, passenger cars and truck/ heavies. Observations were made on 100 motorcycles, 100 passenger cars, 25 trucks and 25 buses travelling along the medians under study. Only vehicles running less than 1.00 m from the medians were considered as it assumes that drivers’ decision on positioning the vehicles at a distance more than 1.00 m is not influenced by the existence of the median, and is not based on their hazard perception on the median types.

3. Results and Discussion

Wide medians. Results show that 17% passenger cars move 0.6-0.7 cm from the medians, and a small number (0.24%) run very closely (<10 cm) to the medians and 0.4% shy 10-20 cm from the medians. The ranges of 40-50 cm and 50-60 cm are each chosen by 16% of drivers.

Motorcycle movements show a significant difference compare to the passenger cars. No motorcycles run less than 0.20 m from the medians. The majority distance is 0.80-0.90 m from medians, indicating that in an unrest raining conditions where the drivers have options to safer lane-positioning motorcycles will shy a safe distance from wide medians.

Only a small percentage of trucks run within the range of 0.10-0.20 m from the medians (1.11%). The vehicle-to-median distances of 0.40-0.50 m (20%) and 0.50-0.60 m (23.33%) appear to be adopted by the majority of truck drivers. Therefore it can be assumed that in an unrest raining conditions the majority of trucks (53.33%) will shy between 0.40 and 0.60 m from wide medians indicating their perceptions of a safer distances to wide medians.

Buses do not show a linear change of the percentages of vehicle-to-median distances as three groups of distance ranges appear to be equally adopted by buses: 0.40-0.50 m, 0.70-0.80 m and 0.90-1.00 m. This shows that the existence of wide medians does not determine the lane positioning of buses, and the distance-to-medians may not show the drivers perception of hazard. The shortest distance-to-median is 0.30 m showing that the minimum safe distance of buses is bigger than that of trucks (0.10-0.20 m), motorcycles (0.20-0.30 m), and passenger cars (0-0.10 m).
The analysis shows that the most acceptable distance for all categories of vehicles is 0.50-0.60 m, the range which is commonly shared by all types of vehicles categories. This range represents the safe vehicles' distance-to-medians which is perceived to contain the least hazard effect in relation to the existence and dimension of wide medians. A distance longer than 0.60 m is not affected by the medians. This finding is in line with the assumption adopted in this research that only vehicles moving at a distance longer than 1.00 m from the medians are recorded and analyzed.

**Median with fence.** There are no passenger cars moving at a distance less than 0.20 m from the medians with fence and 1.15% cars move at 0.20-0.30 m from the medians. The percentages increase with the distance-to-median and the range of 0.80-0.90 m constitutes the biggest percentage (30.15%) while the range of 0.90-1.00 m constitutes the percentage of 24.17%. The data of motorcycles movement along medians with fence shows similar results compare to wide medians where the biggest percentage lies within the range of 0.80-0.90 m (35.47%) and the smallest percentage lies within the range of 0.30-0.40 m from the medians (1.07%). This indicates that motorcycles perceive the hazards caused by the wide median with fence relatively equal and in unrestraining conditions motorcycles shy a safe distance from medians with fence.

The minimum distance-to-medians of trucks moving along medians with fence is longer than along wide medians, where no trucks move at a distance shorter than 0.30 m. This distance range of 0.30-0.40 m is constituted by 4.46% of the trucks, and the biggest group of range mostly adopted by trucks is 0.80-0.90 m (27.32%). The rest of the percentage is quite equally shared by the other distance ranges, indicating that truck drivers do not perceive medians as hazards when driving at a distance of more than 0.50 m. The minimum distance-to-median of buses is 0.20 m, and 2.99% of buses move 0.20-0.30 m from the median. The number of buses are evenly distributed to the ranges of 0.70-0.80 m, 0.80-0.90 m and 0.90-1.00 m. Similar with trucks drivers, bus drivers seem to perceive equally the risk level once the distance is bigger than 0.60 m

**Raised medians.** Passenger cars lanes positioned with raised medians is relatively different compared to other types of medians. The minimum distance is 0.20 m (0.25%) and the range of 0.50-0.60 m is the most occupied lane sections (22.2%) and the rest spread over the other distance ranges quite evenly.

A number of motorcycles were recorded to be travelling at a very minimum distance to the medians: 0.10-0.20 m (0.19%), while the biggest percentage of motorcycles shy 0.50-0.60 m from the raised medians (18.05%). The data shows even distributions of motorcycles from 0.40 to 0.80 m from the median. This indicates that distance is perceived to be safe and the medians are not perceived to be hazardous to the motorcycles.

Some trucks (1.23%) were observed to move very close to the raised medians, at a distance of 0.10-0.20 m. The distance-to-median most occupied range is 0.40-0.70 m (23.3%). The shortest distance of buses to the raised medians is 0.20 m, and the majority of buses occupy the lane section 0.40-0.80 m from the raised medians, and there are 20.63% of buses on the lane section 0.60-0.70 m from the medians.

**Non-physical medians (line medians).** The distribution composition of passenger cars appears to be homogen for vehicle-to-median distance of 0.40 m to 0.80 m whilst there are 0.66% of the cars moving at the distance of 0.10-0.20 m. This small distance to the median indicates that drivers consider that the lane capacity can still accommodate the excess volume and that the non-physical medians are not perceived as hazards.

The number of motorcyclists occupying the lane section 0.10-0.20 m from the medians is around twice the number of passenger cars occupying the same range of section (1.24%). The majority of motorcyclists move 0.40-0.50 m away from the medians while trucks move closer to the line medians (0.10-0.20 m) constituting 5.13% of the total. This number is comparatively significant in relation to the number of passenger cars and motorcycles as the percentages are smaller for the two types of vehicles. This finding indicates that truck drivers do not perceive the line medians as hazards and that trucks are more risk-taking regarding the opposing vehicles. This lane positioning of trucks might be also due to the predominant and ‘intimidating’ size of the vehicles resulting in the tendency of opposing vehicles to sway and provide bigger safe distance. Buses movements also differ significantly as there are 3.03% of the buses moving 0.10-0.20 m from the line medians. The distance-to-median range of 0.30-0.40 m is occupied by the majority of buses. This similar profile with that of trucks may be triggered by the outstanding dimensions of the two kinds of vehicles which then lead to the relatively more risk-taking movement behavior.

**Mean Value of Vehicle-to-Median Distances.** The mean distances of passenger cars differ by types of medians. The smallest mean value of passenger cars is 0.592 m from line medians, 0.630 m from raised medians, 0.638 m from wide medians and 0.771 m from medians with fence which is the widest/largest distance.

Motorcycles mean distances to medians also change with median types. The smallest mean value is 0.592 m
to line medians, 0.613 m to raised medians, 0.764 m to wide medians and 0.805 m to median with fence.

Although trucks also show changes in the mean distance to medians, the sequence is different. The smallest mean distance for trucks is wide medians with 0.568 m followed by line medians with 0.574 m, raised medians 0.581 m and the biggest distance is median with fence which is 0.730 m.

The mean value of the distance-to-medians of buses also vary by types of medians. The smallest mean distance, 0.492 m, is to line medians, followed by the distance to raised medians 0.636 m, 0.706 m to wide medians, and the biggest value is 0.731 m which is to medians with fence. These values indicate that bus drivers decide to avoid medians with fence which may be due to the vertical dimension of buses. However, line medians do not suggest any hazards impact toward buses. The safe distance provided by buses may be due to the risk perception generated by the existence of opposing vehicles.

Compared to passenger cars and motorcycles, there are bigger percentages of buses and trucks moving very close to the non-physical medians (line medians). This situation indicates that there is a tendency of the passenger cars and motorcycles to shy away from the median. As the line medians are obviously non-hazardous, this tendency may be due to the hazard caused by opposing vehicles. Line medians are non-hazardous but provides least protection from potential crash from opposing vehicles. Elvik, [4] notes that there is an increase in number of crashes with median presence but a reduction of the level of severity for these crashes.

In general, the fact that an obstacle is placed within the roadway environment that provides a target for collisions can lead to an increased number of crashes. The type of median barrier is also important: studies have shown that different types (especially concrete) have the potential to increase crashes [14]. This is in line with the findings that passenger behave differently towards different types of medians.

**Reduction of effective lane width.** Effective lane width is the width available for traffic movement. When evaluating the potential adverse impacts of lane width on safety, speed is a primary consideration. Based on the Highway capacity Manual (Manual Kapasitas Jalan), lane widths of less than 3.60 m reduce travel speeds on high-speed roadways. The reduction of lane width will result in capacity reduction and on the traffic operation particularly for high-speed roadways. The interaction of lane width with other geometric elements, primarily shoulder width, also affects the whole operations. When determining highway capacity, adjustments should be made to reflect the effect of lane width on free-flow speeds.

The safe distance, the space of which is not travelled due to the perceived hazards, which drivers create when travelling along various medians will reduce the effective lane width thus affecting the speed and the capacity of the roads. Drivers behave differently towards medians thus requiring some adjustments in deciding on the capacity of the road. This safe distance of vehicle-to-median reduces the basic capacity. To determine the magnitude of lane width reduction, a statistical indicator is used to analyze the distance. Despite finding the mean values which basically generalize the behavior of the drivers as reflected in the safe distance to medians, a more realistic statistical indicator of percentiles are adopted. The use of 90 percentile of vehicle-to-median distance is considered to represent the distance of the majority of vehicle to the median. This is also considered to be the distance with the least perceived hazard by the majority of drivers. The 10 percentile is adopted to represent the distance exceeded by only 10 percent of vehicles. This distance is assumed to be the distance that drivers perceive to have the minimum safety level for the existence and types of medians. Therefore taking into account the two sets of values will provide the effective widths of the travelled lanes.

The tendency of vehicles to shy from medians will result in reduced capacity of the lane. Design Manual for Road and Bridges [15] indicates that the changing of lane width from 3.25 to 3.00 m will lower the capacity from 1,320 pcu/hour to 1,020 pcu/hour. The Indonesian Highway Capacity Manual in 1993 does not take into account this median-related factor in the calculation of road capacity. Therefore by adopting the values of 10 percentile and 90 percentile, an adjustment factor which corresponds to a reduction of basic lane capacity due to the shy distance should be formulated. Effective lane width is the main variable in the calculation of road capacity and reduction in the effective lane will reduce the road capacity. For roads with mixed-traffic, it is therefore important to consider the combined acceptable vehicle-to-median distances which represent the perceived safety distance of all types of vehicles. This hazard-driven drivers choice of vehicle-to-median safe distances results in different effective lane widths.

As deciding on the effective lane width should mean the required minimum reduction of lane width, the lane width which will be effectively used should be reduced to a value within the range of minimum value of 10 percentile and minimum value of 90 percentile of vehicle-to-median distance which is between 0.27 m and 0.82 m. The effective one-way width of the 4/2D carriageway then falls from 6 m to the range of 5.18 m - 5.73 m; and using linear interpolation on the carriage
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Figure 1. Types of Medians

Table 1. The Values of 10 Percentile and 90 Percentile of Vehicle-to-Median Distances

<table>
<thead>
<tr>
<th></th>
<th>Wide Medians</th>
<th>Median with Fence</th>
<th>Raised Median</th>
<th>Line Median</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 percentile</td>
<td>90 percentile</td>
<td>10 percentile</td>
<td>90 percentile</td>
</tr>
<tr>
<td>Passenger Car</td>
<td>0.40</td>
<td>0.90</td>
<td>0.54</td>
<td>0.96</td>
</tr>
<tr>
<td>Motorcycles</td>
<td>0.55</td>
<td>0.95</td>
<td>0.60</td>
<td>0.95</td>
</tr>
<tr>
<td>Trucks</td>
<td>0.35</td>
<td>0.82</td>
<td>0.48</td>
<td>0.95</td>
</tr>
<tr>
<td>Buses</td>
<td>0.46</td>
<td>0.95</td>
<td>0.45</td>
<td>0.95</td>
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</tbody>
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way width adjustment factor in IHCM, the factor is then reduced to 0.69–0.78. As the base capacity for the two-way two lane (4/2D) carriageway is 5,700 pcu/h or 2,850 pcu/h per way, the lane reduction due to the vehicle-to-median safe distance causes the carrying capacity to drop considerably to the range of 2,453 pcu/h–2,719 pcu/h for each way.

4. Conclusion

The results of this study shows that drivers behave differently towards different types of medians. Vehicles do not shy away from non-physical medians which are obviously non-hazardous despite the minimum protection if potential collision from opposing traffics occurs. On the other hand, vehicles travel closer to the line medians compared to the physical medians. This finding suggests that drivers acknowledges the physical medians as hazards but do not consider the potential hazard of opposing traffic despite the least protective function of non physical medians like line medians. Vertical dimension of medians also determines the choice of safe distance; less massive vehicles such as passenger cars and motorcycles tend to provide bigger distance compared to trucks and buses. By adopting the reduction of the effective lane width, it is of paramount importance that the manual be revised and that installation of various medians is based on the safety considerations and the prediction of roads effective widths reduction.

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