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Research Article

Behavioral aspects of safety culture: Identification of critical safety-related behaviors of motorcyclists in Indonesia's urban areas via the application of behavioral-based safety programs

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A B S T R A C T

Many violations and accidents involving motorcyclists occur in the urban areas of Indonesia. It can be said that the failure to develop a good traffic safety culture causes poor motorcyclist behavior, as shaped by existing programs and mechanisms. This study aimed to identify motorcyclists' critical behaviors by conducting investigations using the reciprocal safety culture model as a framework. We tried to identify and clarify the safe behaviors expected by local governments from the existing driving safety program. By applying the antecedent-behavior-consequence model of the behavioral-based safety program, we obtained sixty-three behaviors associated with the six criteria of safe driving. We surveyed motorcyclists ($N = 97$) to review the sixty-three motorcyclist behaviors in the urban area. The relationship between the behavioral and psychological aspects of the reciprocal safety culture model was investigated to obtain the motorcyclists' critical behaviors. Multiple linear regression model, optimized by the stepwise regression, described the influence motorcyclist behavior on the perception of driving safety. We identified eight critical safety-related behaviors engaged in by motorcyclists. Observation revealed some cultural issues embedded in motorcyclists' eight critical safety-related behaviors that need to be intervened by the local government. The reciprocal safety culture model could be applied in the behavioral-based safety program to approach traffic safety culture issues. In order to develop a good traffic safety culture in the urban area, the local government needs to review the existing driving safety program by understanding drivers' behaviors as they relate to such a program.

1. Introduction

Failure by road traffic organizations (RTO) in developing an appropriate traffic safety culture (TSC) causes road users to base their behavior solely on existing beliefs and views held throughout the wider community [1]. Lack of traffic education, imperfect licensing system procedures, and weak law enforcement led drivers mistakenly to understand driving safety programs [2]. Drivers experiencing those conditions acquired knowledge from society and developed driving behavior by their own understanding. Deviant behavior frequently engaged in by road users indicate that they have failed to assess the traffic safety risks facing them properly. Other road users may misunderstand this action, believing that their good behavior may not align with traffic rules. The relationship of the RTO's effort in developing TSC by shaping drivers' behavior as well as maintaining safety perception among road users depicts the reciprocal relationship between situational aspects ("what the organization has"), behavioral aspects ("what people do"), and psychological aspects ("what people feel"). Cooper [3] described this relationship in the reciprocal safety culture (RSC) model. Therefore the investigation on TSC using the RSC model as the framework may reveal behavioral issues related to safety among drivers.

In terms of safety culture, organizations have the authority to manage safety through developing and maintaining procedures and regulations [4] and are responsible for shaping people's behavior in an attempt to instill an understanding of safety culture among individuals [3,5]. Likewise, the development of a culture of safety concerning road traffic can lead to improvements in traffic safety [6]. Among road traffic organizations, the government has the highest jurisdiction in terms of regulating road traffic safety [1,7]. The government needs to establish safety

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policies (laws and regulations), provide driver education and training, ensure road safety facilities are well maintained, and are responsible for conducting testing, evaluation, and the issuing of driver licenses so as to ensure that a positive culture of safety is practiced by drivers [7].

The government needs to identify specific safety-related behaviors which need to be intervened in via significant law enforcement and education [1,8,9]. The State of Qatar, for example, investigated professional drivers in committing risky driving behavior to improve TSC [8]. The Australian government shaped motorcyclist safety behavior by focusing on two significant safety-related behaviors (drunk driving and speeding). Thereby demonstrating organizational intervention via law enforcement (random breath testing) and public education campaigns (through sustained media campaigns) [1]. Past studies have shown that interventions aimed at promoting traffic safety could be done by specifying, targeting, and researching drivers' behaviors. From this point of view, it is important to identify prevalent critical safety-related behaviors among drivers in order to improve a TSC. In this research, we investigated TSC by focusing on behavioral aspects. According to Cooper [3,10], investigating behavioral aspects of safety culture can be approached by behavioral-based safety (BBS). Although the implementation of BBS on traffic safety is rarely found, however, the previous study on bus drivers [11] and road freight vehicles [12] have successfully applied BBS to improve traffic safety. In this sense, investigating behavioral aspects by using the RSC model to the BBS may hold promise for revealing critical safety-related behaviors that the RTO must address.

2. Theory

2.1. Behavioral aspects of safety culture

The Australian road traffic case demonstrates the influence that can be had by organizational safety management in changing motorcyclists' behavior via the development of safety programs [1]. Driver behavior is an input needed by safety management systems in order to review their safety programs. Changes in behavior determine the efficacy of safety programs [13]. Cooper [3,14] described the reciprocal influence between safety behavior and safety management systems in developing a safety culture. There are three aspects of the reciprocal safety culture (RSC) model developed by Cooper [3,14]: the psychological aspect, behavioral aspect, and situational aspect – as demonstrated in Fig. 1. The psychological aspect reflects individual/group values, attitudes, and perceptions about safety ("how people feel"). The behavioral aspect reflects safety-related actions and behaviors undertaken through daily activity ("what people do"). The situational aspect draws upon "what the organization has" to guide safety with policies, procedures, regulation,

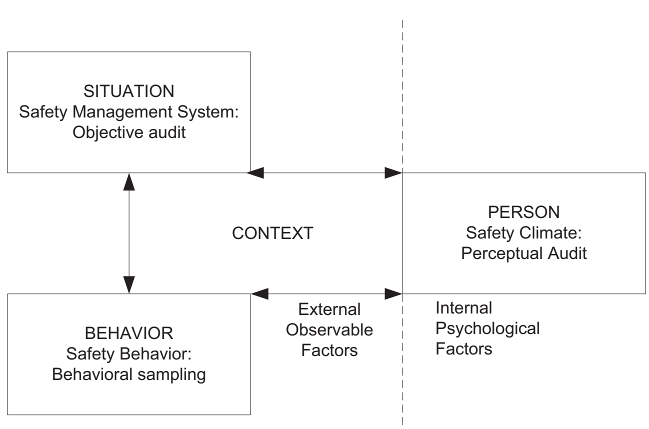

Fig. 1. Reciprocal of safety culture model [3].

organizational structure, and management system. From this perspective, using the RSC model as a framework is suitable for addressing TSC-related issues. Investigation of the behavioral aspect of the RSC model promises to identify some critical safety behaviors by considering additional elements.

The behavioral aspect of safety culture can be investigated through peer observations, self-reporting, and/or outcome measures [3,15]. A behavioral approach has previously been shown to succeed in promoting occupational safety [13,16–18]. The term "What People Do" is in line with the principle of behavioral-based safety (BBS) [19,20]. The steps for investigating the behavioral aspect can follow the steps used in promoting BBS programs [10,18]. Previous researchers have taken a behavioral approach to improve driving safety; Reason, Manstead, Stradling, Baxter, & Campbell [21] tried to improve driving safety by examining driver error behavior; Geller [20] proposed the use of BBS to develop driving safety behavior. However, the application of BBS programs for improving traffic safety on urban roads remains limited.

2.2. BBS challenge in investigating driver behavior

Basically, a BBS program focuses on a certain location that is occupied by workers with a specific job for observation [19,20,22]. Previous projects that are similar with the BBS programs have been implemented in specific places – such as intensive care units [16], food factories [13], oil and gas processing facilities [17,23], and throughout the construction industry [17]. A BBS program observes front-line personnel's behavior based on workers' daily activities in a specific field [5,18,22]. A BBS program needs a supervisor/trainer or safety leader to mentor employees during the program [22].

According to those conditions, there are three challenges in applying a BBS program for the identification of critical safety behaviors regarding road traffic and, thus, needs some modifications prior to being applied. First, road traffic (as a location) is not the same as the workplace: unpredictable climate changes may occur, and all vehicles and pedestrians use the same road for movement and transport. Physical environments (temperature, humidity, noise, and illumination) in the workplace can be controlled for, and employees work in a specific place and at a particular time. Secondly, although drivers can be seen as front-line employees, they fulfill a different purpose and face uncertainties on the road (traffic jams, collisions, new/changed rules, etc.), and have greatly varying driving behaviors. Road users have different levels of importance; as such, risk-taking is employed to achieve individuals' respective goals. This situation causes road users to repeatedly change their behavior in order to maintain their safety. Employees' behavior at work is based on certain work types, which have the same general goals, making deviant behavior by employees clearly visible. Third, no personal supervisor, trainer, or safety leader can continue to oversee licensed drivers' activities throughout a trip [7].

For this research, we used the RSC model as a framework – emphasizing the behavioral aspect – to determine the critical safety-related behaviors of motorcyclists. By relating the behavioral aspect with that of the situational aspect, the expectations of drivers' behavior as it relates to existing safety program can be identified. The safety driving program represents the group's (RTO) values, attitudes, and perceptions about traffic safety. Therefore the psychological aspect assesses drivers' performance of how well they implement an existing safety program in their daily driving activities. Based on the RSC model in Fig. 1, we observe drivers' behavior using the relationship between psychological and behavioral aspects. We link these three aspects of the RSC model with BBS steps to identify critical behaviors.

2.3. The objectives of the current study

According to the Global Status Report on Road Safety released by the World Health Organization (WHO) [24], in 2018, deaths involving motorcyclists in the Southeast Asia region covered 43% of road users.

Indonesia and Thailand have the highest death rate of motorcyclists accounts for 74% of road users in that region, followed by Cambodia with 73%. Indonesia is a developing country with significant traffic accidents involving motorcyclists across several provincial capitals. Therefore, due to the limited travel distance of motorcyclists in one urban area, local governments such as provincial capitals are suitable for dealing with the problems [25].

Bandung City – which is one of the provincial capitals – has approximately 1.3 million registered motorcycles registered (as of 2017) and has been faced with the same concerns as other provincial capitals vis-à-vis motorcyclist safety. For example, in 2012, the Bandung City Transportation Department stated that 80% of urban road traffic accidents involve motorcyclists [26]. Although the percentage of motorcyclists' contribution to urban road traffic accidents had been decreasing by 2017, it still represents the highest urban traffic accident rate at 68% in Bandung City [27]. Data concerning traffic violations committed by motorcyclists revealed the number of violations was dominated by traffic-sign and road-mark violations, followed by document violations (driving license) [26]. This situation illustrates the poor prevailing traffic safety culture (as developed by the local government). Another example, Denpasar, the capital city of Bali province, also had the same issues in traffic accident-related motorcyclists' risky behavior. In the year 2014, Bali Regional Police claimed 70% of accidents involved motorcyclists [28]. Previous research on several province capital cities in Indonesia also claimed a high rate of accidents applied motorcyclists' behavior in disregarding traffic regulations [29]. However, both studies did not address safety culture issues.

Driving safety program developed by Bandung police precinct to educate drivers before and after obtaining a driving license [30]. The program is updated periodically accustomed to the condition and situation of Bandung city traffic. Socialized to academic, organizations, and public by police officers annually. The driving safety manual describes traffic regulation in Indonesia (driving requirements and driving license), driving procedures (technical and non-technical skills), traffic conditions (road traffic condition and climate in Bandung city), and punishment based on the type of violation including fine.

The research on situational aspects ("what the organization has") into the sub-organizations of the local government in Indonesia revealed some weak elements (pertaining to safety culture) embedded in the motorcyclists' licensing system [2]. The licensing system is supposed to confirm motorcyclists' safe behaviors meet with the driving safety program expectation. However, previous research revealed the lack of knowledge and weak comprehension of traffic signs and the poor appraisal of the traffic situation embedded in licensed motorcyclists [2]. In addition, the weak of law enforcement, ignoring lessons learned, and inadequate quality licensing procedures had developed a poor traffic safety culture among motorcyclists. This investigation showed that the sub-organization traffic safety development had not met expectations to shape driver behaviors as they relate to safety concerns. Therefore, it is necessary to identify the behavior of motorcyclists via the local government's driving-safety program so as to develop a good TSC.

These investigations indicate that the development of poor driving behavior has been carried out a societal level. Although the local government has a safe driving program aimed at educating motorcyclists and shaping their behavior, it does not seem to work appropriately. Subsequently, motorcyclists' behavior-related safety programs need to be reviewed. The objective of this study is to investigate motorcyclist behaviors as developed by the relevant local government sub-organization. By implementing the RSC model through the BBS program, we expected to identify some critical behaviors that can be reviewed for interventions.

3. Material and methods

3.1. Behavioral-based safety

The behavioral-based safety approach uses the antecedent-behavior-consequence (ABC) model to analyze behavior and improve safety in the workplace [17–20,22]. Fig. 2 depicts the relationship between stimuli before engaging in certain behaviors (driving-safety program expectations), what drivers do in terms of their daily driving activities (the target behavior), and the events experienced after engaging in certain behaviors (near misses, incidents, accidents, and other events related to safety as recorded in the database).

Based on the behavior-based safety guide [22], the implementation of a BBS program consists of the following steps:

1. Creating the BBS team (consisting of management and frontline employee)
2. Targeting behaviors (selected from records of safety incidents, near-miss report, safety audits, and observations)
3. Developing a checklist (comprising the list of behaviors obtained from Step 2)
4. Measurement systems (a frequent count of safe and risky behaviors)
5. Observation (observing employees)
6. Feedback (describing the observed behavior, discussing the potential impact, and listening to the observation)
7. Applying the observation result to change management
8. Set improvement goal

Regarding the research purpose, we conducted steps 1–6 of the above. It is the onus of the local government to carry out steps 7 and 8. We draw the conceptual framework of this research in Fig. 3.

Step 1: creating the BBS team

The observation team consisted of the sub-organization of the local government, representatives of motorcyclists and an academic institution located in the urban area. In this regard, the Urban Police Traffic Education and Engineering Unit of the Bandung City Police Precinct had the authority to make decisions and supervise the research. The Urban Transportation Department also supported this research in providing road events data and secondary data for investigation. The academic institution invited representatives of motorcyclists with criteria driving experience above 5 years and understood driving safety program. We, as an academic institution, did research by providing methods, tools, and surveys.

Step 2: targeting behaviors

This research focused on investigating motorcyclists' behavior. In the second step, we applied the ABC model so as to investigate the relationship between the situational aspect (driving-safety program) and the behavioral aspect (the driver's behavior). We studied the existing driving-safety program and identified the expectations held by the program in terms of motorcyclists' behavior so as to describe the

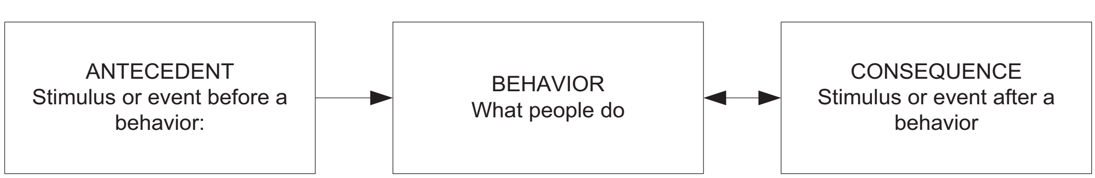

Fig. 2. The ABC model [21].

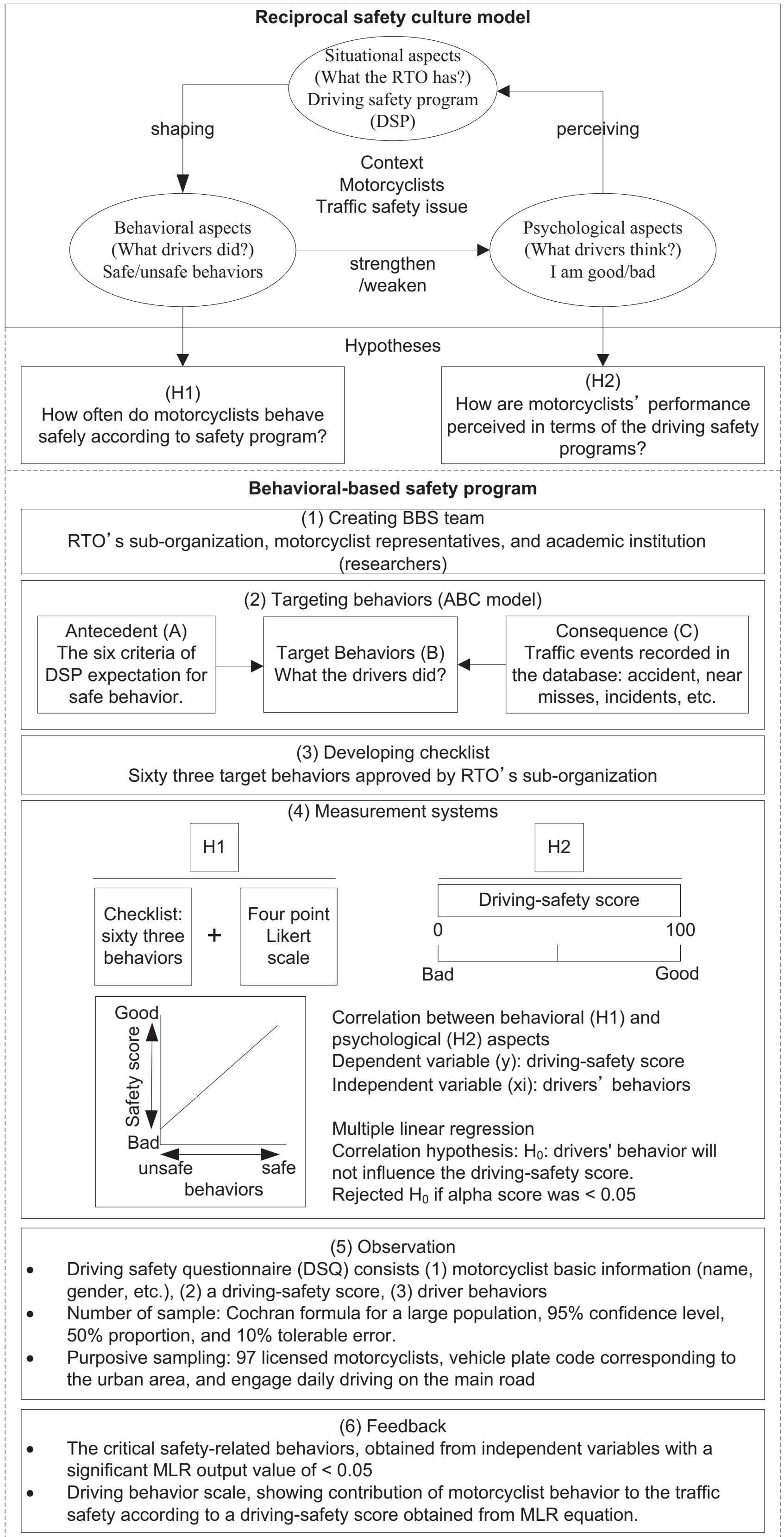

Fig. 3. The conceptual framework.

antecedent (A). The current driving-safety program is expected to shape driver behaviors based on the following six criteria:

1. *Ethics*: this criterion describes safe behaviors that focus on politeness in driving. It is expected that drivers will not provoke aggressive/defensive responses from road users, which can cause unsafe situations on the road. Drivers should also be able to assess an emergency on the road (fire truck, ambulance, etc.).
2. *Driving skills*: drivers are expected to maintain safe road conditions by implementing the basics of driving skills in their behavior. These criteria include the ability to drive properly (holding the steering with both hands), vehicle control (acceleration, braking, and maneuvering), and assessing road situations (recognizing damaged roads and traffic flow).
3. *Complying with traffic rules*: drivers are expected to understand and follow traffic rules, including obeying traffic signs, traffic lights, road marks, and other traffic regulations (vehicle standard equipment for driving).
4. *Mutual safety awareness*: the driver must behave cautiously while traveling with other people (family, passengers) in one vehicle, sharing the road with other users (car, pedestrian), and using road facilities together with other users.
5. *Striving for mutual safety*: drivers are expected to consider hazardous situations that can arise due to unsafe behavior on the road (driving without safety gear) and traffic violations.
6. *Responsibillity*: drivers are responsible for all road traffic events caused by their behavior. In this case, drivers are expected to behave obediently and cooperate with the authorities (police officers) when an incident occurs on the road because of their actions.

The target behaviors (B) of the ABC model is determined after obtaining consequence (C) from the expected behavior (A). The consequence (C) describes the event-related safety measures taken on the road in reference to expected behavior (A) – such as accidents, incidents, near misses, and emergencies (as recorded in the database). The expected behavior (A) is a safe behavior, as per the safety driving criteria. The target behaviors (B) describe what the drivers did regarding consequence (C). The determination of target behaviors (B) is finalized via discussions with the staff of the Urban Police Traffic Education and Engineering Unit and the Urban Transportation Department.

Table 1 shows the relationship between behavior expectation (A), consequence (C), and target behaviors (B) along the ethics criterion, upon which we defined five expected behaviors. Every expected behavior has several consequences. Each consequence is related to a target behavior (what the driver did). This method is also applied to other criteria to determine the target of the behavior (B).

Table 1
Target behaviors for ethichs criterion.

Behavior Expectations (A)	Consequence (C)	Target Behaviors (B)
Not provoking other users	Collision/near misses due to glare	Using blinding headlights
	Near misses due to being distracted by noise	Using the horn excessively
	Near misses due to being distracted by noise	Using a noisy exhaust
	Collision/near misses due to mispredicting the direction of a vehicle's movement in heavy traffic	Zigzagging on the busy road
	Near misses due to being distracted by noise	Yelling at other road users
Avoiding the sudden response of other vehicles at risk of a collision	Collision/near misses due to mispredicting the direction of a vehicle's movement on road	Suddenly merging into other lanes without signaling
	Collision/near misses due to unpredictable situations at traffic lights	Ignoring the traffic lights when a road is deserted
	Collision/near misses due to mispredicting the direction of a vehicle's movement at a corner	Changing the direction of a vehicle that is turning
Avoiding the aggressive actions of other vehicles	Collision/near misses due to mispredicting the direction of a vehicle's movement in traffic jam	Use a safe distance between cars when moving during a traffic jam.
	Colliding with a vehicle approaching from the opposite direction or near misses in avoiding collision	Using the opposite lane for taking over another vehicle
Supporting emergency situations	Preventing traffic jams caused by special occasion	Following police instructions during an incident
	Emergency	Clearing the lane for special vehicles (ambulances and fire trucks)
Driving in a polite manner	Collision/near misses due to mispredicting the direction of a vehicle's movement making a U-turn	Making a U-turn then suddenly cutting into a lane without assessing the situation
	Near misses in avoiding dirt	Spitting on the road
	Near misses in avoiding obstacle	Driving slowly while chatting with other motorcyclists on a busy road

Note: provoking other users means that behaviors may trigger either aggressive or defensive response. For example: regarding glare (coming from the opposite direction), other vehicles might challenge by applying a blinding headlight (an aggressive response). Alternatively, the driver can also try to change their vision in another direction so as to avoid the light source (a defensive respons).

3.4. Step 3: developing a checklist

According to guidance concerning BBS [22], the checklist comprises the behavioral targets identified in Step 2. The targeted behaviors should be listed on a sheet of paper. After discussions with the Urban Police Traffic Education and Engineering Unit, we obtained 63 target behaviors – as shown in Table 2 – and were approved for further investigation. Variables x_1 to x_{15} are behaviors concerning criterion no. 1; x_{16} to x_{29} concern criterion no. 2; x_{30} to x_{41} pertain to criterion no. 3; x_{42} to x_{43} are behaviors concerning criterion no. 4; and x_{45} to x_{60} are behaviors pertaining criterion no. 5. The remainder are behaviors based on the sixth criterion.

3.5. Step 4: measurement systems

Based on the RSC model [4], a driving-safety program was developed by RTO (situational aspects) to shape motorcyclist behavior (behavioral aspects) and to create a perception among motorcyclists about safety related to the program (psychological aspects). A driver's behavior in conducting a driving safety program in daily activities reflects safety perceptions. Regarding motorcyclists' behavior and perceptions related to safety programs, two questions should be investigated: (1) how often do motorcyclists behave safely according to safety programs?, (2) how are motorcyclists' performance perceived in terms of the driving-safety programs?

The original system measurement is simply count of safe and unsafe behaviors [20,22]. It is a challenge to measure motorcyclists' behavior because road traffic is different from normal workplace behavior. We could not observe motorcyclist behaviors one by one, as we would be able to with employees. As suggested by Cooper [3], we made use of a self-assessment method (self-report) to measure motorcyclists' behavior, through which we modified the original BBS method. Researchers have recently made use of a self-assessment method to study drivers' behavior [21,31,32]. The modification was done to limit the number of behaviors and make the observation relatively simple [19].

Table 2
The list of target behaviors.

Var	Target Behavior	Var	Target Behavior
x_1	Using blinding headlights	x_{33}	Giving a sign when overtaking
x_2	Using the horn excessively	x_{34}	Using a slow lane for normal driving
x_3	Suddenly merging into other lanes without signaling	x_{35}	Turning off the indicator after turning
x_4	Using a noisy exhaust	x_{36}	Turning on the indicator before turning
x_5	Use a safe distance between cars when moving during a traffic jam	x_{37}	Not driving while exceeding the vehicle's capacity (more than one passenger)
x_6	Zigzagging on the busy road	x_{38}	Not carrying oversized goods
x_7	Following police instructions during an incident	x_{39}	Waiting at the stop area when a train passes
x_8	Using the opposite lane for taking over another vehicle	x_{40}	Using vehicles with standard equipment according to regulation
x_9	Clearing the lane for special vehicles (ambulances and fire trucks)	x_{41}	Having driving license and vehicle documentation with the driver when driving
x_{10}	Making a U-turn then suddenly cutting into a lane without assessing the situation	x_{42}	Realizing some people wish for your safety when traveling (family)
x_{11}	Yelling at other road users	x_{43}	Awareness of the consequences of unsafe behavior and violations commited
x_{12}	Spitting on the road	x_{44}	Realizing that there are mutual interests on the road that must come first
x_{13}	Ignoring the traffic lights when a road is deserted	x_{45}	Wearing a standard helmet (following regulations)
x_{14}	Driving slowly while chatting with other motorcyclists on a busy road	x_{46}	Checking the vehicle before driving (tire pressure, fuel)
x_{15}	Changing the direction of a vehicle that is turning	x_{47}	Driving while in a good physical and mental condition
x_{16}	Using brakes intensively to maintain a safe distance in heavy traffic	x_{48}	Being careful when crossing damaged roads
x_{17}	Stopping immediately to avoid collisions due to suddenly stopping without changing lane	x_{49}	Queuing when crossing at an intersection
x_{18}	Using front and rear brakes for a sudden stop	x_{50}	Not taking risks to cross a traffic light that turns red (from yellow).
x_{19}	Holding the steering wheel with one hand	x_{51}	Paying attention to signals from other vehicles (brake lights, turning indicators)
x_{20}	Following the lane demarcations when turning	x_{52}	Not smoking while driving
x_{21}	Estimating a safe space and speed before overtaking other vehicles	x_{53}	Not using cell phones while driving
x_{22}	Assessing road and weather conditions when driving	x_{54}	Not eating/drinking while driving
x_{23}	Controlling the speed (accelerate/decelerate) to keep a safe distance	x_{55}	Not chatting with passengers while driving
x_{24}	Considering the speed in relation to visibility at night or due to rain	x_{56}	Waiting until the main road is empty to pass safely
x_{25}	Parking in the right place with the correct position (not blocking other vehicles)	x_{57}	Speeding with other road users
x_{26}	Using the correct indicator to turn according to direction	x_{58}	Following other drivers' traffic violations because there is no law enforcement visible
x_{27}	Avoiding chain reaction collisions	x_{59}	Notifying other drivers of unsafe conditions of the vehicle
x_{28}	Checking wing mirrors intensively when changing lane	x_{60}	Using the pedestrian sidewalk to drive when there are traffic jams
x_{29}	Assessing situations before changing lanes due to an obstacle up ahead	x_{61}	Not running away from traffic inspections on the road
x_{30}	Recognizing traffic signs and rules that apply on the road.	x_{62}	Not running away from traffic accidents or incidents
x_{31}	Slowing down near zebra crossings and railroads	x_{63}	Receiving a penalty ticket when a violation is found
x_{32}	Not driving aganst the flow of traffic		

The first question was investigated by applying the behavior checklist with a four-point Likert scale (to rate how often an individual performs the behavior). Motorcyclists answered: never (1), rarely (2), often (4), and very often (5) for safe behaviors; and never (5), rarely (4), often (2), and very often (1) for unsafe behaviors. The unsafe behaviors in Table 2 consists of variables x_1, x_2, x_3, x_4, x_5, x_6, x_8, x_{10}, x_{11}, x_{12}, x_{13}, x_{14}, x_{15}, x_{19}, x_{57}, x_{58}, and x_{60}. These variables indicate that motorcyclists' behavior does not comply with the criteria for safe driving. These unsafe behaviors include using non-standard vehicle equipment, violating traffic rules, driving aggressively (zigzagging), and taking risky actions (changing lanes suddenly).

The second question was investigated by measuring the perception of motorcyclists regarding their performance in implementing driving-safety programs. They rated the driving-safety score by selecting a value between 0 and 100 (bad – good performance).

The reciprocal relationship between behavioral and psychological aspects of the RSC model makes it possible to apply multiple linear regression (MLR) in order to identify the critical behavior undertaken by motorcyclists. RTO shapes the safety behavior of motorcyclists using a driving safety program. We derived target behaviors (63 driving behaviors) from the criteria described in the driving safety program. So the perception of motorcyclists in implementing a driving safety program could be explained by their driving behavior. MLR (dependence technique) could explain the influence of driving behaviors (behavioral aspects) on motorcyclists' perceptions of their performance in implementing a driving safety program (psychological aspects).

Previous research has proved the correlation between driver behavior and such as performance scale for investigating the effects of organizational safety culture on driver behaviors [31]. In this research, the correlation between several safe/unsafe behaviors that motorcyclists perform on the road will affect the driver's safety perception. This correlation will increase the safety score if the driver's safe behavior is widely applied. On the other hand, the safety score will decrease if the driver's unsafe behavior is widely used. Thus, drivers will perceive safe by their performance if they frequently behave safely in driving. The MLR could analyze the correlation between the driver's behavior and the driving safety score. Therefore, the driver's behaviors become independent variables, and the driving safety score becomes the dependent variable. The null hypothesis for correlation of driver behaviors (*xi*) to the driving-safety score (*y*) is written as H_0: drivers' behavior will not influence the driving-safety score. If the alpha score was <0.05, then H_0 is rejected.

3.6. Step 5: observation

The original BBS program suggested involving all employees in the observation process. However, there are more road users in urban areas than employees in discrete companies. For this purpose, we calculated a sample number using the Cochran formula for a large population, with a 95% confidence level, 50% proportion, and 10% tolerable error. A questionnaire was constructed to investigate motorcyclist behaviors and driving-safety scores. This questionnaire was approved by the Urban Police Traffic Education and Engineering Unit for distribution throughout urban areas. We used purposive sampling, with questionnaires distributed to 97 licensed motorcyclists who had a vehicle plate code corresponding to the urban area in question, and who engaged in daily driving on the main road.

The driving-safety questionnaire (DSQ) (Appendix A) was constructed based on a driving behavior questionnaire [21]. The DSQ consists of three sections: motorcyclist information, a driving-safety score, and safe/unsafe behaviors. The motorcyclist information consists of name, gender, age, driving experience (year), and driving a car (yes/

no). A driving-safety score is a score between and 0–100; the motorcyclist rates their performance in implementing the driving-safety program by answering the question: "How good am I at performing a driving-safety program?" The last section consists of sixty-three behaviors; the motorcyclist indicated their actions by answering the question: "How often do you perform this action in your daily driving?"

According to Geller [20], the observation identifies conditions that influenced behavior, such as environmental conditions and management systems. We investigated critical behaviors identified from questionnaires to describe those conditions. Interviewing police officers and representative motorcyclists as well as studying urban traffic databases and a licensing system revealed useful information for RTOs to intervene.

3.7. Step 6: feedback

We analyzed the data from the questionnaires using the classical assumption test before applying MLR. The classic assumption test consists of testing data sequentially, starting with validity, reliability, normality, linearity, autocorrelation, multicollinearity, and heteroscedasticity. The critical behaviors can be determined from variables with a significant MLR output value of <0.05.

We observed the critical behaviors to find out internal and external factors. Findings were reported to the Urban Police Traffic Education and Engineering Unit.

4. Results

4.1. Classical assumption test

The classical assumption test removed 19 of 63 variables: 44 variables were valid, normal, linear, and no autocorrelations. The multicollinearity test resulted in a VIF value <10 for all variables (as shown in Table 3). The scatter plot in Fig. 4 shows no heteroscedasticity; all dots spread above and below the zero point of the y-axis and do not form a specific pattern.

4.2. Multiple linear regression

We calculated multiple linear regressions (MLR) to determine the influence of driving behavior on the safe driving perception of a motorcyclist. A regression was significant for $F\ (44, 52) = 1.822$, $p = 0.019$, with an R^2 of 0.607. Because the p-value was $0.019 < 0.05$, then H_0 was rejected. The regression equation can be written as follows:

$$
\begin{aligned}
y = {} & 40.217 – 1.236x_1 + 5.781x_3 – 1.240x_4 – 3.221x_7 + 1.496x_9 \\
& + 0.004x_{11} – 1.252x_{12} + 2.020x_{15} + 2.876x_{19} – 1.732x_{20} \\
& + 2.087x_{21} – 0.612x_{23} + 0.442x_{24} – 1.157x_{25} + 3.064x_{26} \\
& + 3.907x_{27} – 5.137x_{28} – 1.241x_{29} + 0.065x_{30} + 0.997x_{31} + 0.596x_{32} \\
& + 2.254x_{34} + 2.886x_{35} + 1.813x_{36} – 0.617x_{37} – 0.109x_{38} – 0.661x_{39} \\
& + 0.331x_{40} + 4.627x_{41} – 0.442x_{42} + 0.046x_{43} + 0.424x_{44} \\
& + 1.184x_{45} - 3.096x_{48} - 0.716x_{49} - 2.597x_{50} + 2.515x_{51} + 0.776x_{53} \\
& + 1.113x_{54} + 0.273x_{55} - 5.761x_{56} + 0.561x_{57} \\
& + 0.383x_{58} - 3.382x_{60}
\end{aligned}
$$

4.3. Stepwise regression

Multiple linear regression model resulted in forty-four variables, as shown in Table 3. Although the Variance Inflation Factor (VIF) value showed a score below 10, due to the small sample size ($N = 97$) compared to the number of independent variables (44), the possibility of multicollinearity was still present in the model. Thus, we applied the stepwise regression (SR) to deal with the data.

We performed the SR to calculate 44 independent variables corresponding to one dependent variable. The number of independent variables were significantly reduced by 36 variables. We obtained eight independent variables have significant $p < 0.05$ with VIF value <2.0. The regression model was significant with $F\ (8, 88) = 7.716$, $p < 0.05$. Table 4 shows the result of stepwise regression. The regression model would be as follows:

$$
\begin{aligned}
y = {} & 42.260 + 5.760x_3 – 3.230x_7 + 3.216x_{27} – 4.159x_{28} + 4.247x_{35} \\
& + 2.464x_{41} + 2.552x_{45} - 2.461x_{60}
\end{aligned}
$$

Table 3
Multiple linear regression output.

Var	Unstandardized Coefficients		t	Sig.	Collinearity Statistics		Var	Unstandardized Coefficients		t	Sig.	Collinearity Statistics	
	B	Std. Error			Tolerance	VIF		B	Std. Error			Tolerance	VIF
Constant	40.217	12.393	3.245	0.002									
x_1	−1.236	1.236	−1.000	0.322	0.433	2.308	x_{35}	2.886	1.856	1.555	0.126	0.313	3.197
x_3	5.781	2.082	2.776	0.008	0.310	3.231	x_{36}	1.813	1.936	0.936	0.353	0.271	3.687
x_4	−1.240	1.645	−0.754	0.454	0.351	2.852	x_{37}	−0.617	1.684	−0.366	0.716	0.198	5.041
x_7	−3.221	1.666	−1.934	0.059	0.323	3.095	x_{38}	−0.109	1.573	−0.070	0.945	0.204	4.893
x_9	1.496	2.188	0.684	0.497	0.201	4.976	x_{39}	−0.661	1.666	−0.397	0.693	0.147	6.787
x_{11}	0.004	1.881	0.002	0.998	0.306	3.263	x_{40}	0.331	1.530	0.216	0.829	0.406	2.465
x_{12}	−1.252	2.425	−0.516	0.608	0.255	3.920	x_{41}	4.627	1.653	2.799	0.007	0.279	3.579
x_{15}	2.020	2.285	0.884	0.381	0.230	4.344	x_{42}	−0.442	2.268	−0.195	0.846	0.213	4.689
x_{19}	2.876	1.908	1.507	0.138	0.250	4.003	x_{43}	0.046	1.793	0.026	0.980	0.242	4.130
x_{20}	−1.732	1.619	−1.070	0.290	0.357	2.800	x_{44}	0.424	1.917	0.221	0.826	0.249	4.024
x_{21}	2.087	1.557	1.340	0.186	0.374	2.673	x_{45}	1.184	2.117	0.559	0.578	0.288	3.476
x_{23}	−0.612	2.418	−0.253	0.801	0.213	4.694	x_{48}	−3.096	1.829	−1.693	0.096	0.311	3.218
x_{24}	0.442	2.169	0.204	0.839	0.254	3.944	x_{49}	−0.716	1.266	−0.566	0.574	0.440	2.270
x_{25}	−1.157	1.580	−0.732	0.467	0.295	3.390	x_{50}	−2.597	1.506	−1.725	0.090	0.263	3.802
x_{26}	3.064	2.216	1.383	0.173	0.238	4.201	x_{51}	2.515	1.625	1.547	0.128	0.410	2.441
x_{27}	3.907	1.418	2.756	0.008	0.336	2.972	x_{53}	0.776	1.908	0.407	0.686	0.142	7.026
x_{28}	−5.137	1.755	−2.928	0.005	0.330	3.029	x_{54}	1.113	1.930	0.577	0.567	0.142	7.043
x_{29}	−1.241	1.759	−0.705	0.484	0.270	3.698	x_{55}	0.273	1.512	0.181	0.857	0.239	4.182
x_{30}	0.065	1.668	0.039	0.969	0.301	3.323	x_{56}	−5.761	1.996	−2.886	0.006	0.245	4.082
x_{31}	0.997	1.665	0.599	0.552	0.367	2.728	x_{57}	0.561	1.640	0.342	0.733	0.271	3.687
x_{32}	0.596	1.370	0.435	0.665	0.277	3.605	x_{58}	0.383	1.607	0.238	0.813	0.309	3.241
x_{34}	2.254	1.386	1.627	0.110	0.375	2.667	x_{60}	−3.382	1.535	−2.203	0.032	0.318	3.145

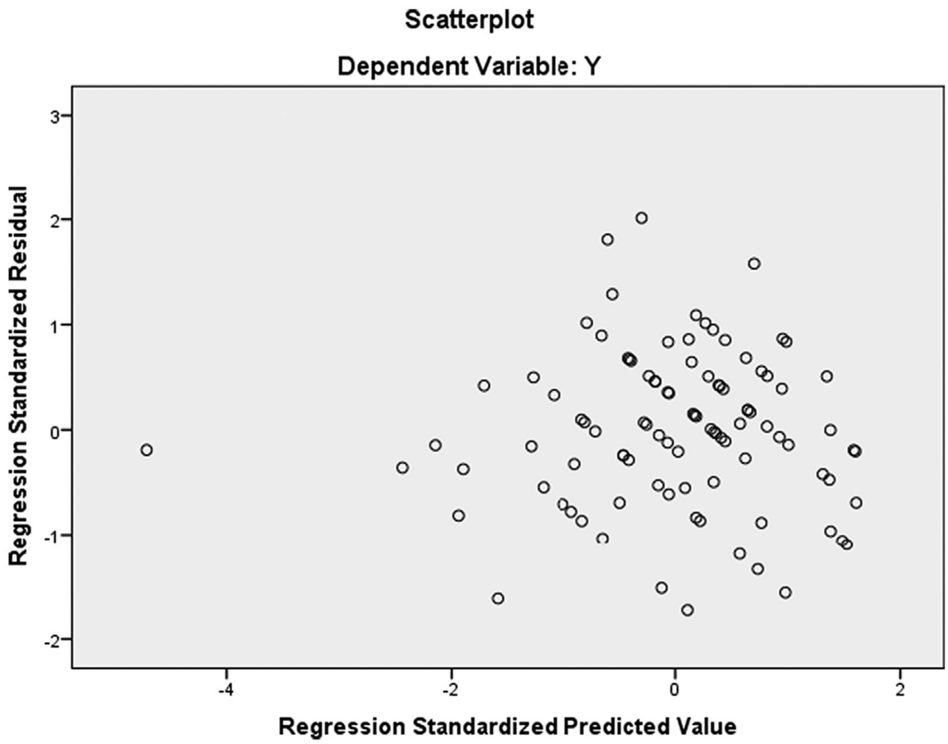

Fig. 4. Scatter plot of heteroscedacity.

Table 4
Stepwise regression output.

Var	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics		R^2	Adjusted R^2
	B	Std. Error	Beta			Tolerance	VIF		
Constant	42.260	7.076		5.972	0.000	–	–	0.412	0.359
x_3	5.760	1.350	0.432	4.268	0.000	0.650	1.538		
x_7	−3.230	1.067	−0.297	−3.028	0.003	0.696	1.437		
x_{27}	3.216	0.873	0.340	3.682	0.000	0.782	1.278		
x_{28}	−4.159	1.204	−0.359	−3.454	0.001	0.619	1.616		
x_{35}	4.247	1.157	0.356	3.670	0.000	0.710	1.409		
x_{41}	2.464	0.991	0.245	2.486	0.015	0.686	1.457		
x_{45}	2.552	1.231	0.195	2.073	0.041	0.751	1.332		
x_{60}	−2.461	0.972	−0.247	−2.533	0.013	0.701	1.427		

4.4. Hypothesis

In this study, we investigated the relationship between driver behavior and the perception of driving-safety. This relationship followed a reciprocal relation between behavioral and psychological aspects of the RSC model. Since the MLR led to the rejection of H_0, the result was in line with the safety culture theory [3]. Therefore, we could predict critical behaviors by identifying a variable with a significance value of <0.05.

Likewise, the results of the SR rejected H_0. The resulting regression model had fewer variables and was significant for $p < 0.05$. The VIF value below two indicates that this model has no collinearity between variables. All variables exhibit the critical behavior of motorcyclists.

4.5. Survey results related to critical behaviors

We identified six safe behaviors in variables x_7, x_{27}, x_{28}, x_{35}, x_{41}, and x_{45}—two unsafe behaviors in variables x_3 and x_{60}. The survey result of those behaviors is shown in Fig. 5. Behavior “avoiding chain-reaction collisions” (x_{27}) draws to motorcyclist's skill in braking and controlling speed. Behaviors “stopping immediately to avoid collisions due to suddenly stopping without changing lane” (x_{17}) and “using front and rear brakes for a sudden stop” (x_{18}) describe the braking ability. The controlling speed ability is reflected in behavior “controlling the speed (accelerate/decelerate) to keep a safe distance” (x_{23}). Therefore, we showed the survey result of these behaviors in Fig. 6 for discussing variable x_{27}.

5. Discussion

5.1. Critical driver behaviors

Regarding the MLR results in Tables 3, 44 behaviors were identified to have an influence on driving-safety scores (as shown in Table 5): seven variables from the first criterion, 11 variables from the second criterion, 10 variables from the third criterion, three variables from the fourth criterion, 12 variables from the fifth criterion, and no variables from the sixth criteria. The critical behaviors were identified by a significance-value of $p < 0.05$.

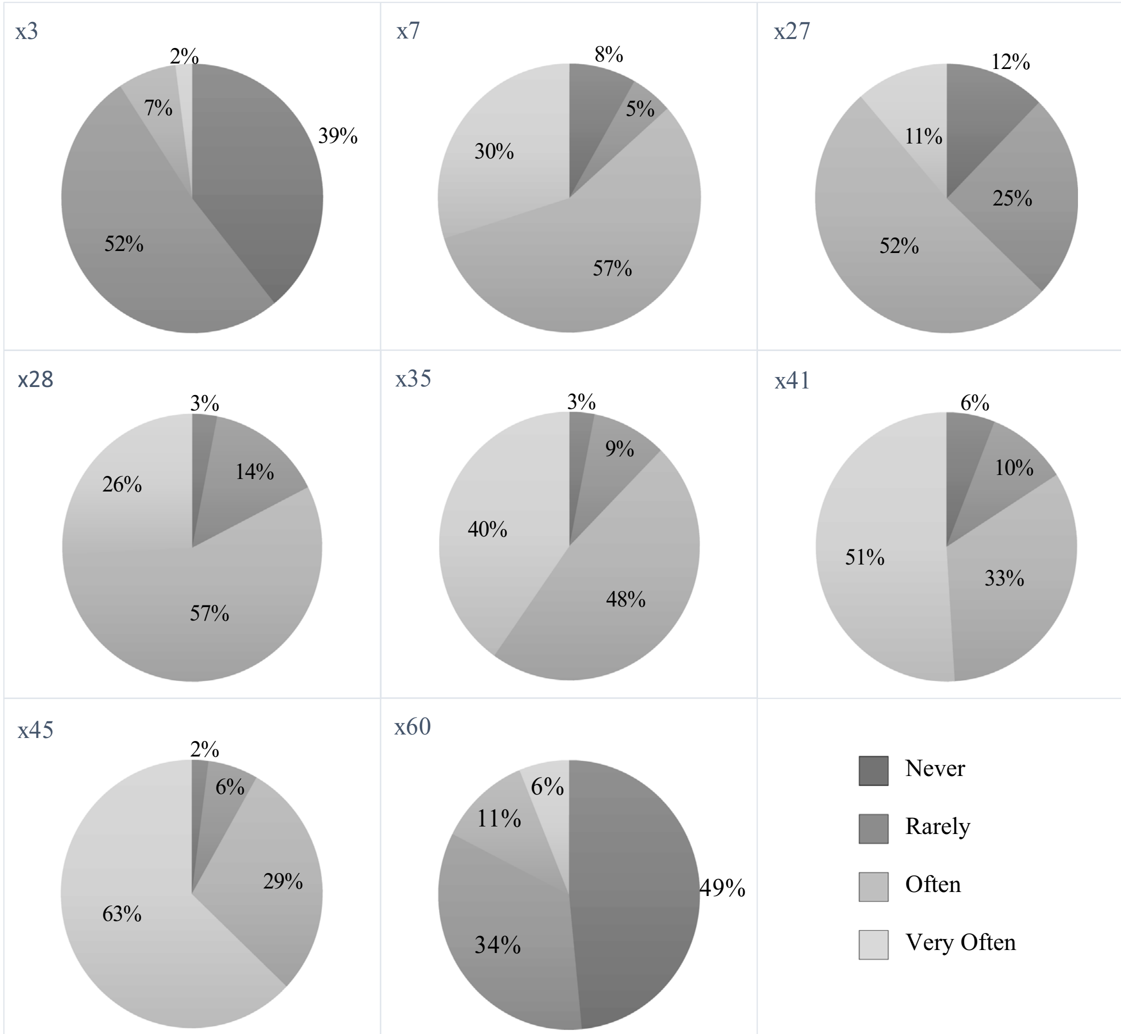

Fig. 5. Survey result of the critical safety behaviors.

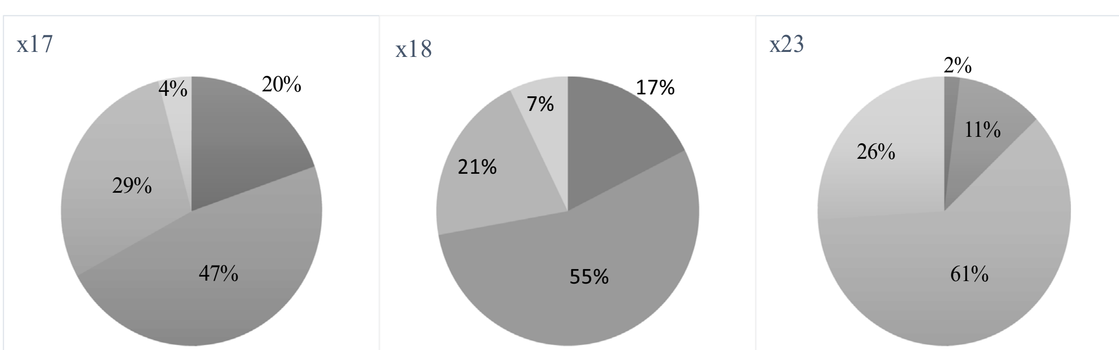

Fig. 6. Survey result of variables x_{17}, x_{18}, and x_{23}.

Table 5
Identified and significant variables of each criteria from MLR.

Criteria	Identified Variables	Total	Sig.Var.
1	$x_1, x_3, x_4, x_7, x_9, x_{11}, x_{12}, x_{15}$	8	x_3
2	$x_{19}, x_{20}, x_{21}, x_{23}, x_{24}, x_{25}, x_{26}, x_{27}, x_{28}, x_{29}$	10	x_{27}, x_{28}
3	$x_{30}, x_{31}, x_{32}, x_{34}, x_{35}, x_{36}, x_{37}, x_{38}, x_{39}, x_{40}, x_{41}$	11	x_{41}
4	x_{42}, x_{43}, x_{44}	3	–
5	$x_{45}, x_{48}, x_{49}, x_{50}, x_{51}, x_{53}, x_{54}, x_{55}, x_{56}, x_{57}, x_{58}, x_{60}$	12	x_{56}, x_{60}
6	–	0	–

From Table 3, the significant variables are: x_3 ($\beta = 5.781$, $p < 0.05$), x_{27} ($\beta = 3.907$, $p < 0.05$), x_{28} ($\beta = -5.137$, $p < 0.05$), x_{41} ($\beta = 4.627$, $p < 0.05$), x_{56} ($\beta = -5.761$, $p < 0.05$), and x_{60} ($\beta = -3.382$, $p < 0.05$).

Regarding the SR model, Table 4 shows eight variables were significantly identified critical behaviors: x_3 ($\beta = 5.760$, $p < 0.05$), x_7 ($\beta = -3.230$, $p < 0.05$), x_{27} ($\beta = 3.216$, $p < 0.05$), x_{28} ($\beta = -4.159$, $p < 0.05$), x_{35} ($\beta = 4.247$, $p < 0.05$), x_{41} ($\beta = 2.464$, $p < 0.05$), x_{45} ($\beta = 2.552$, $p < 0.05$), and x_{60} ($\beta = -3.382$, $p < 0.05$)

Table 6
Significant variables and critical behaviors from MLR and SR.

Criteria	Significant variables		Critical behaviors
	MLR	SR	
1	x_3		suddenly merging into other lanes without signaling
	–	x_7	following police instruction during an incident
2	x_{27}		avoiding chain reaction collisions
	x_{28}		checking wing mirrors intensively when changing lanes
3	–	x_{35}	turning off the indicator after turning
	x_{41}		having driving license and vehicle documentation with the driver when driving
4	–	–	–
5	–	x_{45}	wearing a standard helmet (following regulations)
	x_{60}		using the pedestrian sidewalk to drive when there are traffic jams
6	–	–	–

MLR identified six critical behaviors, and SR identified eight. Five variables of each method identified the same critical behavior, namely the variables x_3, x_{27}, x_{28}, x_{41}, and x_{60}. However, SR did not select x_{56} of MLR as a significant variable. Therefore we omitted x_{56} from the list of critical behaviors. In addition, the SR identified three other essential variables that did not appear in the MLR. Thus we derived eight critical behaviors that the RTO must address, as shown in Table 6.

5.2. Traffic violation record

Almost all behaviors of motorcyclists identified in this study relate to nearly all types of traffic violations in the city of Bandung [26]. Therefore, we collected the number of traffic violations in general from the year 2012–2016 (last recorded in February 2016) from the RTO's database, as shown in Fig. 7.

Critical behaviors related to traffic violations revealed that the development of a weak TSC had shaped the behavior of motorcyclists to deviate from the driving safety program. The role of behavior in traffic violations depicted motorcyclists having a wrong understanding of traffic signs, poor knowledge of traffic rules, and poor safety appraisal, all of which illustrate the elements of the weak safety culture developed by the RTO [2,10]. For example, "wearing a standard helmet" is related to a helmet violation. Driving with a non-standard helmet or without a helmet can not assure safety when an accident occurs, so it described motorcyclists having poor knowledge of traffic rules and being weak to appraise safety for themself. The breach of standard equipment is related to the behavior of "checking mirrors intensively when changing lanes." We found that motorcyclists had poor knowledge and might replace the wing mirrors with aftermarket products that do not comply with the safety standard or remove the wing mirrors (one or both) [2]. The violation of license (and documents) related to behavior "having a driving license and vehicle documentation with the driver when driving" [2]. Finally, behaviors associated with the violation of traffic signs (and road marks) are "following police instructions during an incident,"; "avoiding chain-reaction collisions," and "using the pedestrian sidewalk to drive when there are traffic jams." Usually, police officers put a warning sign a few meters before the incident to inform drivers. In addition, a warning sign for maintaining a safe distance and a prohibited sign to driving on the pedestrian sidewalk also can be seen on particular roads. Thereby, the RTO should address these behaviors in traffic rule violations.

The violation type of the number of passengers and the traffic flow was not so many compared with other violations. Therefore, both violations did not appear in critical behaviors identified in the investigation. However, it does not mean the RTO can ignore these violations in maintaining road safety.

5.3. Investigation on external and internal factors

5.3.1. Suddenly merging into other lanes without signaling (x_3)

Regarding this behavior, Bandung Road Safety Annual Report 2017 [27] claimed 1% of accidents contributed by motorcyclists from failing to give a signal. The survey in this research showed in Figs. 5, 9% of motorcyclists frequently failed to give signals. We found from the interview that motorcyclists were always in a hurry and then forgot to give signals. The ethics criteria expect motorcyclists must remember to give signals in any situation. Failing to give a signal will confuse other road users in predicting the vehicle's direction. Other drivers could respond with a sudden action that might affect traffic safety.

Most of the participants who answered the question by "rarely" and "never" giving a signal experienced near misses. However, the incident was not recorded by the traffic information system. The safety driving program said the motorcyclists would be punished if fail to give the signal. Obviously, it is not easy for the RTO to monitor motorcyclists using signals during their activities. Still, motorcyclists will be punished if their signal lamps are not working properly.

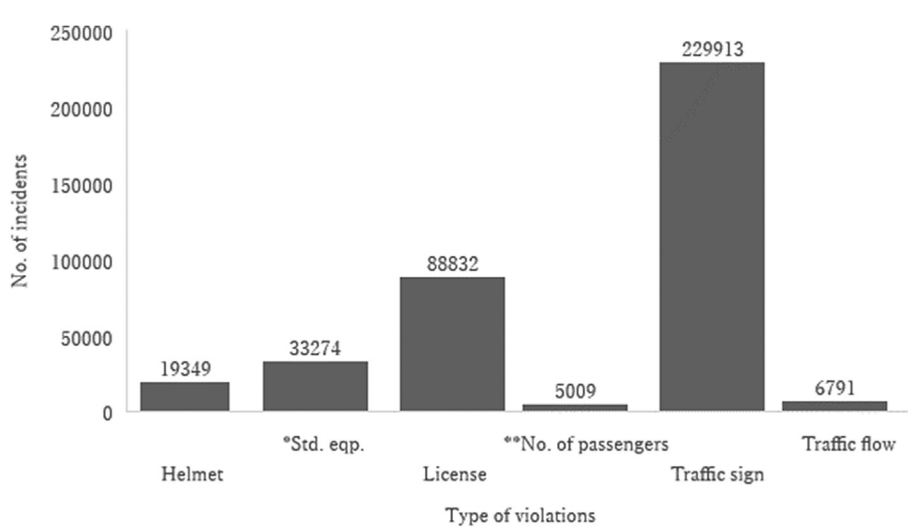

Fig. 7. Motorcyclists' traffic violations year 2012–2016.
*Std. eqp.: Standard equipments.
**No. of passengers: Number of passengers.

We observed the driving license test. Overall the use of signals has not seemed to be an important point in the assessment because it did not appear in the track driving test. Although the performance to give signals was assessed in the simulator driving test, candidate motorcyclists mainly focused on operating the simulator instead of performing to drive well. Investigation of the motorcycle simulator test revealed the simulator applied manual transmission, while 38% of motorcyclists were familiar with automatic transmission [2].

5.3.2. Following police instruction during an incident (x_7)

The survey in Fig. 5 states that most motorcyclists followed police instructions when an incident occurred (87%). However, 13% of motorcyclists might disobey police directives. Ethically, motorcyclists must respect other road users by patiently following police directions when a traffic incident occurs. Police said the motorcyclist's behavior of following instructions helped restore the traffic post-incident. However, the police admitted that if some motorcyclists disobeyed the instruction and police officers did not take action immediately, their behavior would provoke obedient motorists not to follow police directions. For example, motorcyclists were excited to watch an accident of a car collision. However, instead of obeying the instruction of the police to keep away from the accident area, they tried to come near to the scene and disrupted the traffic flow.

Furthermore, the police explained that traffic conditions would become challenging to control if they were too late to anticipate deviated behavior of motorcyclists. Even if only one or two motorcyclists were disobedient, it would give the impression that the police approved their behavior, which compliant motorcyclists would respond to as the correct course of action. Representatives of motorcyclists explained that they were confused by circumstances where the orders given by the police seemed to be inconsistent with the activities that many other motorcyclists did. Therefore, motorcyclists might misunderstand tracking the police order.

5.3.3. Avoiding chain reaction collision (x_{27})

The driving skills criteria expect drivers should be skillful enough to encounter hazardous situations on the road. Obviously, motorcyclists are not protected by the vehicle in use. The motorcyclist needs more attention to road traffic conditions and situations. So avoiding chain-reaction collisions such as the sudden brake situation will help them from the fatal accident. The RTO concerned about this situation because the questionnaire resulted in Fig. 5 37% of participants had experienced a chain-reaction collision. However, the number of incidents related to this situation was very limited in the traffic database system; mostly recorded fatal accidents.

The ability to use brakes and control vehicles are necessary to support motorcyclists in avoiding chain-reaction collision. We identified 72% of participants were not accustomed to using both brakes (front and rear) for sudden stops (x_{18}) as shown in Fig. 6. The interview with representatives of motorcyclists revealed that motorcyclists might not understand the function of front and rear brakes and could not operate it simultaneously. We observed the driving license test and found that 3 of the six assessment points of the simulator driving test are about braking. The test assesses the driver's ability to stop the vehicle and control speed. However, how to use the brake properly is not the main concern in the test. The track driving test assessed driving skills to follow the path smoothly, but it did not assess motorcyclists' skills to perform the sudden brake.

Investigation of the representative motorcyclists revealed some important points about the near misses situation related to chain-reaction collision. In sudden brake cases, most motorcyclists stop at a very close distance and sometimes crashed the front car's rear bumper. The impact between tire and bumper was sometimes a little bit rough, and it left a deep scratch or cracked on the car bumper. Some motorcyclists tried to avoid collision by changing lanes suddenly, but it also failed; they might crash the car's tail lamp. The survey result in Fig. 6 showed 62% of motorcyclists were unable to brake without changing lanes (x_{17}). In this situation, a car driver might stop the car immediately and go out to check the car's condition. The car driver and motorcyclist then argued, “who was wrong?” in the middle of the street. The traffic becomes crowded because the vehicle behind the motorcycle could not move. In many cases reported by car drivers, motorcyclists just run away after hitting the car. Only a few say sorry to the car driver without compensation for damage. Usually, no police officers are involved in the incident because near misses are not fatal accidents. Therefore, the traffic information system could not record the near misses case.

In addition, the behavior to keep a safe distance (x_{23}) also relates to the motorcyclist's ability to avoid chain-reaction collision. Eighty-seven percent of motorcyclists claimed their ability to control speed for maintaining distance, as shown in Fig. 6. However, the simulator and track driving tests did not assess this ability. Hence, we needed to question the habit of motorcyclists in maintaining a safe distance.

5.3.4. Checking wing mirrors intensively when changing lanes (x_{28})

The driving skills criteria expect drivers should monitor the surrounding situations by using a vehicle's wing mirrors before taking some actions. Furthermore, the driving safety program has explained the importance of wing mirrors. As well as, motorcyclists will be punished for driving a vehicle without wing mirrors or not equipped with proper wing mirrors. In this investigation, 83% of participants claimed to monitor wing mirrors frequently, as shown in Fig. 4. However, police officers doubted it because they found that motorcyclists might remove one or both mirrors in the vehicle inspection. In addition, a previous study also revealed 21% of motorcyclists had modified wing mirrors [2]. The RTO argued that motorcyclists would have difficulty monitoring wing mirrors if the vehicle was not properly equipped with the standard wing mirrors. These conditions showed that motorcyclists seemed not to understand the traffic regulation and function of wing mirrors correctly.

We observed the driving license test, either simulator or track test; neither assessed the wing mirrors checking. Both tests did not concern how drivers check the surrounding with wing mirrors. Therefore, motorcyclists might not consider checking wing mirrors as an important habit. From this point of view, although the vehicle is equipped with proper wing mirrors, we assumed motorcyclists have not been accustomed to this habit. Related to this issue, representatives of motorcyclists said people always say, “if you can ride a bicycle, of course, you can ride a motorbike,” this analogy usually is used as a benchmark for a motorcyclist's ability to ride a motorbike. But as we know, a bicycle is not equipped with wing mirrors.

5.3.5. Turning off the indicator after turning (x_{35})

Fig. 5 showed 88% of motorcyclists admitted to turning off the signal after turning. However, if a motorcyclist forgot to turn off the signal during heavy traffic, other road users might be wrong in determining the vehicle's direction. Furthermore, unexpected events can occur due to this negligence; a misunderstood driver can hit a motorcyclist. In addition, representatives of motorcyclists explained that if they forgot to turn off the signal, other vehicles could honk excessively, provoking anger.

This behavior is related to the ability of motorcyclists to use signals and apply them in accordance to follow regulations. Motorcyclists should have a habit of turning on and off signals appropriately. Therefore, the RTO needs to confirm the motorcyclist's ability to perform this action. In this case, the licensing system has a simulator to assess motorcyclists' ability to use signals. However, we found the system did not prove motorcyclists habit in the driving test on the track.

5.3.6. Having driving license and vehicle documentation with the driver when driving (x_{41})

The traffic rules criteria expect drivers understood and follow any traffic rules. The driving safety program stated every driver must bring a driving license and vehicle document when driving. Failing to bring those documents is categorized as a traffic violation. There is a punishment for violating the rule. In fact, a document's violation was the second issue in traffic safety in Bandung city [26]. The investigation of the licensing system revealed some weaknesses of the safety culture embedded in the system that resulted in the driving license might be issued un-procedurally [2]. Representatives of motorcyclists understood driving license is important for legitimating their activities with a vehicle on the road. However, the resulting survey in Fig. 5 showed 16% of motorcyclists frequently did not bring documents when driving. Based on the experience of motorcyclist representatives, the driving license might be lost or expired, but motorcyclists did not try to obtain a new license. The reason for not applying for a new license was that the procedure consumed time and money. Violating the traffic rule by not bringing the license was more convenient for them. The police officer might not know, and motorcyclists might escape from driver inspection on the road. The police officer confirmed that situation; during the driver's inspection, many motorcyclists tried to escape.

We observed motorcyclists' behavior at some driver inspection spots. A few motorcyclists ran away by countering and cutting the traffic flow spontaneously when finding the inspection was running in front of them. The situation endangers traffic safety; an accident might occur if a motorcyclist loses control and does not focus on the road environment. In some cases, police officers chased and caught suspects. Instead of submitting to the officers, some motorcyclists attempted to argue with the officers and refused to be inspected. From this perspective, we assume motorcyclists perceive the importance of a driving license to feel safe when facing a driver inspection.

5.3.7. Wearing a standard helmet (following regulations) (x_{45})

Violations of motorcyclists not wearing helmets properly accounted for 5.1% of the total breaches over five years. This type of violation includes the behavior of motorcyclists who do not wear helmets and who do not use standard safety helmets. The resulting survey in Fig. 5 showed that 92% of motorcyclists claimed to use a helmet correctly. Compared with data from the Bandung city traffic annual report in 2017 [27], which shows 61% of motorcyclists using helmets correctly, the survey result in Fig. 5 was still higher. According to annual report data, frequent media campaigns and road inspections affect the percentage of motorcyclists wearing helmets correctly, with the highest achievement being 70%. Therefore, it is necessary to conduct further research to determine the habits of motorcyclists in using helmets properly. RTOs need to ensure that motorcyclists wear helmets correctly while riding, as failing to do so could result in death when an accident happens.

5.3.8. Using the pedestrian sidewalk to drive when there are traffic jam (x_{60})

This behavior was also categorized in the mutual safety criteria. The driving safety program has described the punishment and fine for motorcyclists using the pedestrian sidewalk to avoid traffic jams. Regulation will convict the suspect by two clauses, violating the prohibition sign and endangering pedestrians. Fig. 5 showed that 51% of participants used the pedestrian sidewalk during a traffic jam. Representative motorcyclists explained the reason for using pedestrian sidewalks during traffic jams might because "in a hurry," "only temporarily time," "there are no pedestrians exist," and "there is no space on the road for motorcyclists to keep moving." It seemed motorcyclists did not understand the traffic regulation well and their actions influenced traffic safety, especially for pedestrians.

We observed pedestrian sidewalks around urban roads with high traffic flow intensity in the mid-day. We saw motorcyclists were parking on some pedestrian sidewalks, and no law enforcement taking action. In that area, pedestrians had to walk on the vehicle road instead of the sidewalk. The investigation of motorcyclists' understanding of traffic signs revealed motorcyclists also used the sidewalk for parking by violating the prohibition sign of parking [2]. In a traffic jam area, we found a few motorcyclists using the sidewalk to move. Most pedestrians gave way to motorcyclists; they were afraid to be crashed by motorcyclists. A few pedestrians confronted motorcyclists by standing still to block the way, some motorcyclists argued before leaving those pedestrians. Law enforcement seemed not to work appropriately to control the situation. We saw some pedestrians had difficulties reaching public transportations because motorcyclists blockedthe way to enter the vehicle. In some cases reported by pedestrians, motorcyclists hit pedestrians when getting out of public transportation. We assumed motorcyclists perceive unsafe just because of many conflicts that occurred in this action.

5.4. Driving safety score

We clarified that safety scores were unbiased by the effects of age and driving experience. The average age, driving experience, and safety score, respectively, are 22.8 years, SD = 6.36; 7.8 years, SD = 5.37; and 76.9, SD = 12.2. Next, we calculated the correlation between safety scores with age and safety scores on the driving experience. Both calculations yielded negative Pearson correlation values −0.065 and −0.007. In this case, we conclude no correlation between safety scores with age and driving experience.

The range of driving-safety scores can be calculated by inputting value of one (1) as the x-variable of the linear regression model in order to obtain the minimum value and by inputting five (5) so as to obtain the maximum amount. We thus obtain a driving-safety score range, as determined by the MLR model, of 49.9–88.4, with an average rating of 69.1. The SR obtained a driving-safety range of 53.7–99.2, with an average rating of 76.4.

If we assume the average rating reflects the driving-safety perception of motorcyclists at the time the research was conducted – from 0 to 100, proportionally, indicating low, medium, and high – the score falls into the high-level category of safety. Low levels indicate that unsafe behavior predominates. At the medium level, both practices share the same proportion. A high level illustrates that many safe behaviors dominate. The driving behavior scale in Fig. 8 explains the driving behavior-related safety of motorcyclists surveyed in this research. We can validate that score by comparing with the questionnaire data; the average rating was 76.9, SD = 12.2. All scores are slightly different, but they fall along the same level. In this case, we returned the decision to the RTO to determine the value to be used. In their opinion, the score from the MLR was closer to the real condition.

5.5. Limitation of regression model

In this study, we generated a linear model to describe the driving behavior of safety perceptions. This model has a p-value <0.05, indicating

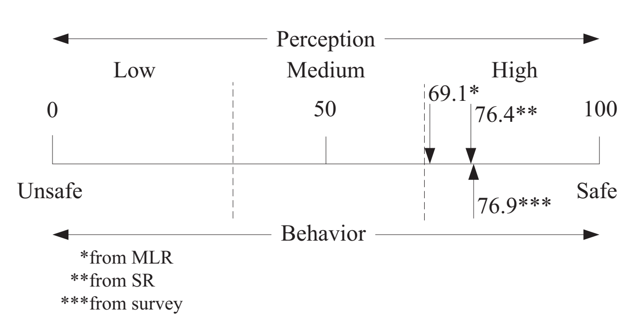

Fig. 8. Driving behavior scale.

that the model could explain the influence of independent variables on the dependent variable. However, the regression model may not be able to be used as a predictive tool to forecast driving-safety scores in the future. The model describes the present conditions (as to when the observations were conducted). In terms of safety culture, cultural change is related to the problem-solving process enabled by organizational activities in improving safety performance – such as changes to behaviors and perceptions of safety [5]. Therefore, after the intervention by the RTO, driving behavior and driving-safety perceptions may change, and the model would need to be reviewed. According to DeJoy [5], periodic testing can show the progress of an organization's efforts to change the safety culture. Therefore, after several years, the same procedures can be carried out to review the intervention toward driver behavior; the result may cause the driving-safety program to be re-evaluated.

On the other hand, some of the coefficients of the independent variables have opposite meanings. Further studies are necessary to reveal the true meaning of the independent variable's coefficient (− / +) with its contradictory statement. Hence, the direction of the contribution of the independent variable's coefficient to the dependent variable becomes clear. For example, +5.760 x_3 ("Suddenly merging into other lanes without signaling") is unsafe behavior but had a positive contribution. Therefore, it is necessary to check the answer to reveal its true impact. In the questionnaire, variable x_3 had the largest number of "Never" (5) responses, which indicates that the action will make a positive contribution if it is not done. The questionnaire results indicated that most motorcyclists rarely performed that action (average scale: 4.186, SD: 0.917). Related to this behavior, the Bandung local government has also claimed that motorcyclists contributed to 1% of all road-related injuries and deaths by failing to signal [27]. Therefore, the positive contribution of the coefficient of this variable makes sense. Another case, − 4.159 × $_{28}$, ("Checking wing mirrors intensively when changing lane") is a safe behavior but had a negative contribution. Further research is necessary to determine the mechanism at play in this case; in the previous research showed 21% of motorcyclists in urban areas modified their wing mirrors for aesthetic reasons [2] Wing mirrors modification disabled motorcyclists' ability to check their rear conditions correctly. In this research, police officers also confirmed the assumption: during vehicle inspection, they found that many vehicles did not use a standard product. In addition, they have also found that some vehicles were not equipped with a wing mirror and, in some cases, were only equipped with one side wing mirror. Thus, it would seem useless for the motorcyclist to frequently check the wing mirror if they did not equip the vehicle with an appropriate product. From this perspective, the negative contributions of *the* x_{28} variable make sense. Likewise, with the variable x_{60} (−2.461), "using the pedestrian sidewalk to drive when there are traffic jams." The behavioral survey in Fig. 5 shows that 51% of motorcyclists use pedestrian sidewalks when traffic jams occur. Although 49% of motorcyclists claimed not to use a pedestrian sidewalk to pass during traffic jams, motorcyclists representative doubted it. They said a few waiting motorcyclists might use pedestrian sidewalks during a heavy traffic jam. In this case, there are always motorcyclists using the pedestrian sidewalk when traffic jams occur. Therefore, even though only one motorcyclist passes on pedestrian sidewalks, it will reduce the safety of pedestrians. Thus, the negative coefficient of variable x_{60} becomes reasonable. In addition, we obtained a negative coefficient of variable x_7 (−3.230), following police instruction during an incident. In observation, we saw a tendency for motorcyclists to engage in misbehavior if they thought it would give a personal advantage. In this context, other riders might follow one or two motorcyclists who didn't follow police instructions because they believed the police officers allowed it (if police officers did not react immediately to prevent the behavior). This situation would make traffic chaotic, which could reduce traffic safety. Furthermore, a large number of motorcyclists posed a challenge for a police officer in giving instructions in the event of an incident. As a result, there might be misunderstandings in responding to police officers' instructions between them. The police officer said although the survey results showed only a few motorcyclists disobeyed the instructions, they could trigger the above incident. Thus the negative coefficient on the variable x_7 describes the situation explained by the police officer.

Regarding the negative coefficient of independent variables, multicollinearity on the regression model obtained from MLR has been suspected to be this cause. We solved the multicollinearity issue by applying the SR. However, the stepwise regression resulted in the regression model with a negative coefficient at the same variables identified by MLR. Hence, we strived to investigate the variable with a negative coefficient instead of modifying data to obtain a positive coefficient. We expected to reveal the actual situation by analyzing the related behavior more profound. For example, "Checking wing mirrors intensively when changing lane" (negative coefficient), we could reveal that motorcyclists used inappropriate wing mirrors so that the behavior gave a negative contribution to the safety score.

We determined the sample size using the Cochran formula for a large population. However, the number of samples did not meet the minimum ratio requirement between observations and independent variables for the regression model (5:1). Although the classical assumption test has reduced the number of variables from 63 to 44, it was insufficient to avoid collinearity. Therefore, we applied SR to analyze 44 independent variables with one dependent variable. The result met the minimum requirement for the ratio between samples and the independent variable (12:1).

5.6. The road traffic system

We clarified the traffic regulations have already covered all critical behaviors. Furthermore, the driving safety program explained violations related to the applicable rules, including penalties and fines. We also confirmed that the RTO managed traffic signs for controlling motorcyclists' behaviors appropriately around the urban area.

We expected that all variables of critical behavior would positively contribute to the safety score, reflecting the motorcyclists carried out safe behaviors (x_7, x_{27}, x_{28}, x_{35}, x_{41}, x_{45}) and avoided unsafe behaviors (x_3 and x_{60}) for maintaining road traffic safety. However, SR identified negative contributions on variables x_7, x_{28}, and x_{60}. Describing the road traffic situations and the organizational condition regarding critical behavior might explain the negative contribution of these variables to the safety scores. Therefore, we explored each behavior's external and internal factors in section 5.3. The external factors would be the road traffic situation (i.e., motorcyclists' interaction with other road users, motorcyclist's representatives' opinion). The internal factor would be the RTO condition (i.e., driving test, availability of traffic signs, police officers' effort, and thoughts).

Furthermore, we studied variables x_7, x_{28}, and x_{60} in more detail in section 5.5. to interpret the negative contribution in the regression model. For example, variable x_7 expects motorcyclists to obey the police officer's instructions. On the contrary, they might follow the wrong behavior of other motorcyclists instead of attempting the correct instruction. Likewise, variable x_{28} expected motorcyclists to check wing mirrors intensively. However, they might modify or remove wing mirrors that make it challenging to examine the road environment appropriately. These situations negatively impacted the safety score because motorcyclists might perform unsafe behavior instead of driving safely.

According to the organizational safety culture theory, the safety culture weaknesses (i.e., weak comprehension, lack of knowledge) can be traced to organization members' behavior [10]. Our findings identified a lack of knowledge embedded in motorcyclists' behavior to understand the RTOs program regarding driving safely. We found this weakness reflected in the opinion of motorcyclist representatives. They perceived road safety differently from the RTO expectations; for instance, using the pedestrian sidewalk for moving during traffic jamb (x_{60}) was acceptable if no pedestrians were walking. However, RTO expects motorcyclists to follow the rule by not driving on the pedestrian sidewalk.

Regarding the lack of knowledge, from the previous research, we found the mechanism to socialize the program also was limited. For example, the RTO recorded 62 safety campaigns and only one visitation to campus/school in a year [2]. In addition, issues in the licensing system had weakened motorcyclists' understanding by following the test procedure incorrectly [2]. Moreover, we identified the system did not assess the motorcyclist's abilities appropriately in sudden braking, checking side mirrors, and using signals—thus, these lack of capabilities embedded in their critical behaviors. The RTO program to educate motorcyclists on safe driving seemed not to develop their knowledge effectively. For example, a previous study revealed only 5% of motorcyclists learned about traffic from police officers [2].

In those situations above, the RTO had to make more effort to control motorcyclists' safe behaviors on traffic roads. However, those efforts did not fulfill RTO's expectation to shape motorcyclists' behavior correctly. For example, motorcyclists were aware of using helmets only when RTO often carried out campaigns [27]. In addition, motorcyclists tended to violate the traffic signs when they found no police officers around them, as reflected in variable x_{60}.

5.7. Limitation of the study

We had difficulty getting new information during the study, including data on motorcyclists' traffic violations in the current year. We understand the technological limitations of the organization's information systems in presenting these difficulties. The system used manual input to update the database; as such, the raw data were spread across the organization. We conducted interviews and direct observations of officers. However, the information obtained from several sources may differ and needs to be confirmed by supervisors. In this case, the bureaucracy and level of authority prolonged the confirmation process, and sometimes ended with ambiguous answers.

We conducted a study on the safe behavior of motorcyclists in urban areas. The survey method was used to obtain direct data from motorcyclists. Questionnaires were distributed in parking lots around the city. Although motorcyclists were willing to fill out the questionnaires, we could not ensure that they read every question correctly. Some motorcyclists were asked to confirm the questions, but most of them seemed in a rush to fill out the questionnaire.

We asked motorcyclists to fill out the questionnaire honestly, as they answered each question subjectively. However, it is possible that they did not answer according to actual conditions and experiences.

We analyzed data based on a self-evaluation questionnaire to investigate drivers' behaviors. We did not observe drivers' behaviors directly. However, T. Ozkan and T. Lajunen [32] said the driver behavior research, which used a self-evaluation report, gave information corresponding to actual driving behavior. Furthermore, they showed several shreds from evidence of past studies indicating a correlation between driving observation and a scale behavior measurement.

According to Geller [14], behavior questionnaires supposedly avoid the psychological questions that are difficult to measure. However, we measured one psychological aspect using a driving safety score (0 −100) to correlate with behavioral aspects described in the RSC model. In line with this research, B. Oz and T. Lajunen [31] demonstrated a similar method to measure drivers' perceptions to investigate the effects of organizational safety culture on driver behaviors. However, they assumed psychological aspects as safety culture itself. Regarding the individual bias in the driving safety score, we calculate the correlation of safety score vs. drivers' age and safety score vs. driving experience. As a result, both calculations show a negative Pearson correlation, −0.065 and − 0.007. Thus individual biases did not correlate with the driving safety score.

In this study, RTO wanted to use the MLR model with 44 independent variables as a reference for future researchers to understand that many motorcyclists' behavioral problems still need to be reviewed, not only the identified critical behaviors. However, the MLR model had multicollinearity problems and an insufficient sample size. We solved those problems by implementing SR. In this paper, we presented the result of MLR and SR so that future studies can consider the sample size in order to get a good regression model when applying MLR.

6. Conclusion

The reciprocal relationship between the situational aspect, the behavioral aspect, and the psychological aspect of the RSC model developed by Cooper [3] was applied to investigate the TSC in an urban area. From the observed relationship between situational and behavioral aspects, we identified the safe driving behaviors expected by the RTO. By focusing on the relationship between behavioral and psychological aspects, we identified critical safety behaviors that need to be addressed by the RTO.

The RSC model was implemented in the BBS program [22] and could investigate driving behaviors from a motorcyclist's perspective. However, the results did not describe the entire safety condition on the road. We realize that other road users interact with motorcyclists in their daily driving activities. We understand that the consequences of a driver's behavior can affect the perception of the motorcyclist by other road users. Their perception might lead to other critical behaviors that need to be considered when intervening with the RTO. Investigations using the same methodology, but from the perspective of other road users, are expected to provide a broader picture of TSC.

We identified eight critical safety-related behaviors in following police instruction, wearing helmet, signaling, braking, using side mirrors, driving license, and using pedestrian sidewalks. Those behaviors are associated with the database of general traffic violations committed by motorcyclists in five years, such as wearing a helmet appropriately, using standard equipment (i.e., side mirrors), driving license, and traffic rule (i.e., prohibition sign for driving on a pedestrian sidewalk). In line with previous research on the behavior of motorcyclists who ignore traffic regulations in Indonesia, Susilo et al. [29] identified these behaviors as significant enough to affect traffic safety, such as turning without warning (e.g., signaling), driving licenses, and driving on pedestrian sidewalks. In addition, a past study about motorcyclist risky behaviors in Indonesia (Bali) by Wedagama et al. [28] showed these behaviors have a significant indicator for risky riding behavior such as riding fast on curves, changing lanes to overtake other vehicles, and braking hard to stop. However, both studies did not relate those behaviors to such a program developed by the RTO to shape motorcyclist behavior in addressing traffic safety culture issues.

The previous study in TSC in the urban area shows weaknesses embedded in the licensing system have directed candidate motorcyclists to ignore lessons learned and experience inadequate quality licensing procedures. In addition, weak law enforcement amplified motorcyclists to practice unsafe behaviors. Furthermore, the lack of education and training has weakened motorcyclists' knowledge of appropriately comprehending the driving safety program. As a result, motorcyclists might fail to appraise traffic road risk by frequently violating traffic rules [2]. Hence, in this research, we clarified the critical safety-related behaviors developed by the existing system. We revealed their eight behaviors related to lack of knowledge, ignoring lessons and learning, and quality of driving license procedure. For example, motorcyclists could not use brakes appropriately for a sudden stop, and they were not accustomed to using mirrors to check the surroundings. In addition, motorcyclists have poor risk appraisal by entering the main road without waiting and using pedestrian sidewalks during traffic jams. We found issues in licensing systems also appeared in motorcyclists' unsafe behavior when they faced police inspections. Although research showed motorcyclists have a high perception of driving safety by frequently performing safe behaviors, a road traffic organization needs to confirm this condition by reviewing the perceptions of other road users toward motorcyclists' behaviors.

According to Geller [19], observing each other people for certain safety conditions may reveal unrealizing risk behavior when performing activities. The investigation of car drivers and pedestrian perspectives is necessary to confirm the motorcyclists' critical behavior, as identified in this research. "Suddenly merging into other lanes without signaling" (x_3), for example, may provoke car drivers. Their responses can be aggressive or defensive. "Avoiding chain reaction collisions" (x_{27}), "checking wing mirrors intensively when changing lane" (x_{28}), and "turning off the indicator after turning" (x_{35}) mostly involve interactions with car drivers. "Using the pedestrian sidewalk to drive when there are traffic jams" (x_{60}) is an interaction with pedestrians.

We will apply the same method in this study to investigate motorcyclists' behaviors from the perspective of other road users. Sixty-three motorcyclist behaviors are reviewed based on the interactions between motorcyclists and both car drivers and pedestrians. The driving behavior scale is reviewed by comparing the driving-safety scores obtained from car drivers and pedestrians. The critical behavior of motorcyclists obtained from car drivers and pedestrians will be discussed to obtain a big picture of how a driving-safety program as developed by the RTO had shaped motorcyclists' behavior in the urban area.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

Driving Safety Questionnaire.

(Motorcyclist)

Introduction

Introduce the observer affiliation and the purpose of research.

Section 1 – General information.

Name:

Gender: MALE / FEMALE

Age: years old

Driving experience: years

Experiencing to drive car?: YES / NO

A driving safety program is a way to drive safely and comfort for drivers' self and other road users.

Ethics is safe behaviors that pay attention to politeness in driving. It expects that drivers will not provoke aggressive/defensive responses from road users, which caused unsafe situations on the road.

Driving skill is drivers' ability to maintain safe conditions on the road by implementing the basics of driving skills in their behavior.

Complying traffic rules, drivers are expected to understand and follow traffic rules.

Mutual safety awareness, drivers must behave cautiously while traveling with other people in one vehicle, sharing the road with other users, and using road facilities together with other users.

Strive to mutual safety, drivers consider hazard situations that can arise due to unsafe behavior on the road and traffic violation.

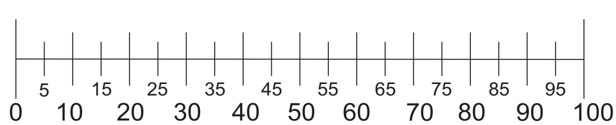
Responsibility, drivers have to responsible for all road events according to their behavior.

Section 2 – 1st questionnaire.

From 0 to 100.

How good am I at performing a driving safety program? (Circle the score).

Bad Performance Good Performance



Section 3 – 2nd questionnaire.

From the following table, please indicate.

How often do you perform this action in your daily driving? (Give mark "V" at the selected option).

Questionnaire		Never	Rarely	Often	Very Often
Ethics					
1	Using blinding headlights				
2	Using the horn excessively				
3	Suddenly merging into other lane without signaling				
4	Using noisy exhaust				

(continued on next page)

(*continued*)

Questionnaire		Never	Rarely	Often	Very Often
5	Use a safe distance between cars when moving during a traffic jam				
6	Zigzagging on the busy road				
7	Following police instructions during an incident				
8	Using the opposite lane for taking over another vehicle				
9	Clearing the lane for special vehicles (ambulances and fire trucks)				
10	Making a U-turn then suddenly cutting into a lane without assessing the situation				
11	Yelling to other road users				
12	Spiting on the road				
13	Ignoring traffic lights when a road is deserted				
14	Driving slowly while chatting with other motorcyclists on a busy road				
15	Changing the direction of the vehicle that is turning				
Driving skills					
16	Using brake intensively to maintain a safe distance in heavy traffic				
17	Stop immediately to avoid collision due to suddenly stopping without changing lane				
18	Using front and rear brakes for a sudden stop				
19	Holding the steering wheel with one hand				
20	Following the lane demarcation when turning				
21	Estimating a safe space and speed before overtaking other vehicles				
22	Assessing road and weather conditions when driving				
23	Considering the speed (accelerate/decelerate) to keep a safe distance				
24	Considering the speed in relation to visibility at night or due to rain				
25	Parking in the right place with the correct position (not blocking other vehicles)				
26	Using the correct indicator to turn according to direction				
27	Avoiding chain reaction collisions				
28	Checking wing mirrors intensively when changing lane				
29	Assessing situations before changing lanes due to an obstacle up ahead				
Complying traffic rules					
30	Recognizing traffic signs and rules that apply on the road.				
31	Slowing down near zebra crossing and railroads				
32	Not driving against the flow of traffic				
33	Giving a sign when overtaking				
34	Using a slow lane for normal driving				
35	Turning off the indicator after turning				
36	Turning on the indicator before turning				
37	Not driving while exceeding the vehicle's capacity (more than one passenger)				
38	Not carrying oversized goods				
39	Waiting at the stop area when the train passes				
40	Using vehicles with standard equipment according to the regulations				
41	Having driving license and vehicle documentation with the driver when driving				
Mutual safety awareness					
42	Realizing some people wish for your safety when traveling (family)				
43	Awareness of the consequences of unsafe behavior and violations committed				
44	Realizing there are mutual interests on the road that must come first				
Strive for mutual safety					
45	Wearing a standard helmet (following regulations)				
46	Checking the vehicle before driving (tire pressure, fuel)				
47	Driving while in a good physical and mental condition				
48	Being careful when crossing damaged roads				
49	Queuing when crossing an intersection				
50	Not taking risk to cross a traffic light that turns red (from yellow)				
51	Paying attention to signals from other vehicles (brake lights, turning indicators)				
52	Not smoking while driving				
53	Not using cell phone while driving				
54	Not eating/drinking while driving				
55	Not chatting with passenger while driving				
56	Waiting until the main road is empty to pass safely				
57	Speeding with other road users				
58	Following other drivers' traffic violations because there is no law enforcement visible				
59	Notifying other drivers of unsafe conditions of the vehicle				
60	Using the pedestrian sidewalk to drive when there are traffic jams				
Responsibility					
61	Not running away from traffic inspections on the road				
62	Not running away from traffic accidents or incidents				
63	Receiving a penalty ticket when a violation is found				

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