Factors Influencing Motorcyclists' Intention in Violating Railway Crossings in Indonesia: A literature review

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Abstract

In Indonesia, with high railway use, many of the rail infrastructures intersect with roads in the form of active and passive crossings. Several measures had been put to ensure safety on railway crossings, which are the use of flashlights, sirens, and gates. However, there were still violating behaviors of road users that cause accidents on railway crossings. The study of road users' behavior at railway crossings had been conducted in numerous countries. However, the study of road users' intention on violating railway crossings in Indonesia is still limited, especially for motorcyclists. The motorcycle is the highest transport mode used in Indonesia, which took 80% of total vehicle ownership. Hence, underlying factors that might influence motorcyclists' intention on violating railway crossings need to be further studied. In this study, several factors were elaborated, which consist of demographical factors, environmental factors, and the use of The Theory of Planned Behavior to explain risky crossing behavior. The findings in this study would be used as a reference for further study.

Keywords
Railway crossing, risky behavior, traffic violation, motorcyclist, theory of planned behavior

1. Introduction

Traffic accidents were the eighth biggest cause of all casualties in the world with 1,35 million casualties each year (World Health Organization, 2018). Among traffic safety issues that need to be concerned is the safety issues at railway level crossing. Railway level crossing, often referenced as a railway crossing, level-crossing, highway-railroad crossing, or railroad crossing, is the intersection of a road or highway with a railway that is equipped with traffic signs and safety devices to ensure a safe crossing of road users (United Nations Economic and Social Council, 2008). Despite all the measures to ensure safety at the railway crossing, there were still accidents that took place every year involving road users. In Europe, though accidents had reduced significantly in 2020, there were still 1331 railway accidents with 687 persons killed and 468 seriously injured (Eurostat, 2022). More than half of fatalities involved unauthorized persons on tracks with one-third occurring at level crossings (Eurostat, 2022). In the USA, collisions on railway crossings had increased about 13% from 2020 (1902 collisions) to 2021 (2147 collisions) with 236 fatalities and 666 injuries (Federal Railroad Administration, 2022). There were 180 accidents caused by road users on highway-rail crossings that consisted of user inattentiveness, misjudgments, violation, weather, deliberately disregarded crossings, and others (Federal Railroad Administration, 2022).

In Indonesia**,** rail trip is a widely used transportation mode. There are still many railway infrastructures intercepted by highways and roads. Until 2019, there were 4,716 crossings, of which 2,046 (43,4%) of them are passive crossings, and 1,431 (30,3%) of them are illegal crossings (Kementrian Perhubungan Direktorat Jenderal Perkeretaapian, 2019). It is noted that until October 2020, 198 accidents happened at railway crossings (KAI, 2020). The accidents that happened in railway crossings are involving train drivers, rail systems, and road users which are dominated by motorized vehicle drivers. The impacts of the accidents are not only the loss of lives and injury, but also infrastructure damages, traffic disruptions, and damage to railway institutions' reputations (I. Watson et al., 2020). In Indonesia, KAI (Indonesian Railway Company) experienced losses which was the damage to the trains that escalates from 2020 (208 damages) until 2021 (213 damages) (Ministry of Transportation Republic of Indonesia, 2022). Recently, until March 2022 there were 36 damages to train locomotives. Not only damage to the locomotives, but the accidents also resulted in delays in trips that escalated by 14% from 2020 (3.982 minutes) until 2021 (4.554 minutes). Delayed trips

are caused by the handling needed to sterilize the railway, inspection, and the replacement of the means (Ministry of Transportation Republic of Indonesia, 2022).

In 1968, United Nations Economic Commissions for Europe (UNECE) stated that trains had priority and road users must wait for the train to pass. In Indonesia, the laws had also stated that trains have priority in railway level crossings. Hence, since 2015, accidents in railway level crossings are not categorized as rail accidents (Kementrian Perhubungan Direktorat Jenderal Perkeretaapian, 2019). The laws and regulations in Indonesia oblige road users to stop if one of the warning signs has been activated in active railway crossings (Indonesia, 2009). In passive railway crossings, the road users that intend to cross must stop and look to the right and left directions before crossing the railway (Directorate General of Land Transportation, 2018). Hence, the behavior of road users plays a vital role in causing accidents at railway level crossings. The study of the road user's behavior while crossing level railway crossings should be considered as a guide in implementing better regulations and future interventions in railway crossing to better reduce the number of accidents caused by risky behavior.

Driver's non-compliant behavior could be divided into errors and violations (Reason et al., 1990). The violation was defined as the volitional deviation of needed practice to ensure safe operation in a potentially dangerous system (Reason et al., 1990). Recently, the study of road user's behavior in violating railway crossings had been studied in several publications, whether using a systems approach (Mulvihill et al., 2016; Read et al., 2016), observations and simulations (Beanland et al., 2017; Kim et al., 2018; Larue et al., 2018, 2020; Liang et al., 2017, 2018), as well as behavioral intention predictions from a set of factors (Palat et al., 2017; Stefanova et al., 2018; Zhao & Khattak, 2017). Palat et al., (2017) started the research by modeling road users' behavioral intentions while passing railway crossings using a social cognitive approach. The intention in passing railway crossing was modeled by extending the constructs from The Theory of Planned Behavior (TPB), a social cognitive theory to predict behavior or intention (Ajzen, 1991). The intention of car drivers and pedestrians while passing active railway crossings was modeled using constructs from TPB, extended with past behavior, familiarity with crossings, and comparative judgment of risks (Palat et al., 2017).

Some of the psychological models that had been used in modeling drivers' intention and behavior are The Theory of Planned Behavior (TPB), Health-Belief-Model (HBM), and Locus of Control (LC) (Özkan et al., 2012). These three models were used to examine intentional violating behavior (Özkan et al., 2012). TPB which was developed by Ajzen (1991) is a popular framework as a reference to explain and predict the behavior or behavioral intention of drivers (Özkan et al., 2012). TPB was developed from the Theory of Reasons Action Ajzen (1980) which was unable to explain behavior with incomplete behavioral control (Ajzen, 1991). TPB predicts intention with factors which are attitude, subjective norm, and perceived behavioral control (PBC) that come from behavioral beliefs, normative beliefs, and control beliefs as illustrated in Figure 1.

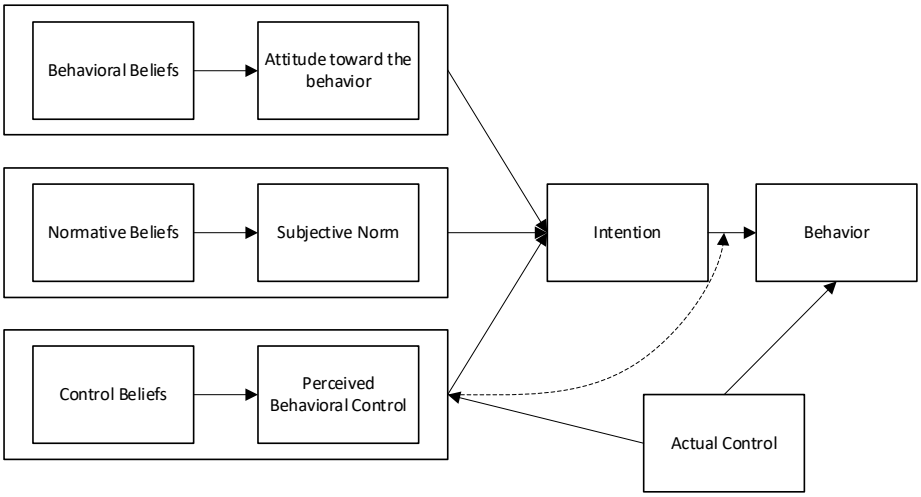

Figure 1. Theory of Planned Behavior (Bosnjak et al., 2020)

Theory of Planned Behavior (TPB) had been widely used and extended to predict the behavior of road users in traffic situations which were speeding (Atombo et al., 2016, 2017; Etika et al., 2020; Qaid et al., 2021; Vankov et al., 2021), the use of the mobile phone (Bazargan-Hejazi et al., 2017; Eren & Gauld, 2022; Nguyen et al., 2020), red light running (Shen et al., 2020), illegal parking (Zheng et al., 2018), engaging with distracting activities (H.-Y. W. Chen et al., 2016). TPB is also used to predict violating behavior of cyclists/e-bikers (Jiang et al., 2019; Yang et al., 2018) and pedestrians (Barton et al., 2016; Demir et al., 2019a; Jiang et al., 2017; Piazza et al., 2019; H. Zhou et al., 2016). TPB had also been used to model violating behavior while crossing signalized intersections (Satiennam et al., 2018; Shen et al., 2020; Tang et al., 2020; Yang et al., 2018; H. Zhou et al., 2016).

However, to the best of our knowledge, until recently there had not been found research in this area that focuses on motorcyclist or powered-two-wheel riders' risky behavior while passing railway crossing in various risky situations. This appears to be important to be studied further, knowing the mass number of motorcyclists in Low and Middle-Income countries (LMIC), especially Indonesia and other countries in Southeast Asia. Indonesia had the greatest number of motorcycle owners in Southeast Asia with roughly 131 million vehicles registered and 80% of them are motorcycles (ASEANStats, 2022). Besides that, the various characteristics of railway crossings in Indonesia, and the different characteristics of the riders, were thought to induce varying behavior while passing the railway crossings. Therefore, a literature review about factors that might influence motorcyclists' intention on violating railway crossings needs to be further studied as a ground for future study.

1.1 Objectives

The objective of this study is to conduct a literature review on factors that might influence motorcyclists' intention in violating railway crossings in Indonesia, concerning studies that had been conducted about road users' behavior on railway crossings and signalized intersections, and also motorcyclists' behavior as a ground for a future quantitative study.

2. Methods

To achieve the objective of this study the methods used are a literature review of recent studies on road users' behavior on railway crossings on Scopus ranging from 2016 until 2022 with keywords "driving behavior" "motorcyclists' behavior" "bikers' behavior" "violating behavior" "railway crossing" "level crossing" "red-light-running" and "theory of planned behavior". The information was also gathered using Google Scholar to review theoretical models that were used in the studies. The study is divided into three categories. First, recent studies and methods were used to explain road users' violating behavior at railway crossings. Second, the factors and theories used in explaining road users, especially motorcyclists and bikers' intention on violating railway crossings and signalized intersections. Third, based on the study conducted, the factors that might influence motorcyclists' behavior in violating railway crossings are concluded as a reference for future study.

3. Result

3.1 Risky behavior among different types of road users

Studies on road users' non-compliant and violating behavior on railway crossings had been conducted across countries which are summarized in Table 1. Different type of road users on railway crossings has different decision-making processes that were mapped using Rasmussen Decision Ladder (Mulvihill et al., 2016). It was found that different type of road users has different decision-making process in engaging compliant and non-compliant behavior on level crossings. Efficiency was found to be the main goal for road users who were not compliant, meanwhile, safety and compliance were the main goals for compliant road users. The non-compliant road users would use active warnings to evaluate whether they could pass the crossing on time. It was also found that motorcyclists and cyclists who were compliant made use of the time on the crossing to rest before continuing riding. Beanland et al. (2017) further elaborated on possible underlying reasons why drivers choose to not stop while noticing the "stop" sign on level crossings without active gates. Possible reasons are the time required to decelerate and accelerate, also the scarcity of the train passing in rural areas, hence the drivers choose to pass through the crossing without stopping at first. The difference between the crossing intention of pedestrians and car drivers was further researched by Palat et al., (2017). Pedestrians were found to have higher risky crossing intentions than car drivers, which was in line with previous studies (Beanland et al., 2017; Mulvihill et al., 2016). The size of the car which is bigger and heavier would limit the driver from doing risky behavior.

Having different characteristics from cars, motorcycles which are smaller and easier to navigate, induce higher risky behavior, hence being separately studied in numerous studies. Motorcyclists' tendency to do speeding and red light running, was found to have a significant relationship with numerous factors. Personality factors, demographic factors, psychological factors, and environmental factors were studied regarding motorcyclists and powered-two-wheel riders' risky behaviors. Among personality factors that were found to have a significant effect on motorcyclist risky behavior were sensation seeking, amiability, and impatience (Wong et al., 2010). Sensation-seeking and impatience directly affect attitudes towards unsafe riding (Wong et al., 2010). Demographic factors, such as age, gender, experience, education, and marital status had also been studied about their relationship with unsafe driving. The studies on road users' non-compliant behavior at railway crossings are summarized in Table 1.

Table 1. Studies on road users' non-compliant behavior at railway crossings

Study	**Type of crossing**		**Road user**				**Methods used**	**Country**	**Findings**
	active	**passive**	**Car drivers**	**Motorcylist /e-bikers**	**Cyclist**	**pedestrian**			
(Mulvihill et al., 2016)	✓		✓	✓	✓	✓	Cognitive Task Analysis: Rasmussen Decision Ladder	Victoria, Australia	Pedestrians and cyclists are likely to be alerted and informed by auditory warnings. Compliant and non-compliant road users have different decision-making processes on crossing
(Read et al., 2016)	✓	✓				✓	cognitive work analysis	Melbourne, Australia	Pedestrians have complex nature of decision-making on level crossings that influenced by time, effort, and social pressure
(Beanland et al., 2017)		✓	✓				Field experiment, Critical Decision Method (CDM) interview	Australia	Non-compliant drivers do not differ from compliant drivers in approach speed but spent less time visually checking for trains. Some drivers disregard the stop sign while others did not notice the stop sign
(Liang et al., 2017)	✓		✓	✓			Field observation	France	The peak violation rate in the morning is later than the actual rush hour. The violation rate of drivers decreases as time advances from the activation of red flash and siren until the barriers come down. Violation rate during the barriers down decreases

Study	Type of crossing		Road user				Methods used	Country	Findings
	active	passive	Car drivers	Motorcylist /e-bikers	Cyclist	pedestrian			
									when the duration is prolonged
(Palat et al., 2017)	✓		✓			✓	Survey Questionnaire	France	attitude, injunctive norm, descriptive norm (only car drivers), perceived behavioral control (only car in situation 1), risky crossing frequency, and risk level affected risky crossing intention
(Liang et al., 2018)	✓		✓	✓			Field observation	France	Motorists are more likely to commit zigzag violations at the LX located close to railway stations with dispersive barriers down duration. Troop crossing phenomenon inclined to occur at crossings with higher density.
(Stefanova et al., 2018)	✓					✓	Survey Questionnaire	Australia	Past unsafe behavior, descriptive norms, and perceived risk of being involved in a crash were significant predictors of the likelihood to engage in risk-taking behavior at level crossings
(Larue et al., 2020)	✓		✓				Experimental design	Australia	Increased waiting times result in a higher level in higher frustration and an increased likelihood of risky driving behavior.

3.2 Demographical and Environmental Factors on Risky Crossing

Some studies found that age correlates positively with a higher risky behavioral intention on railway crossing (Palat et al., 2017) and speeding (Atombo et al., 2016). Age could indicate drivers' experiences in driving, hence drivers with higher experience would have more ability to engage in risky behavior that is also in line with perceived behavioral control of risky behavior (Palat et al., 2017). Meanwhile, other studies on powered-two-wheel riders

violating signalized intersections (Wu et al., 2012; Yang et al., 2018) or violating traffic rules in general (Susilo et al., 2015) showed that younger drivers had more tendency to violate. The contrasting result of powered-two-wheel riders could be understood since two-wheelers are smaller and easier to learn than cars, hence age doesn't necessarily indicate experience in driving.

Though gender had been found significant in numerous studies regarding risky driving behavior male riders have more tendency in engaging risky driving behaviors (Abdul Manan et al., 2020; Chang & Yeh, 2007; C. F. Chen, 2009; Palat et al., 2017; Wu et al., 2012), some studies had also found the effect is not significant, whether on powered-two-wheel riders (Borhan et al., 2018; Susilo et al., 2015; Yang et al., 2018) or drivers on general (Vankov et al., 2021). Some studies had found that riders having higher education have a lower intention for risky driving (Borhan et al., 2018; Yang et al., 2018), which indicate that riders' education influence risky driving intention, though other study had found students have a positive correlation with repetitive violation (Susilo et al., 2015) that might be linked with younger riders' tendency to violate. Marital status had also been studied and been found significant in rider's violating behavior on signalized intersections (Yang et al., 2018). Studies also found that drivers' familiarity with the road or intersection they had been passing affected intention on non-compliant behavior (Palat et al., 2017; Palat & Delhomme, 2012).

Environmental conditions, such as location, traffic, hour, and weather had also been studied for their relevance to risky driving behavior. On railway crossing, non-compliant behaviors were observed more near multi-lane (Abraham), near railway stations (Liang et al., 2018), on higher road traffic density (Liang et al., 2018), and during rush hour (Liang et al., 2017). In line with the study conducted by Palat et al. (2017) that also found that railway crossings with higher traffic density showed higher violating behavior on the road users while passing the railway crossing. Other risky behavior in driving, such as non-compliant behavior on signalized intersections such as red-light-running and yellow-light-running, are also affected by environmental conditions such as location (Palat & Delhomme, 2012; Susilo et al., 2015), traffic (Shen et al., 2020; Susilo et al., 2015), hour (Shen et al., 2020; Susilo et al., 2015), and weather (Satiennam et al., 2018; Shen et al., 2020). The railway crossing located near the station was observed to be related to more risky behavior than crossing located far from the station (Liang et al., 2018).

3.3 Factors of Theory of Planned Behavior on predicting risky crossing behavioral intention

Social cognitive factors have been used to explain various risky behavior. The Theory of Planned Behavior factors which consists of attitude, perceived behavioral control, and subjective norm, also extended to other factors—specific to the context—were studied to be found their relationship with risky driving intentions. The factors were studied using hierarchical linear regression (Yang et al., 2018), multiple regression (Palat et al., 2017), and structural equational modeling (Satiennam et al., 2018; Shen et al., 2020; Tang et al., 2020), some are using multi-group analysis to further explain the difference among groups of the population which were divided by age groups and experience (Shen et al., 2020). Attitude shows the individual evaluation of the behavior studied, whether the behavior is seen as positive or negative (Ajzen, 1991). Attitude was found to be a strong predictor of risky behavior, especially risky crossing behavior of riders (Satiennam et al., 2018; Shen et al., 2020; Tang et al., 2020; Yang et al., 2018). The positive attitudes toward risky crossing were the belief to not wait and to avoid sudden braking (Satiennam et al., 2018). Meanwhile, negative attitudes that lower the intention of the risky crossing were being hit and hitting others (Satiennam et al., 2018). Some studies linked attitude with personality factors (Wong et al., 2010) and a set of beliefs (Satiennam et al., 2018). Motorcyclists with risky attitudes tend to engage in red-light-running (Satiennam et al., 2018). Meanwhile, the risk of accident was the consequence that lower behavioral intention in risky crossing.

Subjective norm is the individual perception of social perception of the behavior studied (Ajzen, 1991). Subjective norms could be divided into injunctive norm and descriptive norm in numerous studies on risky crossing behavior (Palat et al., 2017; Satiennam et al., 2018; Yang et al., 2018). Descriptive norm was often defined as the impact of other road users' behavior (Palat et al., 2017; Satiennam et al., 2018) or the behavior of important people who are friends and family (Yang et al., 2018). Palat et al. (2017) found that descriptive norm, which was defined as the perception of other drivers' behavior had a significant effect on car drivers' intention on engaging in risky behavior on railway crossings. Meanwhile, injunctive norm, which was defined as the belief of people who are important to the individual would approve of their behavior, had been found to have a significant effect on the intention of risky behavior in car drivers and pedestrians. The contrasting result was found in studies on risky crossings on signalized intersections, where the subjective norm was found not significant to risky crossing intention (Yang et al., 2018). This indicated that family and friends tend to not approve of violating behavior that was found in the context of red light

running. Yet the behavior of family and friends in doing red light running was found to be significant to red light running intention (Yang et al., 2018). Yellow-light-running, is also considered a non-compliant and risky behavior, yet the knowledge of the rules about the behavior tends to differ among drivers, this affected the attitude, thus intention on engaging with such behavior (Palat & Delhomme, 2012). Similar to red-light-running and yellow-light-running studies, the study on railway crossing conducted by Palat et al., (2017) compared three types of situations from the state when the alarm and the lights were set off until the gate was about to close. Different situations indicated the risk level that affected the intention, attitude, and perceived behavioral control on doing the risky crossing. The use of The Theory of Planned Behavior in risky crossing behavior studies is summarized in Table 2.

Table 2. Theory of planned behavior use in risky crossing behavior studies

Construct	TPB						Extended								Method
	BI	IN	AT	SN	DN	PBC	PB	FM	CJ	PR	CT	SI	MN	TE	
Shen et al. (2020)		✓	✓*	✓*		✓					✓*			✓*	Structural equations modelling
Satiennam et al. (2018)	✓	✓*	✓*	✓*		✓*								✓*	Structural equations modelling
Yang et al., (2018)		✓	✓*	✓	✓*	✓*				✓	✓	✓*	✓*		Hierarchical regression model
Tang et al., (2020)	✓	✓*	✓*	✓*	✓*	✓*	✓*								Structural equations modelling
Zhou et al., (2016)		✓	✓*	✓	✓*	✓				✓	✓*				Structural equations modelling
		✓	✓*	✓*	✓*	✓*	✓*	✓*	✓						Multiple regression

BI = Behavioral Intention IN = intention AT = attitude SN = Subjective norm DN = Descriptive norm PBC = Perceived Behavioral Control PB = Past behavior FM = Familiarity CJ = Comparative Judgement of risk PR = Perceived Risk CT = conformity tendency SI = self-identity MN = Moral Norm TE = Traffic environments *significant variables

The intention would turn into behavior if the behavior were within individual control (Ajzen, 1991) which is when an individual could decide whether to engage with such behavior. The intention with opportunity and support, in the form of behavioral control, would result in behavior (Ajzen, 1991). In the railway crossing context, perceived behavioral control is only significant in car drivers' intention to cross on the situation when the alarm and the lights have been set off (Palat et al., 2017). Perceived behavioral control had also been found as a weak predictor of behavioral intention on risky crossing (Satiennam et al., 2018; Shen et al., 2020). The inability of perceived behavioral control on predicting intention indicated that in certain situations, risky behavior is easy to do, though violating signalized intersection would be easier than guarded level crossing with gates.

3.4 Extended factors of TPB to explain risky behavior

Factors of TPB were often expanded to better explain the behavioral intention of risky behavior. Self-identity and moral norms were among the factors which were used in explaining motorcyclist risky behavior (Elliott, 2010; B. Watson et al., 2007; Yang et al., 2018). On rider's red-light-running, self-identity is described as how the riders label themselves whether they are careful riders or not (Yang et al., 2018) which was found significant in riders' intention on red-light-running. The riders who label themselves as careful riders tend to have lower intentions of violating signalized intersections. The addition of self-identity came from identity theory (Stryker, 1987 in Elliott, 2010), which showed that self-identity was determined by the social environment that was occupied by individuals and affected their behavior. Moral norm or personal feelings of moral obligation or responsibility to perform or to refuse a behavior

was among the extended factors of The Theory of Planned Behavior which was suggested to be considered in some contexts (Ajzen, 1991). The addition of moral norms may be useful for explaining socially undesirable behaviors (Parker et al., 1995) and had been used in examining non-compliant e-bikers' behavior in red-light-running (Yang et al., 2018).

Past behavior is among the factors that are often added to extend The Theory of Planned Behavior and is supported by much empirical evidence (Ajzen, 2011). One of the possible explanations is that past behavior has similar measures with behavior in the form of frequency, thus having greater predictive ability in behavior, more than intention (Ajzen, 2011). Though past behavior was argued that it failed to meet the requirement that it constitutes a cause to intention (Ajzen, 2011), recent research still uses past behavior as a predictor of intention and behavior (Palat et al., 2017; Tang et al., 2020). Past behavior was found to moderate the effect of PBC-Intention and PBC-future behavior of e-bikers' red-light-running (Tang et al., 2020).

Risky driving behavior was often explained by the addition of the factors from the Health Belief Model whether helmet wearing (Ambak et al., 2010; Brijs et al., 2014; Fallah Zavareh et al., 2018) and the use of the mobile phone (Hill et al., 2019; Widyanti et al., 2020). Perceived risk, as one of the factors from the Health Belief Model and on other theories in common such as PAPM (Precaution Adoption Process Model) and often in TPB (Brewer & Rimer, 2008), was often used in modeling drivers' violating behavior. Drivers who perceived less risk tend to engage in risky behavior, though perceived risk had also been found insignificant in studies about violation of e-bikers on signalized intersections (Yang et al., 2018). This showed that though drivers perceived the behavior as dangerous or risky to be engaged in, drivers still engage with the behavior, that might also be linked with perceived behavioral control (Yang et al., 2018). Some studies also added conformity tendency in explaining riders violating behavior on the signalized intersection (Shen et al., 2020; Yang et al., 2018). Conformity was among personality treats that were studied in crossing behavior (H. Zhou et al., 2016; R. Zhou et al., 2009). Shen et al., (2020) extended The Theory of Planned Behavior with conformity tendency which was defined as how easy an individual is to be affected by the behavior of other people around them in the study of delivery riders red-light running and was found to be significant in predicting violating intention. However, the operationalization of conformity tendency in violating behavior seemed to be similar to the definition of the descriptive norm (Palat et al., 2017), hence the use of one of the factors would be desirable to achieve parsimony on the model of intention prediction.

The use of The Prototype Willingness Model, aside from The Theory of Planned Behavior, is also often used on examining drivers' violating behavior. The prototype willingness model is a dual-process model that was based on assumptions that there were two types of decision-making involved in health behavior (Gerrard et al., 2008). There were two ways of decision-making, the reasoned path which is similar to the theory of reasoned action, and the social reaction path which is image-based and involves a heuristic process (Gerrard et al., 2008). The social reaction path was developed to explain behavior that is unintentional and unplanned. The prototype willingness model had been used in modeling risky road-users behavior, such as young drivers' risky behavior (Harbeck & Glendon, 2018) and pedestrians' risky behavior (Demir et al., 2019). Factors in Prototype Willingness Model were added to The Theory of Planned Behavior to explain e-bikers red light running behavior (Tang et al., 2020). However, the use of the prototype willingness model to better explain unintentional behavior had been argued to its distinction from The Theory of Planned Behavior. Ajzen argued that the distinction between willingness and intention was unnecessary (Ajzen, 2011) since there were no assumptions in the TPB that people form the intention to engage in behavior after reviewing all available information carefully and systematically.

To sum up, the factors of The Theory of Planned Behavior and extended factors that could be added to predict motorcyclists' non-compliant crossing behavior in railway crossings are summarized on Table 3.

Table 3. Constructs to predict risky crossing behavior

Construct	Description	Relevance to this study
Intention	Intention is described as individual intention to perform a certain behavior. Intention is influenced by motivational factors of an individual in performing the behavior (Ajzen, 1991).	Intention would measure the tendency of motorcyclists to violate railway crossings in various risky situations. Intention would be the independent latent variable explained by other constructs.
Attitude	Attitude shows the individual evaluation of the behavior in question, which could be either positive or negative (Ajzen, 1991).	Attitude in the study would measure individual evaluation of violating railway crossings in various risky situations. Attitude towards violating the crossings would show the individual point of view of the advantages and disadvantages of performing such behavior.
Perceived behavioral control	Perceived behavioral control is an individual evaluation of the behavior whether the behavior is within their control and the situation enables them to perform such behavior. Intention would be realized into behavior if the behavior is within the individual's perceived behavioral control (Ajzen, 1991).	Perceived behavioral control in the study would measure individual evaluation of crossing the railway in risky situations and whether the behavior is within their control and capabilities.
Subjective norm	Subjective norm is individual perception of social pressure regarding the behavior studied (Ajzen, 1991).	Subjective norm in the study would measure motorcyclists' evaluation of the social pressure from people who are important to them while doing the risky crossing behavior.
Descriptive norm	Some studies divide subjective norm into injunctive norm and descriptive norm. Descriptive norm represents the behavior of people who are important to the individual in performing similar behavior given the situations (H. Zhou et al., 2016).	Following Palat et al., (2017), descriptive norm in the study would measure individual evaluation of the impact of other road users of the same group which is other motorcyclists' behavior in doing risky crossing.
Past Behavior	Past behavior is often added to extend the theory of planned behavior and had been used to explain risky crossing behaviors and has been found to have a high predictive ability (Ajzen, 2011).	Following Tang et al., (2020), Past behavior would measure past risky crossing behavior of motorcyclists in various risky crossing situations.
Familiarity	Road users' familiarity with the crossings is used to predict risky crossing behavior which was measured whether by the frequency of passing certain crossings (Palat et al., 2017) or the knowledge regarding the safety signs on the crossings (Stefanova et al., 2018)	Following Palat et al., (2017), familiarity would be used to measure the frequency of the motorcyclist passing through the crossing both compliantly and not compliantly.

Construct	Description	Relevance to this study
Conformity Tendency	Conformity tendency explains how easy an individual is to be affected by the behavior of people around them who are other road users (Shen et al., 2020).	Conformity tendency in the study would measure how easy the motorcyclists are affected by the behavior of other motorcyclists on railway crossings. However, the construct seems to be similar to descriptive norms and should be further evaluated whether the addition is necessary.
Self-Identity	Self-identity is described as how the riders label themselves whether they are careful riders or not. The addition of self-identity was present in predicting bikers' non-compliant behaviors (Elliott, 2010; B. Watson et al., 2007).	Self-Identity would measure how motorcyclists label themselves whether they are careful riders or not. However, the construct should be further considered because of its similarity with attitude.
Moral Norm	Moral norm represents personal feelings of moral obligations to perform or to refuse a behavior that might be useful for explaining socially undesirable behaviors (Parker et al., 1995).	Moral norm in the study would be defined as personal feelings or moral obligations of motorcyclists regarding non-compliant behavior on railway crossings. However, the use should be further considered regarding its similarities with the previous two norms.
Traffic Environment	Traffic environment represents the individual tendency to perform the behavior in various traffic environments (Satiennam et al., 2018; Shen et al., 2020).	Traffic environment would measure whether facilitating or non-facilitating conditions of the environment such as weather and traffic flow would impact motorcyclists' intention on performing non-compliant behavior at railway crossings.

3.5 Pilot Study Result of Violating Intention on Railway Crossings

A questionnaire is made using TPB construct with items from Palat, et al. (2017), Tang et al. (2020), and Shen et al. (2020). Intention to cross the railway crossing was measured by four 5-scale Likert items in three different situations. Situation 1 is when the alarm and the light went off, situation 2 is when the barrier started to go down, situation 3 is when the gate had closed completely. The respondents to the questionnaire are motorcyclists who passed one of the railway crossings regularly. The two railway crossings studied are level crossing 1 which is located near station and markets with dense traffic, and level crossing 2 which is located near offices in the center of the city with less traffic. The difference of crossing intention across three situations in two different level crossings are summarized as follows. (Table 3)

Table 3. Pilot study on violating intention

	N	Situation 1	Situation 2	Situation 3	Group difference
Total	100	2.62	1.83	1.45	F = 62.48 p = 0.000*
Level crossing 1	50	2.55	1.80	1.48	F = 30 p = 0.000*
Level crossing 2	50	2.70	1.87	1.42	F = 32.35 p = 0.000*
Group difference		F = 0.405 p = 0.526	F = 0.134 p = 0.715	F = 0.094 p = 0.76	

Based on 100 respondents, there was no significant difference on the intention to violate in level crossing 1 and 2, though respondents on level crossing 2 had slightly higher intention on situation 1 and 2, and lower intention on situation 3. However, there were significant differences in intention based on situations. The intention to violate decreases as the gate closed. This pilot study would be interesting to be further studied to understand more the underlying factors that influence violating intention among motorcyclists.

4. Conclusion

Studies about road users' non-compliant behavioral intention on railway crossings had been conducted to explain its underlying factors. Palat et al. (2017) conducted a study based on The Theory of Planned Behavior to predict violations of pedestrians and car drivers on railroad crossings in France. Several factors were found to be significant which were past frequency of crossing, attitude, injunctive norm, and descriptive norm. However, different characteristics of motorcyclists compared to other road users, urge the need for further study about motorcyclists' behavior at railway crossings. Though the study of motorcyclist behavior had been studied in numerous publications, especially in Southeast Asia, the study on railway crossings is still limited and needs to be further studied. Besides the factors of The Theory of Planned Behavior, demographic and environmental factors that were relevant to the railway crossings studied need to be analyzed. Among extended factors that might help predict motorcyclists' intention on violating railway crossings are self-identity, moral norms, and past behavior.

References

Abdul Manan, M. M., Mohamad Khaidir, N., & Mohamed Jamil, H, Factors associated with red-light running among motorcyclists at signalised junctions in Malaysia, *Transportation Research Part F: Traffic Psychology and Behaviour*, *73*, 470–487, 2020

Ajzen, I., The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211, 1991

Ajzen, I., The theory of planned behaviour: Reactions and reflections, *Psychology and Health*, 26(9), 1113-1127, 2011

Ambak, K., Ismail, R., Abdullah, R. A., & Borhan, M. N., Prediction of Helmet Use among Malaysian Motorcyclist Using Structural Equation Modeling. *Australian Journal of Basic and Applied Sciences*, *4*(10), 5263–5270, 2010

Atombo, C., Wu, C., Zhang, H., & Wemegah, T. D., Perceived enjoyment, concentration, intention, and speed violation behavior: Using flow theory and theory of planned behavior. *Traffic Injury Prevention*, *18*(7), 694–702, 2017

Atombo, C., Wu, C., Zhong, M., & Zhang, H., Investigating the motivational factors influencing drivers intentions to unsafe driving behaviours: Speeding and overtaking violations. *Transportation Research Part F: Traffic Psychology and Behaviour*, *43*, 104–121, 2016

ASEANStats, *ASEAN Stats Data Portal*, Retrieved from aseanstats: https://data.aseanstats.org/indicator/ASE.TRP.ROD.B.005, Accessed on April 25, 2022

Barton, B. K., Kologi, S. M., & Siron, A., Distracted pedestrians in crosswalks: An application of The Theory of Planned Behavior. *Transportation Research Part F: Traffic Psychology and Behaviour*, *37*, 129–137, 2016

Bazargan-Hejazi, S., Teruya, S., Pan, D., Lin, J., Gordon, D., Krochalk, P. C., & Bazargan, M., The Theory of Planned Behavior (TPB) and texting while driving behavior in college students. *Traffic Injury Prevention*, *18*(1), 56–62, 2017

Beanland, V., Salmon, P. M., Filtness, A. J., Lenné, M. G., & Stanton, N. A., To stop or not to stop: Contrasting compliant and non-compliant driver behaviour at rural rail level crossings. *Accident Analysis and Prevention*, *108*, 209–219, 2017

Borhan, M. N., Ibrahim, A. N. H., Aziz, A., & Yazid, M. R. M., The relationship between the demographic, personal, and social factors of Malaysian motorcyclists and risk-taking behavior at signalized intersections. *Accident Analysis and Prevention*, *121*, 94–100, 2018

Bosnjak, M., Ajzen, I., & Schmidt, P. The Theory of Planned Behavior: Selected recent advances and applications. *Europe's Journal of Psychology*, Vol. 16, Issue 3, pp. 352–356, 2020

Brewer, N. T., & Rimer, B. K., Perspective on Health Behavior Theories That Focus on Individual. In K. Glanz, B. K. RImer, & K. Viswanath, *Health Behavior and Health Education Theory Research and Practice* (p. 150). San Francisco: Josey-Bass, 2008

Brijs, K., Brijs, T., Sann, S., Trinh, T. A., Wets, G., & Ruiter, R. A. C., Psychological determinants of motorcycle helmet use among young adults in Cambodia. *Transportation Research Part F: Traffic Psychology and Behaviour*, *26*(PA), 273–290, 2014

Chang, H. L., & Yeh, T. H., Motorcyclist accident involvement by age, gender, and risky behaviors in Taipei, Taiwan. *Transportation Research Part F: Traffic Psychology and Behaviour*, *10*(2), 109–122, 2007

Chen, C. F., Personality, safety attitudes and risky driving behaviors-Evidence from young Taiwanese motorcyclists. *Accident Analysis and Prevention*, *41*(5), 963–968, 2009

Chen, H.-Y. W., Donmez, B., Hoekstra-Atwood, L., & Marulanda, S., Self-reported engagement in driver distraction: An application of the Theory of Planned Behaviour. *Transportation Research Part F: Traffic Psychology and Behaviour*, *38*, 151–163, 2016

Demir, B., Özkan, T., & Demir, S., Pedestrian violations: Reasoned or social reactive? Comparing theory of planned behavior and prototype willingness model. *Transportation Research Part F: Traffic Psychology and Behaviour*, *60*, 560–572, 2019

Directorate General of Land Transportation. *Direktur Jenderal Perhubungan Darat No: SK.407/AJ.401/DRJD/2018.*

Elliott, M. A. Predicting motorcyclists' intentions to speed: Effects of selected cognitions from the theory of planned behaviour, self-identity, and social identity. *Accident Analysis and Prevention*, *42*(2), 718–725, 2010

Eren, H., & Gauld, C., Smartphone use among young drivers: Applying an extended Theory of Planned Behaviour to predict young drivers' intention and engagement in concealed responding. *Accident Analysis and Prevention*, *164,* 106474, 2022

Etika, A. A., Merat, N., & Carsten, O., Do drivers differ in their attitudes on speed limit compliance between work and private settings? Results from a group of Nigerian drivers. *Transportation Research Part F: Traffic Psychology and Behaviour*, *73*, 281–291, 2020

Eurostat. *Railway Safety Statistics in the EU*. Retrieved from Eurostat Statistic Explained: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Railway_safety_statistics_in_the_EU Accessed on July 12, 2022

Fallah Zavareh, M., Mohamadi Hezaveh, A., & Nordfjærn, T., Intention to use bicycle helmet as explained by the Health Belief Model, comparative optimism and risk perception in an Iranian sample. *Transportation Research Part F: Traffic Psychology and Behaviour*, *54*, 248–263, 2018

Federal Railroad Administration, *Accident causes*. Retrieved from Federal Railroad Administration Office of Safety Analysis: https://safetydata.fra.dot.gov/OfficeofSafety/publicsite/Query/inccaus.aspx, Accessed on July 12, 2022

Federal Railroad Administration, *Ten Year Accident/Incident Overview*. Retrieved from Federal Railroad Administration Office of Safety Analysis: https://safetydata.fra.dot.gov/OfficeofSafety/publicsite/Query/TenYearAccidentIncidentOverview.aspx, Accessed on July 12, 2022

Gerrard, M., Gibbons, F. X., Houlihan, A. E., Stock, M. L., & Pomery, E. A, A dual-process approach to health risk decision making: The prototype willingness model. *Developmental Review*, *28*(1), 29–61, 2008

Harbeck, E. L., & Glendon, A. I., Driver prototypes and behavioral willingness: Young driver risk perception and reported engagement in risky driving. *Journal of Safety Research*, *66*, 195–204, 2018

Hill, T., Sullman, M. J. M., & Stephens, A. N., Mobile phone involvement, beliefs, and texting while driving in Ukraine. *Accident Analysis and Prevention*, *125*, 124–131, 2019

Indonesia. *UU No. 22 Tahun 2009 pasal 114* .

Jiang, K., Ling, F., Feng, Z., Wang, K., & Guo, L., Psychological predictors of mobile phone use while crossing the street among college students: An application of The Theory of Planned Behavior. *Traffic Injury Prevention*, *18*(2), 118–123, 2017

Jiang, K., Yang, Z., Feng, Z., Yu, Z., Bao, S., & Huang, Z., Mobile phone use while cycling: A study based on The Theory of Planned Behavior. *Transportation Research Part F: Traffic Psychology and Behaviour*, *64*, 388–400, 2019

KAI. *Kedisiplinan rendah, terjadi 198 kecelakaan di perlintasan bidang KA*. Retrieved from KAI: https://www.kai.id/information/full_news/4045-kedisiplinan-rendah-terjadi-198-kecelakaan-di-perlintasan-sebidang-ka Accessed on July 2, 2022

Kementrian Perhubungan Direktorat Jenderal Perkeretaapian, *Buku Statistik Bidang Perkeretaapian Tahun 2019.* Retrieved from https://djka.dephub.go.id/uploads/202006/Tindak_Lanjut_Buku_Statistik_Bidang_Perkeretaapian_Tahun_2019.pdf, Accessed on July 13, 2022

Kim, I., Larue, G., Ferreira, L., Rakotonirainy, A., & Shaaban, K. *Driver Behaviors at Level Crossings from Fixed and Moving Driving Simulators* (E. Shakshuki & A. Yasar, Eds.; Vol. 130, pp. 103–110). Elsevier B.V., 2018

Larue, G. S., Blackman, R. A., & Freeman, J., Frustration at congested railway level crossings: How long before extended closures result in risky behaviours? *Applied Ergonomics*, *82*, 102943, 2020

Larue, G. S., Wullems, C., Sheldrake, M., & Rakotonirainy, A., Validation of a Driving Simulator Study on Driver Behavior at Passive Rail Level Crossings. *Human Factors*, *60*(6), 743–754, 2018

Liang, C., Ghazel, M., Cazier, O., & El-Koursi, E.-M., A new insight on the risky behavior of motorists at railway level crossings: An observational field study. *Accident Analysis and Prevention*, *108*, 181–188, 2017

Liang, C., Ghazel, M., Cazier, O., & El-Koursi, E.-M., Analyzing risky behavior of motorists during the closure cycle of railway level crossings. *Safety Science*, *110*, 115–126, 2018

Ministry of Transportation Republic of Indonesia, *Penutupan Perlintasan KA Sebidang untuk Peningkatan Keselamatan*. Retrieved from Kementrian Perhubungan Republik Indonesia: https://dephub.go.id/post/read/penutupan-perlintasan-ka-sebidang-untuk-peningkatan-keselamatan Accessed on March 12, 2022

Mulvihill, C. M., Salmon, P. M., Beanland, V., Lenné, M. G., Read, G. J. M., Walker, G. H., & Stanton, N. A., Using the decision ladder to understand road user decision making at actively controlled rail level crossings. *Applied Ergonomics*, *56*, 1–10, 2016

Nguyen, D. V. M., Ross, V., Vu, A. T., Brijs, T., Wets, G., & Brijs, K., Exploring psychological factors of mobile phone use while riding among motorcyclists in Vietnam. *Transportation Research Part F: Traffic Psychology and Behaviour*, *73*, 292–306, 2020

Özkan, T., Lajunen, T., Dogruyol, B., Yildirim, Z., & Çoymak, A., Motorcycle accidents, rider behaviour, and psychological models. *Accident Analysis and Prevention*, *49*, 124–132, 2012

Palat, B., & Delhomme, P., What factors can predict why drivers go through yellow traffic lights? An approach based on an extended Theory of Planned Behavior. *Safety Science*, *50*(3), 408–417, 2012

Palat, B., Paran, F., & Delhomme, P., Applying an extended theory of planned behavior to predicting violations at automated railroad crossings. *Accident Analysis and Prevention*, *98*, 174–184, 2017

Parker, D., Manstead, A. S. R., & Stradling, S. G., Extending the theory of planned behaviour: The role of personal norm. *British Journal of Social Psychology*, *34*(2), 127–138, 1995

Piazza, A. J., Knowlden, A. P., Hibberd, E., Leeper, J., Paschal, A. M., & Usdan, S., Mobile device use while crossing the street: Utilizing the Theory of Planned Behavior. *Accident Analysis and Prevention*, *127*, 9–18, 2019

Qaid, H., Widyanti, A., Salma, S. A., Trapsilawati, F., Wijayanto, T., Syafitri, U. D., & Chamidah, N. Speed choice and speeding behavior on Indonesian highways: Extending the Theory of Planned Behavior. *IATSS, 56(2),* 193-199, 2022

Read, G. J. M., Salmon, P. M., Lenné, M. G., & Stanton, N. A., Walking the line: Understanding pedestrian behaviour and risk at rail level crossings with cognitive work analysis. *Applied Ergonomics*, *53*, 209–227, 2016

Reason, J., Manstead, A., Stephen, S., Baxter, J., & Campbell, K., Errors, and violations on the roads: A real distinction? *Ergonomics*, *33*(10–11), 1315–1332, 1990

Satiennam, W., Satiennam, T., Triyabutra, T., & Rujopakarn, W., Red light running by young motorcyclists: Factors and beliefs influencing intentions and behavior. *Transportation Research Part F: Traffic Psychology and Behaviour*, *55*, 234–245, 2018

Shen, X., Zhang, F., Lv, H., Wei, S., & Sun, Z., The application, and extension of The Theory of Planned Behavior to an analysis of delivery riders' red-light running behavior in China. *Accident Analysis and Prevention*, *144*, 105640, 2020

Stefanova, T., Oviedo-Trespalacios, O., Freeman, J., Wullems, C., Rakotonirainy, A., Burkhardt, J. M., & Delhomme, P., Contextual factors explaining risk-taking intentions at Australian level crossings. *Safety Science*, *110*, 145–161, 2018

Susilo, Y. O., Joewono, T. B., & Vandebona, U., Reasons underlying behaviour of motorcyclists disregarding traffic regulations in urban areas of Indonesia. *Accident Analysis and Prevention*, *75*, 272–284, 2015

Tang, T., Wang, H., Zhou, X., Gong, H., & Chen, F. Understanding Electric Bikers' Red-Light Running Behavior: Predictive Utility of Theory of Planned Behavior vs Prototype Willingness Model. *Journal of Advanced Transportation*, *2020*, 7097302, 2020

United Nations Economic and Social Council, *UNITED NATIONS E Economic and Social Council Inland Transport Committee Working Party on Road Traffic Safety Report Of The Working Party On Road Traffic Safety On Its Fifty-Sixth Session*, 2008

Vankov, D., Schroeter, R., & Twisk, D., Understanding the predictors of young drivers' speeding intention and behaviour in a three-month longitudinal study. *Accident Analysis and Prevention*, *151*, 105859, 2021

Watson, B., Tunnicliff, D., White, K., & Schonfeld, C., *ATSB Research and Analysis Report Road Safety Research Grant Report 2007-04 Psychological and social factors influencing motorcycle rider intentions and behaviour*. www.atsb.gov.au, 2007

Watson, I., Ali, A., & Bayyati, A., *Investigation of factors influencing the efficiency of railways in terms of safety at level crossings* (G. Passerini, J. M. Mera, & R. Takagi, Eds.; Vol. 199, pp. 139–149). WITPress, 2020

World Health Organization, *Global Status Report on Road Safety 2018.* Geneva: World Health Organization, 2018

Widyanti, A., Pratama, G. B., Anindya, A. H., Sari, F. P., Sumali, A., Salma, S. A., Yamin, P. A. R., & Soetisna, H. R., Mobile phone use among Indonesian motorcyclists: prevalence and influencing factors. *Traffic Injury Prevention*, 459–463, 2020

Wong, J. T., Chung, Y. S., & Huang, S. H., Determinants behind young motorcyclists' risky riding behavior. *Accident Analysis and Prevention*, *42*(1), 275–281, 2010

Wu, C., Yao, L., & Zhang, K., The red-light running behavior of electric bike riders and cyclists at urban intersections in China: An observational study. *Accident Analysis and Prevention*, *49*, 186–192, 2012

Yang, H., Liu, X., Su, F., Cherry, C., Liu, Y., & Li, Y., Predicting e-bike users' intention to run the red light: An application and extension of The Theory of Planned Behavior. *Transportation Research Part F: Traffic Psychology and Behaviour*, *58*, 282–291, 2018

Zhao, S., & Khattak, A. J., Factors associated with self-reported inattentive driving at highway-rail grade crossings. *Accident Analysis and Prevention*, *109*, 113–122, 2017

Zheng, Y., Ma, Y., Guo, L., Cheng, J., & Zhang, Y., Prediction of Chinese drivers' intentions to park illegally in emergency lanes: An application of The Theory of Planned Behavior. *Traffic Injury Prevention*, *19*(6), 629–636, 2018

Zhou, H., Romero, S. B., & Qin, X., An extension of The Theory of Planned Behavior to predict pedestrians' violating crossing behavior using structural equation modeling. *Accident Analysis and Prevention*, *95*, 417–424, 2016

Zhou, R., Horrey, W. J., & Yu, R., The effect of conformity tendency on pedestrians' road-crossing intentions in China: An application of The Theory of Planned Behavior. *Accident Analysis and Prevention*, *41*(3), 491–497, 2009

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