

Analysis of Road Accident in Hanoi, Vietnam

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Abstract: Road accident is one of the main traffic problems faced by Hanoi and other big cities in Vietnam. To pull down the road accident, it is necessary to start from road accident analysis. The paper firstly conducts data collection on road infrastructure, road accident and so on. Secondly, some characteristics and causes of road accident will be reviewed by data analysis. Finally, the paper gives some recommendations to reduce road accident in Hanoi.

Keywords: Data Analysis, Road accident, Causes of road accidents

1. INTRODUCTION

Hanoi is the capital, political-administrative headquarters of Vietnam, also is a major center for culture, economics, education, science, and international trade. With natural land area of 3,324.9 square kilometers and approximately 7.5 million people, Hanoi became the largest city of Vietnam by the natural area and the second largest city of Vietnam by population leading to high traffic demand. It is forecasted that by 2020 the traffic demand in Hanoi will be 18 million trips per day (HAIDEP, 2007). Along with that, speedy development of private vehicles (i.e., cars and motorcycles) at both ownership and usage has created high pressure on road infrastructure with slow development. Motorcycle ownership has been increasing at more than 10% per year for the last two decades, and reaches over 600 motorcycles per 1,000 people (Tuan, 2015), while the speed growth of road infrastructure development only is 0.25%, and public transport only meets about 10-12% of traffic demand (Chu & Ha, 2017). The traffic flow is a typical mixed traffic flow with high motorcycle traffic composition of around 86% in the urban area (Bray & Holyoak, 2015). Therefore, the interaction between motorcycles themselves and different types of vehicles becomes very complicated, and that can lead to road accidents as a result. According to statistic data from Vietnam National Traffic Safety Committee (NTSC), about 7.4 percent of total road accident and 7.1 percent of total fatalities by road accident in Vietnam have occurred in Hanoi in 2016, estimated losses due to road accident in Vietnam are 2.45 percent of GDP in 2015 (ASEAN, 2016). Road accidents not only affect the effective transport system but also are greatly affecting the quality of life, public health and so on. It is very essential to know the effects of road accident in Hanoi where a huge number of motorcycles runs every day. The objective of this paper is to analyze road accident of Hanoi in recent years, and to discuss the basic characteristics and causes of road accidents by data analysis, so as to find the factors contributing to road accidents, and to explore the necessary solutions to reduce accidents.

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2. MATERIAL AND METHOD

The necessary data for the present this study such as accident data, registered vehicles and so on are obtained from various websites, journals, and technical published papers. Data of population are collected from the General Statistics Office (GSO, 2017). Accident data and registered vehicle data are collected from the Road and Rail Traffic Police Office, Hanoi Police Department (TPO, 2018). Besides, some accident data and other data are collected from the Hanoi Department of Transport (HDOT), Vietnam National Traffic Safety Committee (NTSC). Accident information is not only general information of road accident such as total accident, fatalities, injuries, mainly cause of accidents but also accident locations, time, cause and so on based on Form 02/TNGT issued by Ministry of Police Security (MPS, 2009). Because of the limitation of equipment for accident investigation, the accident information reported to traffic police is not promptly or/and the scene of the accident has changed before an investigation, thus some information could be obtained to remain inconsistent and incomplete. In this paper, the authors analyze and present using some information in the database with high reliability. The indicators are used in statistical analysis as follows:

- Three main indicators: number of accidents, fatalities, and injuries
- The fatalities per 100,000 inhabitants = $\text{number of fatalities} / \text{population} \times 100,000$
- The fatalities per 10,000 motorized vehicles = $\text{number of fatalities} / \text{registered vehicles} \times 10,000$
- The rate of fatalities per accident number = $\text{number of fatalities} / \text{total accident} \times 100$.
- The rate of injuries per fatalities = $\text{number of injuries} / \text{number of fatalities} \times 100$.

3. OVERVIEW ON URBAN TRANSPORT IN HANOI

3.1 Road Transport Network

The road network in Hanoi basically consists of radial roads and ring roads with thousands of intersections, but only about 10% of them are interchanges. The road network had 1,147 roads with a total length of 2,052 kilometers which includes expressway, national road, provincial road, urban road and others. A total road surface area was 16.1 million square meters in 2016. The average growth rate of road length only is 3.9% per year while the speed of road surface area development only is 0.25% per year in the period of 2011-2016 (Chung, 2017). The road density in the city center reaches 5.94 km/km^2 , it is high compared to the recommended value ($4\text{-}6 \text{ km/km}^2$), but the road area density is 11.38%, in the city center, this criterion is 20-26% (TEDI, 2012). Other transport facilities as walking space, parking stops and parking lots are also very limited. Developing road infrastructure is facing a lot of troubles because of limits of land-use for urban transport. The road network is close to the limits of capacity. This is one of the main factors that Hanoi is are dealing with traffic problems, involving road accidents.

3.2 Public Transport

The existing public transport system of Hanoi includes bus rapid transit (BRT) and bus that bus plays the leading role, there is only BRT Line No. 1 which is also the first route of Vietnam with a distance of 14.7 km to be put into operation from 2016. Two lines in 8 planned lines of the urban railway system are under construction, expected to come into operation in early 2019. In 2016, there are 97 bus routes with 2,826 kilometers being operated

along main axial and radial roads, and inlet/outlet roads to/from Hanoi, that same year, the transport volume reaches 432.8 million passengers by the 1,582-bus fleet (Chung, 2017). So far, the public transport system only meets about 10-12% of traffic demand. This value has not reached a half of the target value of 2020 (30-35%) and is much lower than the developed cities in the world such as Seoul (65%, 2013), Tokyo (51%, 2009), Beijing (44%, 2012), Taipei (35%, 2013), Paris (34%, 2008), New York (33%, 2010), Shanghai (33%, 2009) and Berlin (26%, 2010) (LTA, 2014). Besides, the service quality of the existing public transport system is not convenient, a lot of road users have no choice.

3.3 Registered Vehicles

There are currently over 6.1 million registered vehicles in Hanoi, over 89 percent of which are motorcycles. Besides, about 1.2 million transport modes from other provinces also participate in traffic locality. Statistics of the period from 2010 to 2017 points out that the rate of increase in registered vehicles is average 7.15% per year while the rate of population growth is increasing average 1.61% per year (see Figure 1). Thus, the rate of increase in registered vehicles about 4 times than population growth. The number of motorcycle per 1,000 inhabitants in Hanoi is rather high in comparison with that in other cities of Vietnam's neighboring countries. With this upward trend, in 2017 the motorcycles in Hanoi reached its peak about 739 motorcycles per 1,000 inhabitants as shown in Figure 2. According to estimates, cars will increase to 843,000 units, motorcycles will be 6.1 million units by 2020, and towards 2025 cars and motorcycles will increase to 1.45 million and 7 million respectively, and vision to 2030, cars will be 2 million units and motorcycles will be 7.5 million units (WB, 2016). However, many old and worn-out vehicles remain in circulation, not only threatening traffic safety but also seriously affecting the air quality of the urban, threatening to the health and life of the people (Nguyen & Kajita, 2018).

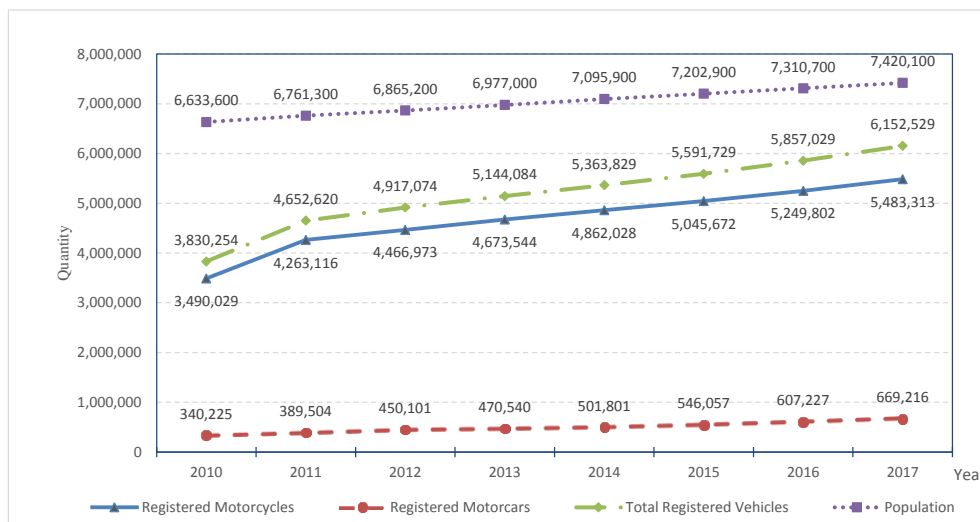


Figure 1. The trend of registered vehicles and population in Hanoi (2010 – 2017)

The rapid growth in the number of registered vehicles (motorcycles, motorcars), has led to a substantial increase in traffic volume which creates unbalances between the traffic demand and the capacity of the road network. Most working people use motorcycles while very few use buses for their traveling. A total number of cars and motorcycles on the urban road is around 80% of the street areas (Chu & Ha, 2017). Meanwhile, the development of road infrastructure does not catch up with the growth of traffic demand in traveling, leads to more

traffic jam and other problems. In peak hours, the average speed of cars and buses is much slower (15 km/h) than of motorcycles (18-20 km/h) in inner-city (Michael, 2011). There were 41 locations congested in 2016. The average time of traffic jams in Hanoi was from 45 minutes to 60 minutes per day, and the economic losses due to the traffic jam were estimated to be around 1.0 billion USD per year (Chung, 2017; Vuong et al., 2018). According to the estimation of experts, if 60% of total motorized vehicles actives simultaneously with the speed of 20 km/h, the area occupied has exceeded over 200%. Consequently, the risk of congestion and accidents are very serious.

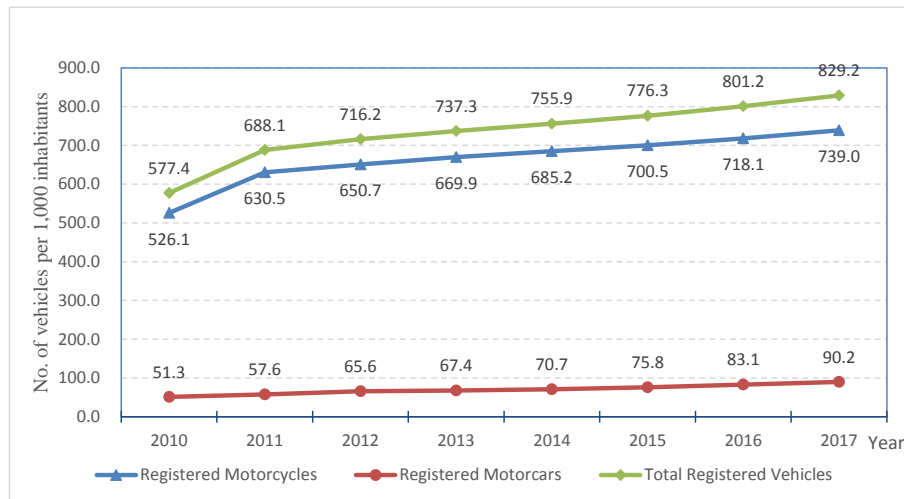


Figure 2. The trend of registered vehicles per 1,000 inhabitants in Hanoi (2010 – 2017)

4. ACCIDENT ANALYSIS

4.1 The Trend of Road Accident

Total accident, fatal and injury were collected to analyze the trend of traffic accident in Hanoi from 2010 to the first 6-month of 2018 as shown in Figure 3. The trend of accidents in the period from 2013 to 2017 had decreased about 35.7% total of accident and 6.9% fatal and 43.9% injury. However, the number of fatalities was still high, approximately 600 cases per year.

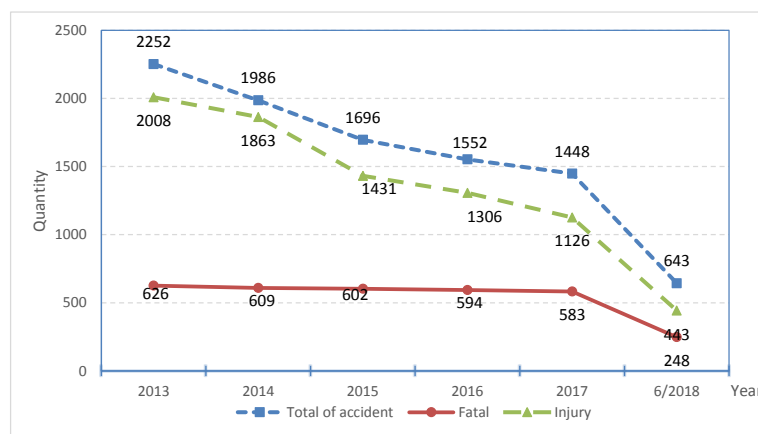


Figure 3. Trend of road accident in Hanoi from 2010 to 6/2018

The fatalities per 100,000 inhabitants of Hanoi from 2015 to 2017 slightly decreased from 8.36 to 7.86 and is lower than that of nationwide, but relatively higher than the rate of most other countries, except Korea and New Zealand (see Figure 4). The fatalities per 10,000 motorized vehicles of Hanoi during 2015 to 2017 also slightly decreased from 1.08 to 0.95 and was lower than that of nationwide, but relatively higher than the rate of most other countries (see Figure 5). Because of road accidents are rare events that happened unexpectedly at unpredictable places. Therefore, the real number of the road accident, the real number of fatalities and the real number of injuries must be much higher than the collected data shown in Figure 4 and Figure 5.

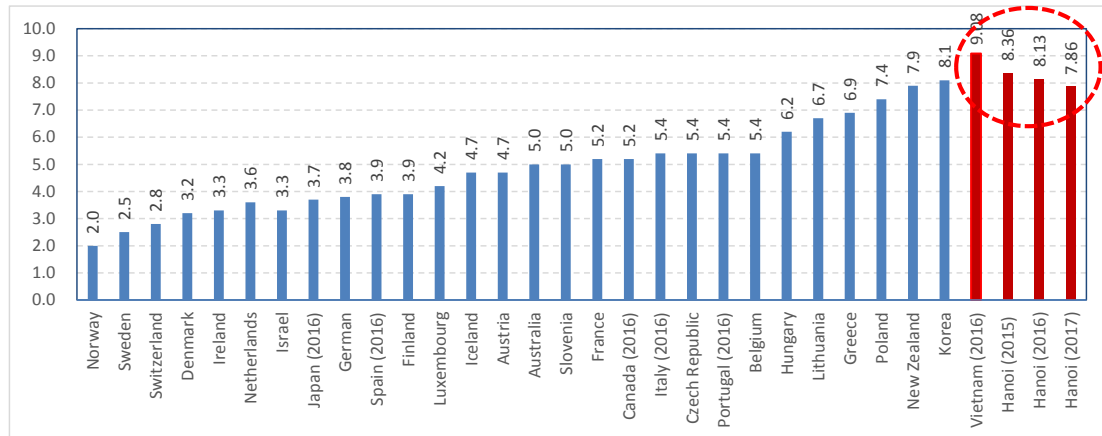


Figure 4. Fatalities per 100,000 inhabitants in Hanoi and Vietnam in comparison with some other countries in 2017 (IRTAD, 2018)

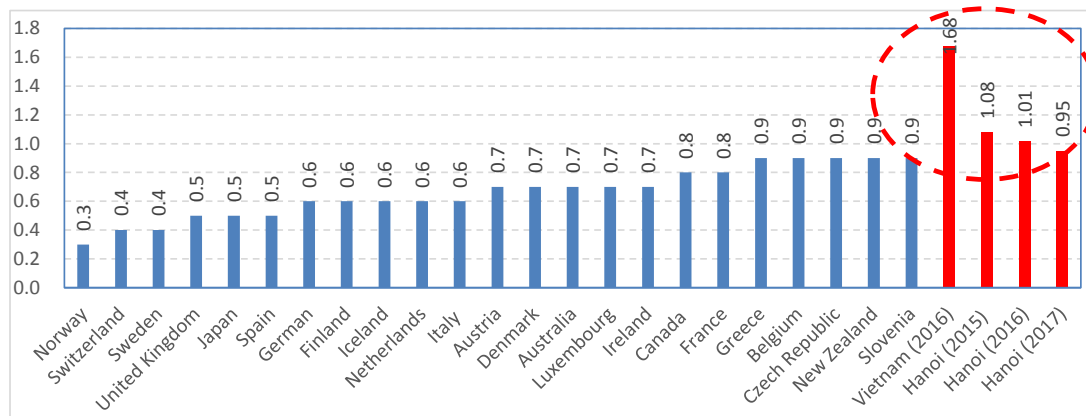


Figure 5. Fatalities per 10,000 motorized vehicles in Hanoi and Vietnam in comparison with some other countries in 2016 (IRTAD, 2018)

The rate of fatalities per accident number in case of Japan, Malaysia was a very small value from 1%-3% (Duc et al., 2009) while the much higher value in case of Hanoi (38.3%, 2016), as well as in Vietnam (39.9%, 2016). It was found that a majority of reported traffic accidents in Hanoi were related to road fatalities. Difference with the rate of fatalities as mentioned above, the rate of injuries per fatalities in Japan was very high value from 13,000%-17,200% (Duc et al., 2009), while this rate was much lower in Hanoi (about 220%, 2016) and in Vietnam (about 226%, 2016). It indicated that road fatalities seemed to be extremely in Hanoi.

4.2 Road Accident by Vehicle Type

Through analysis of transport modes of road accident in collected time period from 2016 to the first 6-month of 2018, the paper was found that about 50.5% of the road accidents are caused by motorcars including truck, passenger car, touring car, taxi, and bus, and 45.3% by motorcycle and the remaining 4.3 % are caused by others such as bicycle, pedestrian and so on (see Figure 6). It could be considered that motorcycles and motorcars are two main vehicle types involving road accidents, and the proportion of road accident motorcar-related is more than for motorcycle occupants. Besides, the motorcycle is the predominant vehicle in Hanoi as in many parts of Vietnam, but the number of accident involved motorcars per 10,000 vehicles is 8-9 times higher than the rate of motorcycles (see Figure 7).

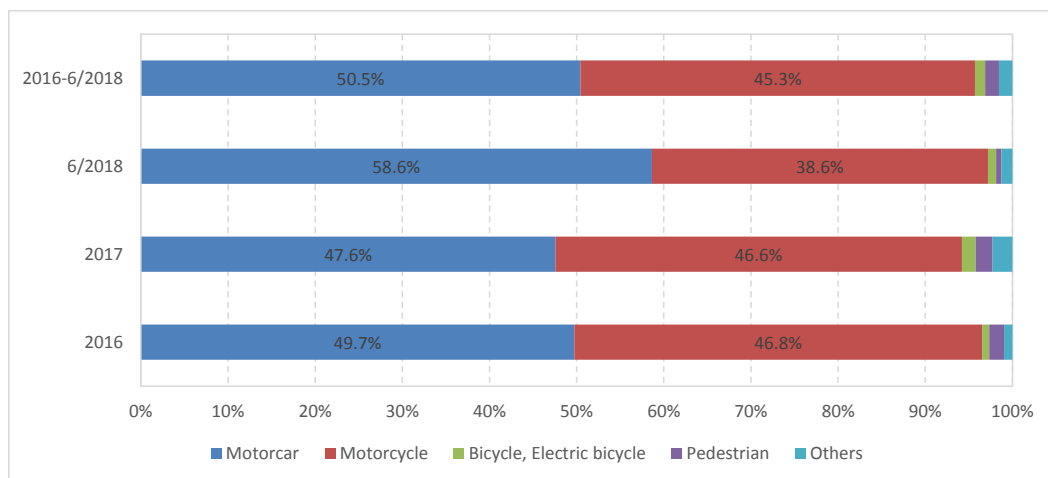


Figure 6. Road accident of vehicle type in Hanoi (2016- 6/2018)

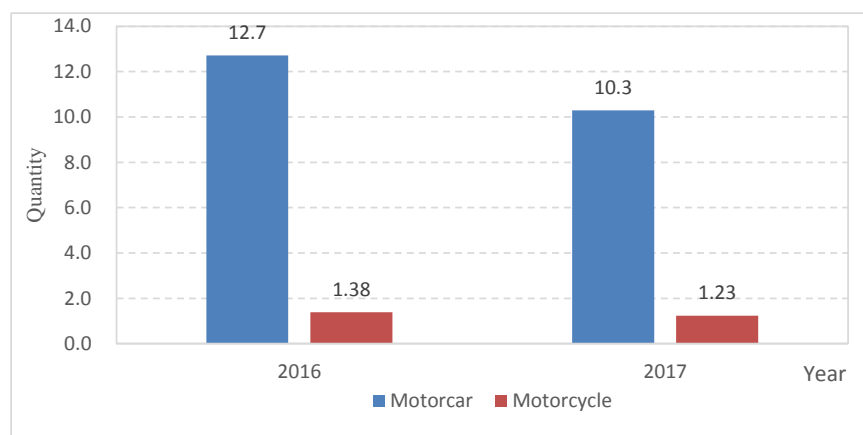


Figure 7. Road accident involved vehicle per 10,000 vehicles in Hanoi (2016-2017)

4.2 Road Accident by Road Type

The distribution of road accident by road type in Hanoi during 2016 to the first 6-month of 2018 period is illustrated as in Figure 8. Most of the road accident was reported to occur at the urban road (about 41%). According to JICA (2007) reported that around 80% of the urban intersections in Hanoi were prone to increasingly serious accidents and heavy congestions.

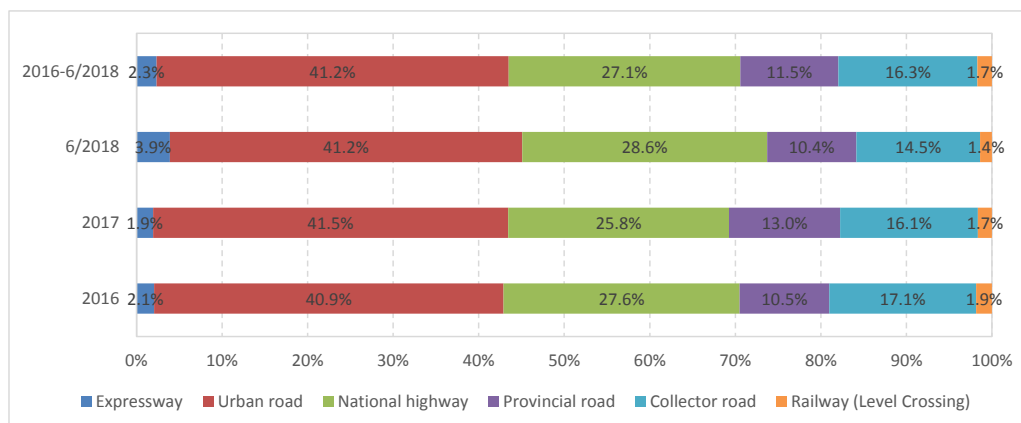


Figure 8 Road accident by road type in Hanoi (2016- 6/2018)

4.3. Road Accident by Time

Regarding the times at which road accident takes place throughout the day, the highest number of accidents occurred at afternoon between the hours of 12:00 and 18:00 (30.2% of accidents) as shown in Figure 9. This is followed by the period from 18:00 to 22:00 (23.1% of accidents) when road users use alcohol in dinner as the custom of Vietnam, so greatly influences to accidents.

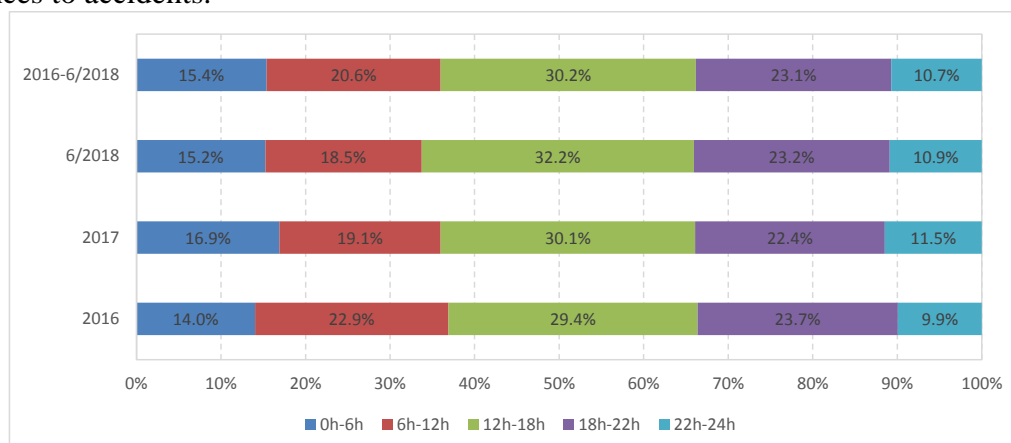


Figure 9 Road accident by time in Hanoi (2016- 6/2018)

4.6. Road Accident by Age Groups

Road accident at the age of 28-55 years old is extreme high (about 57.4%), as shown in Figure 10. This is the main human resource of the society and is also the age group of using the most motorized vehicles, so the risk of road accidents in this age group is very large. This is followed by young people aged 18 to 27 years old (32.8% of accidents).

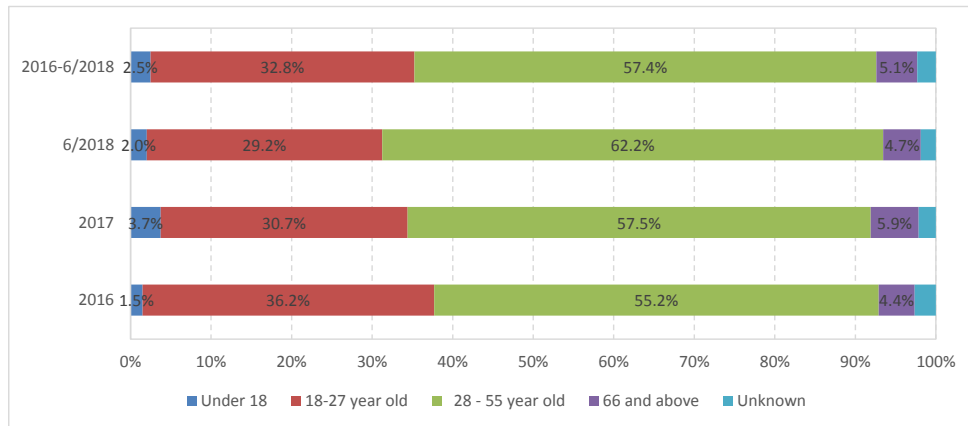


Figure 10 Road accident by age groups in Hanoi (2016- 6/2018)

4.7 Road Accident by Collision Type

According to the Master plan of road safety (JICA&NTSC, 2009), in Vietnam, more than 60% of fatalities are caused by accidents between motorcycles and motorcycles with motorcars while injuries between motorcars have a higher proportion of 17% compared to other accident indicators such as the number of accidents and fatalities. In Hanoi, the number of fatalities and injured in motorcycle and car collisions is 24%, in motorcycle and motorcycle collisions is 16% in 2007 (Hai, 2009), and regarding collision type, rear-end and head-on collisions between vehicle and vehicle are most popular while side- and in-turn-left-swipe collisions contribute notable parts in 2008-2009 (Hoa et al., 2011).

4.8 Causes of Road Accident

Most road accidents in Hanoi in the period from 2016 to 6/2018 are caused by road users' errors (see Table 1), among which, two major errors are identified including "Poor road observation" and "Wrong lane shifting". The former is the primary cause accounting for 28.6%, and the latter is the second cause accounting for 22.2%. There is a very strong correlation between road users' perception and driving on the wrong lane. In addition, other causes such as careless turning direction, speeding and not keeping safe distance are also the main causes of road accidents. Road users tend to speed up in the urban road with relatively less traffic, and should not keep a safe distance and road accident as a result. Besides, the rate of lane-changes in motorcycle-dominated traffic flow with weak lane discipline is high, so the risk of accidents due to misdirection is also high. Moreover, other factors, such as poor road infrastructure, lack of implementation in the public transport system and so on also contribute to traffic accidents.

Table 1 The cause of road accident in Hanoi (2016-6/2018)

Causes	2016		2017		6/2018		2016-6/2018	
	Quantity	(%)	Quantity	(%)	Quantity	(%)	Quantity	(%)
Poor road observation	464	29.9	371	25.6	207	32.2	1042	28.6
Wrong Lane Shifting	412	26.5	307	21.2	91	14.2	810	22.2
Wrong Overtaking	57	3.7	45	3.1	49	7.6	151	4.1
Speeding	140	9.0	135	9.3	43	6.7	318	8.7

Careless turning direction	164	10.6	132	9.1	58	9.0	354	9.7
Not keeping Safe distance	149	9.6	122	8.4	4	0.6	275	7.5
Driving through no-entry road	37	2.4	15	1.0	62	9.6	114	3.1
Careless crossing of pedestrians	8	0.5	6	0.4	2	0.3	16	0.4
Others	121	7.8	315	21.8	127	19.8	563	15.5

5. GOVERNMENTAL POLICIES ON ROAD SAFETY IN HANOI

The Hanoi's People Committee recently focuses on implementing groups of solutions to reduce road accidents and traffic congestion. Groups of solutions are divided into 4 groups as follows:

(1) Development of road infrastructure and improving public transport system: Hanoi focuses on the development of urban transport infrastructure, in which priority has been given to investment in key traffic projects that have a great diffusion, for examples, completed and put into use some expressways (e.g., Phap Van-Cau Gie- Ninh Bình Expressway, Hanoi- Thai Nguyen Expressway, Hanoi-Lao Cai Expressway, Nhat Tan- Noi Bai Expressway), extended some national roads (NR 5, NR 3) and Ring Road 2, completed 7 steel overpasses and Dong Tru bridge, put into operation some interchanges (e.g., Thanh Xuân intersection, Trung Hoa Intersection). Besides, Hanoi has also strengthened the capacity of the bus transport system by increasing network coverage and service quality.

(2) Control of traffic flow: Hanoi has deployed some applications of ITS (e.g., CCTV, Red Light Cameras, Speed Cameras and so on) at several arterial roads in parallel with solutions related to traffic organization such as traffic separation, no parking, changing school hours and working hours and so on. Additionally, numerous policies have been implemented such as the increase of registration fees, the increase of parking fees, new regulations on vehicle registration, etc. to limit the use of private vehicles in the urban center. At the same time, Hanoi has developed a scheme to ban motorcycles entered the inner city by 2030.

(3) Law enforcement: In recent years, the Hanoi Police has implemented many measures such as patrolling, controlling, detecting and handling administrative violations on traffic safety to ensure traffic order and safety. Besides, ITS applications in ensuring traffic order and safety are also initially implemented. Estimated by traffic police, about 20-25% violations only are identified by enforcement forces and handled (Hoa et al., 2009 [20])

(4) Road safety propaganda and education: There are some education programs and propaganda are implemented to raise awareness of road users and public awareness of safe traffic culture, for examples, expansion of safety education in school, strengthen propaganda on traffic safety through media, publishing traffic regulations, etc.

In general, the first two groups of solutions have brought significant efficiency in reducing the number of road accidents, however, the effectiveness of the other two groups is not high. Besides, Hanoi has not been a comprehensive model to develop a traffic safety plan. Therefore, it is necessary to continue to be further researched for extensive deployment.

6. FINDING

(1) The road infrastructure has been paid attention but its development does not catch up with the growth of the vehicles, especially the growth of private vehicles. The people's committees of Hanoi has not yet effective solutions to control the growth of motorcycles. Meanwhile, the public transport system has not met the traffic demand.

(2) Road accidents, fatalities, and injuries in Hanoi are decreasing, but the number of fatalities and the fatalities per 100,000 inhabitants is still high, approximately 600 fatalities per year, equivalent 7.86 fatalities per 100,000 inhabitants.

(3) Hanoi is still depending on private vehicles strongly, especially motorcycles, in term of accessibility and mobility. The rapid increase of private vehicles in lack of control, weak enforcement, low awareness of road users, and poor road infrastructure are closely related to the road safety problem in Hanoi. Statistical analysis shows that road accident related to 4-wheelers vehicles (i.e., car, bus, truck and so on) is higher than the motorcycles (45.3 %), accounting for 50.5%, and the rate of 4-wheelers vehicles related to accidents is 8-9 times higher than the rate of motorcycles. Therefore, the increase of motorcar use is also the cause of traffic accidents in Hanoi.

(4) The rate of road accident seems to increase year by year by the period from 12:00 to 22:00. The age group of 28-55 years old is the most related to road accidents, and the urban road is the most potential places in traffic accidents.

7. RECOMMENDATIONS

In order to achieve the goal of reducing 5-10% of casualties in road accidents in Hanoi year by year from now to 2020 (HPC, 2016), some recommendations would be given as follows:

(1) The traffic accidents database should be more consistent, accurate and complete, as well as easy to access as a reliable basis for traffic accident analysis. The traffic-related authorities need to pay attention to the use of results of analyzing road accident as a useful tool to propose short- and long-term countermeasures to improve road safety.

(2) Currently, motorcycles are the most popular means of transport in traffic flow, are also the main means of transport related to traffic accidents, so it is necessary to establish traffic safety for motorcycles.

(3) Improving awareness of traffic regular and traffic safety culture for road users, especially for motorcyclists, through more practical propaganda and education programs to control road accidents.

(4) Speedy investment in the construction of urban rail according to the approved planning while improving the service quality of the existing public transport system to reduce the use of private vehicles, from which to improve the traffic conditions and traffic safety.

(5) Quick extension of the road network according to the approved planning improves the capacity of the road network to balance traffic supply with traffic demand.

(6) The construction of the safety master plan for Hanoi city based on the application of advanced traffic management, such as intelligent transport system.

8. CONCLUSION

The growth of motorized vehicles (i.e., motorcycles and cars) is very high in Hanoi, as well as motorized vehicles are very much clustered in this urban center, so Hanoi is facing traffic

problems such as traffic congestion, road accidents, and air pollution, among which, road accident is receiving special attention. In this paper, basic characteristics and causes of road accidents in Hanoi were identified by statistical analysis, simultaneously some recommendations were given to improve road safety. The result of this study helps local authority make right and timely decisions to reduce road accident in short- and long-term period.

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REFERENCES

- ASEAN Secretariat. (2016). *ASEAN Regional Road Safety Strategy*. Jakarta: Association of Southeast Asian Nations (ASEAN).
- Bray, D., Holyoak, N. (2015). Motorcycles in Developing Asian Cities: A Case Study of Hanoi. *37th Australasian Transport Research Forum (ATRF 2015)*. Sydney, Australia.
- Michael B. (2011). Comprehensive Strategies for Urban Traffic and Urban Transport and integrative Implementation - Requirements for a sustainable urban development in Vietnam. *Centre for International Migration and Development – FR Germany*.
- Chu X.N., Ha T.D. (2017). Actual situation and solutions for reducing the traffic jams and congestion in Vietnam. *Advances in Natural and Applied Sciences*, 11 (12), 26-33.
- Chung, P.H. (2017). *The result of Collection and Compilation of 10 SUTI index in Hanoi City*. Hanoi, Vietnam: ESCAP.
- Duc, N.H., Huong, N.T., Hoa, D.T.M., Bao, N.N. (2009). *Comparative Study on Vietnam Traffic Safety: The Existence of a 5-Years Cycle in Road Traffic Accidents Development*. Proceedings of the Eastern Asia Society for Transportation Studies Vol. 7.
- General Statistics Office (GSO). (2010-2017). *Statistic Data of Population*, <http://www.gso.gov.vn>, accessed 27/12/2018. Hanoi.
- Hai, N.H. (2009). Traffic accidents in Hanoi: data collection and analysis. *4th IRTAD Conference*. Seoul, Korea.
- Hanoi's People Committee (HPC). (2016). *Decision No. 236 / QĐ-UBND on the target program to minimize congestion and ensure traffic safety in the city in the period of 2016 - 2020*. Hanoi.
- Hoa D.T.M., Duc N.H., Huong N.T., Bao N.N. (2009). Analysis on Activities of Vietnam Traffic Police in Administrative Handling Violations on Traffic Regulations. *Proceedings of the Eastern Asia Society for Transportation Studies Vol. 7*,
- Hoa D.T.M., Duc N.H., Huong N.T., Bao N.N. (2011). Comparative Study on Traffic Accidents and Impacts of the Enlargement in Territory of Hanoi by Data Analysis. *Proceedings of the Eastern Asia Society for Transportation Studies Vol. 8*.
- International Traffic Safety Data and Analysis Group (IRTAD) (2018). *Road safety annual report*. (OECD) Retrieved 12 13, 2018, from

<https://www.itf-oecd.org/road-safety-annual-report-2018>

- JICA & HPC. (2007). *The Comprehensive Urban Development Programme in Hanoi Capital City of the Socialist Republic of Vietnam (HAIDEP)-Final Report*. Hanoi: ALMEC Corporation Nippon Koei Co., Ltd. and YACHIYO Engineering co., Ltd.
- JICA & NTSC. (2009). *The Study on National Road Traffic Safety Master Plan in Vietnam until 2020*. Hanoi: Almec Corporation Nippon Koei Co., Ltd.
- Land Transport Authority (LTA). (2011 and up to date 2014). *Passenger Transport Mode Shares in World Cities*. Singapore.
- Ministry of Public Security (MPS). (2009). *Form 02/TNDB, Attached herewith Circulars 58/2009/TT-BCA (C11)- issued Oct 28th 2009*. Hanoi.
- National Traffic Safety Committee of Vietnam. (2016). *Traffic Safety Annual Reports (in Vietnamese)*. Hanoi, Vietnam: NTSC.
- Nguyen DT, Kajita Y. (2018). Traffic Congestion and Impact on the Environment in Vietnam: Development of Public Transport System. *J Civil Environ Eng* , 8(3), 1000317.
- Road and Rail Traffic Police Office (TPO). (2018). *Traffic accident database updated 6-2018*. Hanoi.
- Road and Rail Traffic Police Office (TPO). (2018). *Traffic Registered Vehicle Database updated 2017*. Hanoi.
- TEDI. (2012). *Transport Master Plan for Hanoi Capital by the year of 2030, vision by the year of 2050*. Hanoi.
- The World Bank (WB). (2016). *Hanoi Urban Transport Development Project*. Hanoi.
- Tuan, V.A. (2015). Mode Choice Behavior and Modal Shift to Public Transport in Developing Countries - the Case of Hanoi City. *Journal of the Eastern Asia Society for Transportation Studies*, 11, 473-487.
- Vuong X.-C., Mou R.-F., Nguyen H.-S., and Vu T.-T., "Signal Timing Optimization of Isolated Intersection for Mixed Traffic Flow in Hanoi City of Vietnam Using VISSIM," in *International Conference on Smart Vehicular Technology, Transportation, Communication and Applications*, 2018, pp. 133-139: Springer.