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User Opinion on Factors Affecting Drivers Frequent Lane-Changing Behavior: A National Sample of Drivers in Pakistan

Iftikhar Jilani[1], Jamal Ahmed Khan[2], Azeem Ullah Shah[3], Muhammad Bilal Khurshid[4]
[1]*Research Scholar,* [2]*Lecturer,* [3]*Research Scholar, Department of Civil Engineering, UET Taxila, Pakistan*
[4]*Deputy Director, Frontier Works Organization, Pakistan*

Abstract: ***In recent years massive traffic volume increase has demanded the implementation of traffic improvement plans in Pakistan. The urban Highway transportation networks are becoming congested in developed as well as in most of the developing countries. The main causes of unmanageable heterogeneous traffic congestion on the highway are an increase in population, change in lifestyle, and economic development of a country. To recognize the characteristics of a driver who frequently changes lanes and analyze the techniques of frequent lane-changing behavior. The researchers collected data via a questionnaire survey and analyzed the influence of traffic environment and driver characteristics violation on frequent lane-changing behavior on travel speed in detail by manually Excel statistics. Results showed that the impact of a heterogeneous traffic environment of two lanes and three lanes cars, and traffic flow density was sharply associated with frequent lane-changing behavior. The drivers were the main factors affecting frequent lane-changing behavior in heterogeneous traffic conditions, which was most popular during aggressive driving. Only 8.33% of drivers were never involved in this behavior. Most liable to frequent lane-changing behavior were males as compared to females, 31–40-year-old drivers, and those with low academic qualifications and private vehicle personalities. Among various traffic factors, changes in required speed had the most significant impact on how often lane changes occurred. The findings of the current study highlight the most significant traffic parameters that influence the lane change frequency. This research recommends strict enforcement of lane discipline to counter traffic congestion and the remedial measures that are to be taken for the improvement of better and sustainable road infrastructure conditions. Overall the research study will have practical implications for improving traffic management and safety on highways, and it provides a foundation for further research in the field of traffic-related technologies.***

Keywords: Lane Changing behavior, Traffic conditions, Traffic Flow rate, Driver Behavior, N-5 Highway, Questionnaire Survey

I. INTRODUCTION

In the recent past, the traffic volume in our country has increased significantly, leading to severe traffic congestion due to the high number of vehicles being leased at nominal rates. The substantial increase in the number of vehicles on the roads has contributed to traffic blockades and created challenges for smooth traffic flow. It has created massive traffic congestion problems in urbanized areas. The congestion problems in most cities have been further complicated by the presence of various types of public transport such as Heavy vehicles, Commercial vehicles, Private vehicles, and motorcycles. Additionally, pedestrians, U-turns, and on-street parking contribute to the traffic challenges. The combination of these factors creates a complex and congested traffic situation, making it difficult for smooth traffic flow and increasing the overall traffic-related issues in urban areas. The NHA manages 39 important highways, motorways, expressways, and strategic routes. These roads cover a total distance of 12,131 kilometers, which is about 4.6% of the entire national road network. i.e. 263,775 km, however, it carries 80% of commercial traffic, and N-5 (Torkham to Karachi) which is the bloodline of Pakistan, carries 65% of this load in the country.

N-5 (Torkham to Karachi) is the busiest route in Pakistan among all the highways observing traffic during peak hours. Different behavioral dimensions of the drivers are observed while overtaking/lane changing, travel speeding, and lane use. It has been observed that the most considerable mistakes committed by drivers are related to lane changing. The issue of improper overtaking and lane usage is treated more serious observation than speeding. Improper use of lanes by heavy vehicle drivers can cause heavy traffic jams on the N-5 highway. Due to their interference with other vehicles, lane-shifting maneuvers have a disproportionate influence on traffic flow characteristics. The interference effect of lane changing is more when heavy vehicles change lanes than compare to when a passenger car undertakes the same maneuver.

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II. LITERATURE REVIEW

Proposed to evaluate the effect of lane change behavior on the speed and flow of the traffic stream using the fundamental diagrams of speed flow density curves (Hanumappa and Ramachandran 2021). Numerous researchers comprehensively reviewed recent developments in modeling lane-changing behavior. The major lane-changing models in the literature are categorized into two groups; the models that aim to capture the lane-changing decision-making process, and models that aim to quantify the impact of lane-changing behavior on surrounding vehicles (Zheng et al. 2014). Similarly, research also shows that the behavior of drivers of urban traffic is also evaluated. According to Santhakumar (2021), vehicle-to-vehicle-to-vehicle interaction plays a vital role in identifying the microscopic characteristics of mixed traffic streams. Researcher went on to say that the movement of bikes and cars in particular, as well as all vehicles in the mixed stream, is significantly lateral. When heavy vehicles change lanes, the interference effect on traffic is more evident than when passenger vehicles make the same maneuver. In the same way, Moridpour, Rose, and Sarvi (2010) also investigated and compared the traffic flow characteristics that influence the lane-changing behavior of heavy vehicle and passenger car drivers.

The most frequent traffic action, where the driver changes the direction or speed of the vehicle by altering its trajectory, was the focus of this study on the effects of lane-changing on urban highways. However, in heavy traffic, when a car changes lanes, the cars behind it in that lane might slow down, causing a chain reaction of delays. In this study, Tracker software was then used to extract vehicle information from the video taken by the drones, including the vehicle operating speeds, etc. Yang et al. (2021). Matcha, Sivanesan, and Ng (2021) proposed a lane-changing model known as minimizing overall braking induced by lane changes (MOBIL) is modified and combined with the intelligent driver model (IDM) to implement the lane-changing rules for different vehicle classes by applying the politeness and vehicle-type factors. Muhammad et al. (2020). In his study examined the heterogeneity of traffic flow dynamics by comparing two different types of vehicles that have different penetration rates on the highway: the manual cars and the manual buses, which are both small and heavy vehicles. Furthermore, two types of lane-changing behavior (aggressive lane changing and polite lane changing) have also been incorporated into the model to better predict lane-change behavior. Proper lane-changing is a vital role for traffic safety.

Predicting a driver's lane-changing actions can greatly enhance driving safety. Wei, Hui, and Khattak (2021) proposed to predict lane-changing behavior accurately and improve the prospective time of prediction. It was proposed by Jia et al. (2021) that a mathematical model could be used to analyze the interaction between the target vehicle and the surrounding vehicle based on the concept of game theory.

The mathematical model also imports the driving status of several vehicles to calculate the vehicle's intention to change lanes based on their driving status. It then used a deep learning algorithm to integrate the vehicle's driving state, and driver consideration, and predict lane-changing behavior accurately by integrating all the variables. Identify and analyze the characteristics of a driver who frequently changes lanes and analyze the mechanisms that lead to frequent lane-changing behavior. Ma et al. (2020) collected data through video recording and questionnaires and analyzed the influence of traffic environment and driver characteristics on frequent lane-changing behavior by mathematical statistics. Backward-moving traffic wave measurements in congestion are used to quantify two traffic characteristics: the gradual return to normal lane-changing behavior by vehicles, and the influence of lane-changing on traffic flow once the return is finalized. Civil, Duret, and Buisson (2011) analyzed the existing model and reformulated it to estimate its parameters using passing rate measurements.

III. OBJECTIVES OF RESEARCH STUDY

Different behavioral dimensions of the drivers are observed while overtaking/lane changing, speeding, and lane use on the majority of National Highways in Pakistan. It has been observed that the most considerable mistakes committed by drivers are related to lane changing.

The issue of improper overtaking and lane usage is treated more serious observation than speeding. Improper use of lanes by heavy vehicle drivers significantly affects the flow of traffic. In local conditions, heavy vehicles often travel in the fast lane obstructing the fast-moving vehicles approaching from the back. This interference and lane-shifting maneuvers have a disproportionate influence on the overall traffic flow on the highway.

This research aims to investigate and compare traffic flow characteristics that influence User opinion on factors affecting drivers' frequent lane-changing behavior on travel speed on highways. Following are the key research objectives that will be dealt with in this Project.

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1) To obtain user responses on lane-changing behavior using a questionnaire survey.



Fig 1a: User response on lane-changing by gender

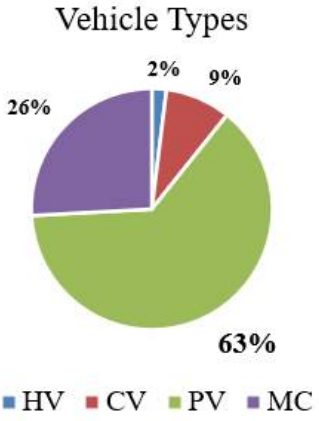


Fig 1b: User response on lane-changing by vehicle type

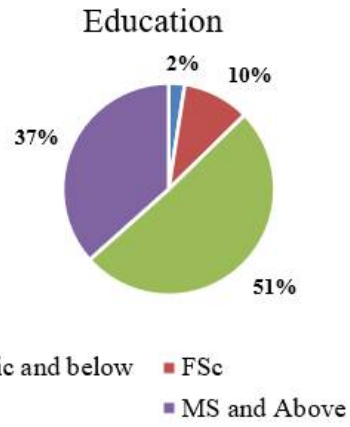


Fig 1c: User response on lane-changing by education

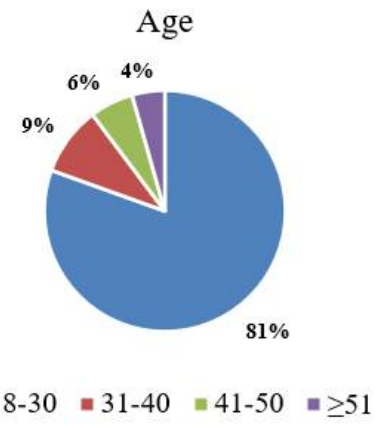


Fig 1d: User response on lane-changing by Age

Figure. 1 shows the basic characteristics of lane-changing drivers frequently. The respondents consisted of 187 male drivers (91%) and 18 female drivers (9%), with an average age of 30, an average driving age is 5.62 years and an average driving range was 5501.7 km. Respondents holding a bachelor's degree accounted for 51%, whereas Postgraduates and Above degree was reported by 37% of individuals. In terms of age, most drivers (81%) were 18–30 years of age, whereas 4% were 51 years old or older. In general, the distribution of driving age is not very different.

IV. METHODOLOGY

A. Data

A method of Questionnaire surveying was used to study the relationship between factors affecting drivers' frequent lane-changing behavior and the road traffic environment. No specialized instruments are needed for this process. Researchers can gain a greater understanding of the variables that affect the development and removal of traffic congestion by using this information to enhance traffic flow models. In this researched every violation of vehicles to gather the necessary data for understanding how the light and heavy flow of vehicles affects the lane-changing behavior on travel speed measurement.

B. Questionnaire design

In this study designed a questionnaire based on the structure and content of the 'Are you an aggressive driver?' questionnaire of the National Highway Authority, National Highway & Motorway Police, and Pakistan's traffic environment situation.

The questionnaire collected People driver's personal information (including gender, age, vehicle types, education level, the constitution of the self-test list, and driving experience), frequency of the driver's lane-changing behavior and causes of frequent lane changes (i.e. due to other drivers, pedestrians, vehicles, road width, weather condition U Turn and traffic environment).

C. Samples

In this research the data has been collected by random sampling through in-person (205 paper questionnaires distributed, of which 197 were recovered for a response rate of 96.1%) and network surveys (205 questionnaires received via WhatsApp, Gmail, Facebook, and other websites). After the screening, 224 valid questionnaires were retained for an effective response rate of 91.2%. Pakistan is divided into five regions: Punjab, Khyber Pakhtunkhwa, Balochistan, Sindh, and Gilgit Baltistan, each region contains different provinces. According to the requirements of the sampling method and the probability distribution of car drivers in various regions, chose representative provinces from each region and determined the sample proportion of each province based on the number of drivers in their provinces. Finally, it was determined that the sample survey covered 5 provinces in Pakistan.

V. RESULTS & DISCUSSION

According to the definition and characteristics analysis of lane-changing behavior, it can be found that lane-changing is related to the driver's characteristics and road traffic environment. Therefore, for the factors that impact lane-changing behavior, mainly considered the road traffic environment and drivers. The latter is from the perspective of drivers, for which collected data by questionnaires. The three lanes had a higher frequency than the two lanes. Traffic flow density was nearly related to the number of lane changes.

Table 1 shows that only 40% of drivers frequently drive on the Highway and also indicates how often drivers change lanes while driving on the Highway showing 51% of drivers change lanes sometimes.

Questions	Daily	Sometimes	More Frequently	Less Frequently	None
Q 1 Reported frequently driving on N-5 Highway?	40 %	32.19 %	14.63 %	10.24 %	2.93 %
Q 2 Do you tend to change lanes frequently while driving on N-5 Highway?	Often	Sometimes	Rarely	Never	
	0.26	0.51	0.19	0.04	
Q 3 What lane will the Driver use on the highway while driving in a car?	Left Lane	Middle Lane	Right Lane		
	16.58%	52.19%	31.22%		
Q 4 Impact of Lane changing on travel speed?	High Impact	Average Impact	Low Impact	NO Impact	
	40.49	51.7	5.85	1.95	

A. Road Traffic Environment

The lane-changing behavior is often influenced by the traffic environment, which is related to the number of lanes, vehicle composition, and traffic travel speed. Multiple lanes provide the driver with more options during the lane-changing process. The intention of drivers to change lanes will intensify, and the lane-changing behavior will rise. Hence, the multiple lanes will affect the frequent lane-changing behavior. The two-lane road can only drivers to change vehicles from one lane to the other lane. In the case of a lanes road, as Table 1 in Question 3 shows the driver can change the vehicle from the right to the left lane through the middle lane or from the left lane to the right lane, whilst the middle lane faces further options. The lane-change selection can be changed to the left to right lane according to demand and the adjacent lane traffic flow conditions. In situations with three lanes, there are many opportunities for lane changing, and it's quite likely to occur. Various types of vehicles have different proportions in road lane change. According to the survey results, the proportion of cars changing lanes is the highest, and the proportion is higher than the sum of mini trucks, wagons, and rickshaws. Lane-changing rate of cars was close to 27% of the total number of lane changes because cars perform best as well as have the strongest flexibility and initiative in lane changing. A higher rate of impact of lane-changing behavior could be found in cars.

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The reason is that small cars have good performance and strong flexibility, but it cannot be ignored that small cars account for a larger proportion of the total traffic volume. Therefore, it is necessary to further consider the proportion of various vehicle models driving on the road.

B. Traffic flow density

The number of lane changes is directly proportional to traffic volume. When traffic flow density is very low, vehicle travel is less delayed, and lane-changing behavior is infrequent. When traffic flow density a little bit increases, vehicle speed decreases. To seek better driving speed, drivers take on lane-changing behavior in congested traffic conditions. Nowadays, the number of lane changes is increasing, and frequent lane-changing behavior incident occurs. When the traffic flow density further increases, the traffic flow speed is stable. The driver maintains stable driving, except for forced-lane change, Free-lane-changing behavior, and frequent lane-changing behavior are decreased. Traffic flow density continues to increase, resulting in unstable traffic flow and lane change behavior.

Table 2 Main reasons for changing lanes on N-5 Highway

Reasons For Lane-changing	Count	Proportion score %
To overtake slower vehicles	144	32
To find a faster lane	42	9.33
To exit the current road or highway	43	9.55
To avoid congestion or traffic jams	48	10.66
Road Width	9	2
Weather Condition	8	1.77
Road Condition	40	8.88
Pedestrian Movement on Road Side	17	3.77
U-Turn	41	9.11
Entry Exist of Vehicle	23	5.11
Traffic Environment	35	7.77

Table 2 shows that 32% of drivers reported the main reason for changing lanes on highways is to overtake slower vehicles. Accordingly, the remainder of this paper emphasizes the analysis of lane-changing behavior. The influence degree of people, vehicles, roads, and environment on frequent lane-changing behavior on highways, compared the role of overtaking slower vehicles, faster lanes, To-exit the current road or highway, avoiding congestion or traffic jams, Road Width, Weather Conditions, Road Condition, Pedestrian Movement on Road Side, U-Turn, Entry Exist of Vehicle and Traffic Environment, which are the eleven main factors that affected frequent lane-changing behavior on the highway (Table 2). Please note that the bad traffic environment' in Table 2 is not consistent with traffic congestion in this paper. The questionnaire defines a 'bad traffic environment', which includes not only 'traffic congestion' but also drivers' judgments on the road driving traffic environments such as road width and lane numbers. As can be seen from Table 2 overtaking slower vehicles and the road traffic environment were the main factors causing frequent lane-changing on highway behavior, among which the drivers were the main cause factor. By comparing some scholars' research [12] on the factors that affect drivers' lane-changing behavior on highways from the four aspects: people, vehicles, roads, and traffic environment, it can be concluded that the results obtained in this paper are similar to those in previous studies, which further proves that the research results in this paper are reliable.

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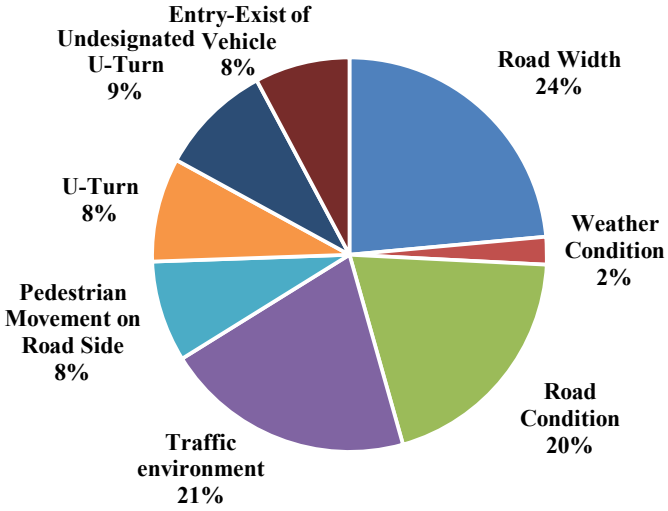


Fig 2: Factors contributing to improper lane changing.

C. Driver Characteristics

Different drivers have different expertise in controlling their behavior. The basic characteristics of driver lane changing vary according to gender, age, education, and other factors as shown in Fig. 3. Fig. 3 shows the frequency of lane-changing behavior while driving on the highway by participant characteristics. In this study defined drivers whose choice was 'often' or 'sometimes' as revealing this behavior with high frequency. This research study use manual Excel statistical methods to analyze the characteristics in detail. Fig. 3a indicates that the probability of males engaging in high-frequency lane changing was higher than the probability of females engaging in this behavior. Fig. 3b shows that drivers with Matric and below as their highest level of education frequently changed lanes, whereas the behavior was uncommon in drivers with F.Sc. education. Age affected the frequency of lane changing (Fig. 3c). Drivers between 18 and 40 years of age reported changing lanes more frequently than those who were under 41 to 50 years old. Drivers older than 51 years paid more attention to safety than the other groups, and thus, rarely exhibited lane-changing behavior 22.22 %. Fig. 3d shows frequent lane-changing driver behavior on Highways associated among drivers with motorcycles, and limited frequent changes were shown by drivers with private vehicles.

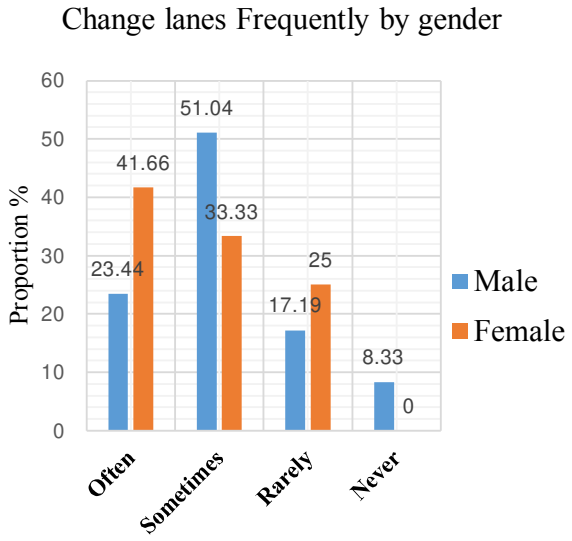


Fig 3a: Frequency of lane-changing by gender

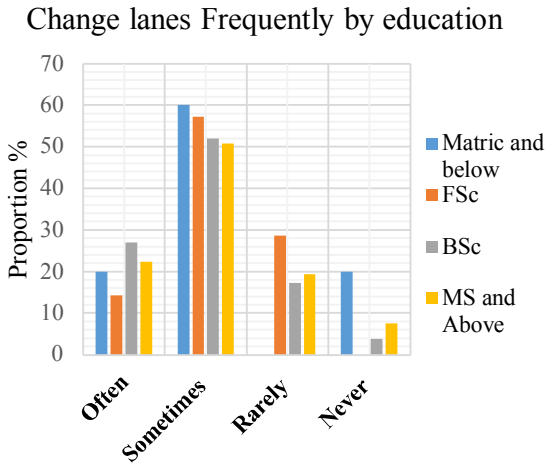


Fig 3c: Frequency of lane-changing by education

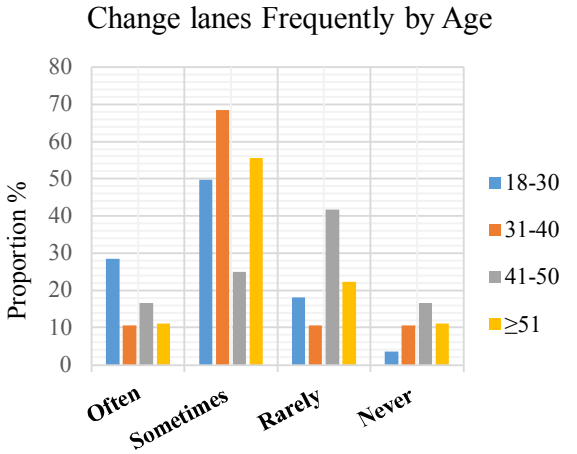


Fig 3b: Frequency of lane-changing by Age

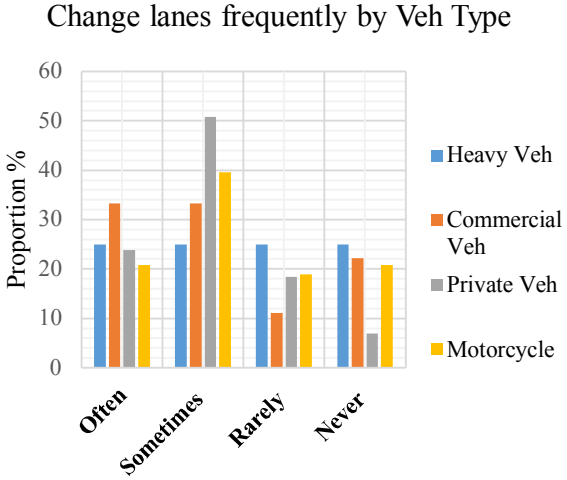


Fig 3d: Frequency of lane-changing by vehicle type

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In this studied and analyzed statistically the main factors affecting frequent lane-changing behavior including road traffic environment, the impact of lane changing on travel speed, and driver characteristics, and explored the drivers' frequent lane-changing behavior on N-5 Highway. A total of 205 data were collected for a response rate of 96.1%. The data were manually Excel statistical method analyzed to obtain the number of lanes, vehicle type, travel speed, traffic flow density, and so on. Furthermore, qualitative and quantitative analysis showed the effect, and impact of lane changing on travel speed, and the main reasons for changing lanes on highways. Driver characteristics data were collected via a questionnaire, in which respondents self-reported driving behaviors. This research adopted a national sampling approach and used a variety of methods to obtain samples. Questionnaires were screened to ensure validity. A network survey collected 205 samples from 5 provinces of Pakistan, with a penetration rate of 91.2%. The research method is worth studying in analyzing other driving behaviors.

In this studied two main factors influencing frequent lane changes: the traffic situation and the driver. In this study on the relationship between frequent lane changes and traffic conditions. Furthermore studied impact of lane changing on travel speed, driver use of lanes while driving on highways, and the main reasons that contribute to improper lane changing on highways as indicated in Question No. 4 in Table 1. This research studied has found a large probability of lane change under three-lane traffic conditions. Cars had the strongest initiative in lane changing, and a strong correlation was determined between traffic flow density and frequent lane-changing behavior. Drivers themselves were the most important factor influencing frequent lane changes. Therefore characterized the relationship between frequent lane changes and driver characteristics and the reasons for these behaviors. First, frequent lane-changing behavior was the most common expression of aggressive driving. Only 8.33% of drivers reported never being involved in such behavior. Despite the availability of lane-changing behavioral evaluations, few studies have directly addressed behaviors associated with frequent lane-changing. This finding is the highlight of this paper. Second, the driver's volition was the most important factor in inducing the behavior than those factors related to people, vehicles, roads, and the environment. Third, driver's distinguished in their ability to control their behavior. Drivers who frequently changed lanes were males, 18–40 years old, and had private vehicles. Fourth, major causes of frequent lane-changing behavior on highways were drivers pressed to overtake slower vehicles, to find a faster lane, to exit the current road or highway, to avoid congestion or traffic jams, road Width, weather Conditions, road Condition, pedestrian movement on the roadside, U-Turn, entry exit of vehicle and traffic environment.

VI. CONCLUSION

Drivers who frequently changed lanes tended to be confident of their driving skills rather than to avoid traffic congestion. The findings give basic information for making roads better, training drivers, and understanding how people travel. This can help stop aggressive driving and support drivers who change lanes a lot. The basic data such as the traffic volume, travel speed, vehicle type, and the lane-changing rate of each vehicle model data have been collected. By manually Excel statistical analysis method, the user opinion on factors affecting the frequent lane changing behavior can be obtained, which are assumed to guide the traffic control management Authority to plan specific rules and regulations and management measures to prevent aggressive driving behavior such as improper lane changing behavior and forcing lane changes. Also, these discoveries can be beneficial in providing theoretical support for creating systems that allow vehicles and infrastructure to cooperate, as well as for the advancement of automatic driving technology. To better assist drivers in real time, it is crucial to address the growing need for efficient and reliable security measures due to increased travel demands.

One way to achieve this is by studying the characteristics of drivers who frequently change lanes and analyzing the reasons behind such behavior. By doing so, research can develop models for driving behavior and traffic data, which will serve as a reference and theoretical foundation for various traffic-related technologies. These technologies include traffic simulation, traffic models, vehicle infrastructure cooperative systems, and automatic driving systems. This comprehensive research will allow us to gain deeper insights into traffic situations, enabling us to make significant advancements in the field of traffic management and safety. Frequent lane-changing behavior research can improve intelligent transport systems and sustainably intelligent mobility by understanding the reasons behind drivers' lane-changing habits. This research can develop more advanced and efficient intelligent transport systems. These systems can then optimize traffic flow, reduce congestion, and improve overall road safety Research on frequent lane-changing behavior can be further studied through simulations, theoretical modeling, and analysis of different traffic environments, vehicle types, and autonomous driving scenarios. This research enriches traffic big data related to lane-changing behaviors and supports intelligent transportation and sustainable mobility systems. Understanding the impact of frequent lane changes on traffic flow can optimize road safety and traffic management.

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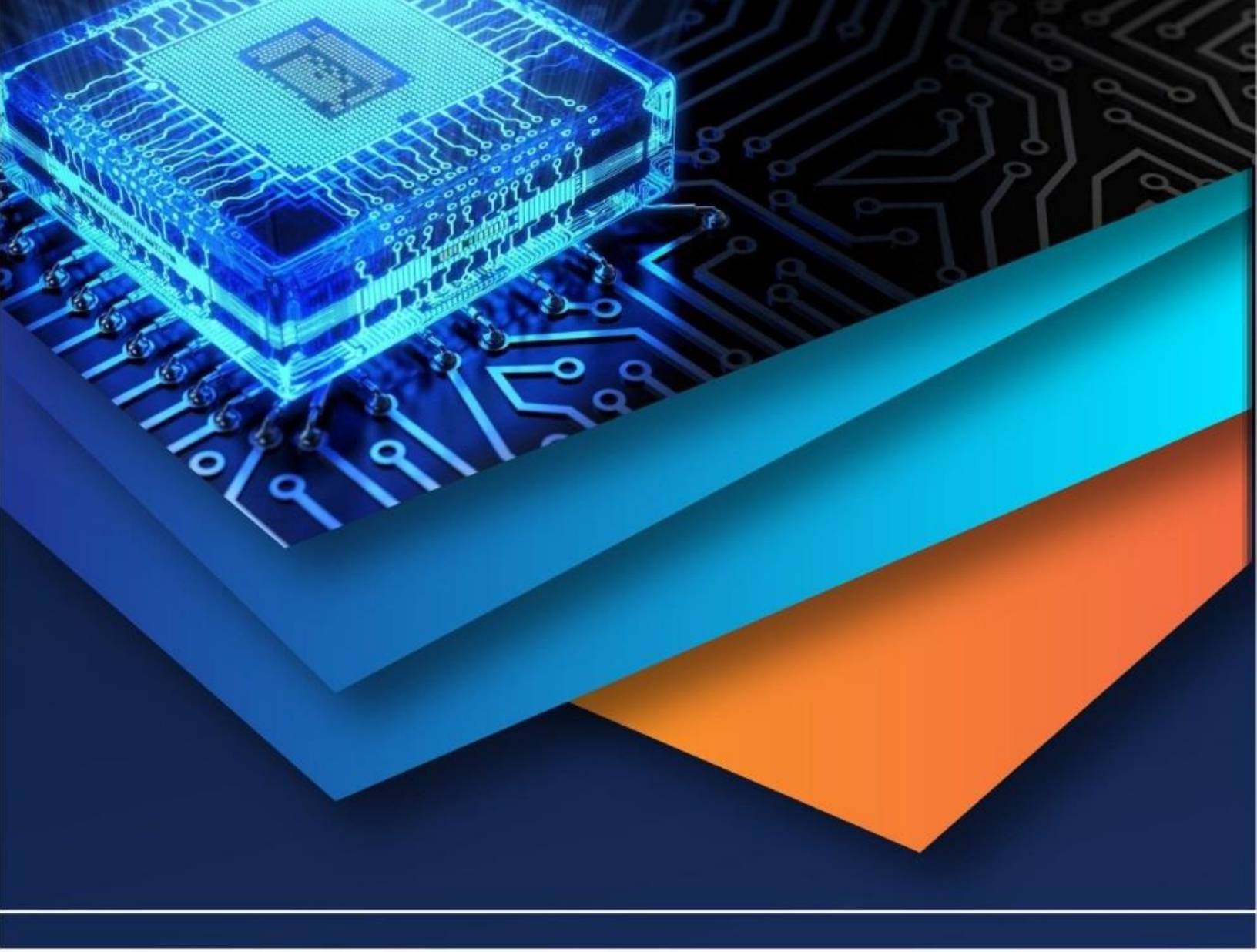
VII. ACKNOWLEDGMENT

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