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Article

Drivers' Speeding Behavior in Residential Streets: A Structural Equation Modeling Approach

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Abstract: Speeding in residential areas is a rampant high-risk driving behavior that occurs worldwide. This study investigated the intention and behavior of speeding in residential streets (with a speed limit of 30 km/h) in Iran based on the Theory of extended Planned Behavior (TPB). A total of 480 participants filled out the TPB-based questionnaire online. Nine different factors were identified by exploratory factor analysis. The interrelationship of these factors, as well as their connection with speeding intention and behavior, was analyzed using the Structural Equation Modeling (SEM) method. The results suggested that the adoption of the extended TPB framework to identify factors related to speeding in residential areas was effective in predicting speeding intention and behavior. Affective attitude, descriptive and personal norms, perceived behavioral control, habits, and specification of residential streets were direct predictors of speeding intention. The intention was also strongly associated with speeding behavior in residential areas, serving as the only factor that directly predicts speeding behavior. The two factors of specification and facilities were also significantly related to speeding behavior on residential streets. The results of this study can have positive implications for preventing and reducing crashes on residential streets.

Keywords: residential streets; speeding behavior; theory of planned behavior; 30 km/h speed limit; structural equation model

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1. Introduction

According to the World Health Organization (WHO), road accidents are the eighth leading cause of death in the world, and about 1.35 million people die annually in car accidents worldwide. According to WHO's report in 2018, one person dies every 24 s on the roads around the world, and traffic crashes are the leading cause of death in the age group of 5 to 29 years. The report also says that the share of road casualties per 100,000 people is only 2.49 in Sweden, 2.81 in the Netherlands, and 3.54 in Germany. The figure rises to 5.74 in New Zealand, 8.85 in Turkey, and 10.04 in the United States [1].

In Iran, this number is 32.30, which indicates the staggering rate of traffic fatalities in Iran [1]. According to statistics reported on the Iranian Forensic Medicine website, more than 17,183 people died in traffic accidents in 2018, which indicates a 1.2% growth compared to 2017. In addition, road traffic injuries (367,451) show a 9.4% surge compared to the same year [2]. In Iran, the road traffic death rate is a grave problem that calls for an effective solution [3].

Today, the rising rate of road crashes in residential streets poses a threat to urban communities, which can severely affect the health of residents in these areas. A major reason for this rising trend of road crashes in urban areas is the violation of traffic laws, especially speeding [4,5]. Speeding is a key factor associated with the severity of accidents, accounting for about 75% of deaths in road traffic accidents [6]. Shams and Rahimi-Movaghar (2009) concluded that high-risk behaviors are an underlying cause of road accidents in Iran [7]. According to another study, about 70% of Iranian drivers reported having committed speeding at some point, and high-risk behaviors are an underlying cause of road accidents in Iran [3]. In addition, about 70% of Iranian drivers reported having committed the offense of driving faster than the legal limit at some point [8].

Speeding is a critical factor in road crashes [9,10]. A speed limit of 30 km/h has been introduced for urban residential areas to ensure traffic safety and protect citizens [11]. The rationale behind the speed limit of 30 km/h is that pedestrians have a 90% chance of survival when struck by a vehicle traveling at a speed of 30 km/h. In contrast, only 20% of people would survive such a collision with a vehicle traveling at a speed of 50 km/h [12]. Studies have shown that the risk of death in pedestrians struck by a motor vehicle traveling at 50 km/h is two-fold and four-fold higher than the risk of death in a pedestrian struck by the same vehicle moving at a speed of 40 km/h and 30 km/h, respectively [13–18].

However, despite extensive efforts to reduce the speed of vehicles, speeding in residential areas is still fairly common, and the rate of exceeding the 30 km/h speed limit is significantly higher in residential areas than in urban arterial streets and non-urban roads [11,12]. This is particularly important as pedestrians and cyclists often have to share the streets with motor vehicles, which exposes them to high-risk crashes [19]. Therefore, it is essential to investigate the causes of speeding by examining the speeding intention and behaviors of drivers in residential areas.

Research on the speeding behavior of drivers has rarely explored driver behavior in residential areas, especially in this region. The primary objective of the current study is to investigate the speeding behavior of drivers in residential areas (30 km/h speed limit) using the extended theory of planned behavior. This study was conducted for the first time in Iran and Qazvin city with nine variables regarding the intention and behavior of illegal speeding. In addition to the TPB-based variables and other related factors reported in the literature, this study introduced two new context-based variables, which are street specification and street facilities. By adding the two variables of street specification (traffic calming strategies such as speed bumps, speed cameras, etc.) and street facilities (examining the impact of street quality levels, for example, pavement quality, street width, etc.), this study seeks to show that whether these two new variables have a significant relationship with the intention and behavior speeding or not.

2. Theoretical Background

2.1. Theory of Planned Behavior (TPB)

As a model of social psychology, the TPB states that people's behavior is driven by their intention [20]. TPB, which itself is a continuation of the theory of rational action (TRA) [21], is now widely regarded as one of the best predictors of behavior. According to this theory, intention is predicted by three variables of attitude, subjective norms, and perceived behavioral control (PBC). Attitude makes a positive or negative evaluation of a particular behavior. The subjective norm explains the perceived pressure or expectation from others to perform a specific behavior. Finally, the PBC indicates the extent to which certain behavior is controlled by one's voluntary decision. These three factors directly predict intention, which is the cornerstone of the TPB model. Intention and sometimes PBC directly predict behavior [20].

The TPB model has been widely used in various studies to predict people's behavior, including research on preventive care [22,23], education [24,25], marketing [26,27], and transportation [28,29]. The TPB model has been adopted in many research studies on intentional driving violations, including studies on speeding and overtaking [30], cell phone use while driving [31], and drowsy driving [32].

The research on driving behavior has partially looked into the speeding behavior of drivers, with the goal of exploring speeding behavior under various conditions [11,33,34]. This factor underlines the fact that the TPB is well-suited to study the speeding behavior of drivers.

2.2. Modified Theoretical Framework of the TPB

From the time the TPB model began to deal with issues such as speeding behavior, a number of novel and recent models have been formulated to justify speeding behavior within the framework of this theory. The results of studies such as Manstead and Parker (1995), which investigated the speeding behavior within TPB theory, revealed that factors such as attitude, subjective norm, and PBC could not sufficiently justify and predict speeding behavior [35]. Thus, while some researchers strived to demonstrate the efficiency of this theory [36,37], others were developing the TPB theory to include new factors or offer a better explanation for behaviors [22,38]. The development of TPB was also reflected in speeding behavior so that more exhaustive models with a greater number of factors are concluding about speeding behavior [33].

2.2.1. Dimensions of Attitudinal and Normative Components of TPB

In previous studies, attitude had been treated as a single concept, but more recent studies suggest that attitude is composed of two parts: instrumental (cognitive) attitude and emotional (affective) attitude. The bulk of studies on this subject confirms the discriminant validity of the two variables of cognitive and affective attitudes [33,38–41]. In addition, both concepts of affective and cognitive attitude may separately predict intention and, subsequently, speeding behavior [39]. It is because an effective attitude embraces the range of emotions that the object of attitude evokes in an individual, and cognitive attitude deals with information that a person has about a particular subject.

Previous research has also made references to the duality of social impacts. Many studies have shown that the subjective norm is a weaker predictor of attitude and PBC for intention and behavior [42,43]. In this regard, several past studies reported that drivers' behavior is imitated on the road [44,45], which was then called the descriptive norm [46]. Rivis and Sheeran (2003) reviewed 14 other studies, finding that the descriptive norm is a stronger predictor than the subjective norm [47]. In recent research on speeding behavior, descriptive norms have been adopted besides subjective norms [11,33,34,37–39]. In this study, both subjective and descriptive norms have been used to explain speeding behavior.

2.2.2. Other Predictor Variables

A habit is one of the factors incorporated in the TPB model, which wields a huge influence on studies on speeding behavior. In former studies, a habit was referred to as past behavior. Wttenbraker et al. and Rothengatter concluded that habit formation based on past behavior could bridge the gap between attitude and behavior variables [48,49]. In many studies on speeding behavior, the presence of past behavior or habit variables is evident [11,33,38,39]. De Pelsmacker and Janssens concluded that habit is a strong predictor of speeding intention, which also directly and strongly predicts speeding behavior [38]. Jovanović et al. also concluded that habit mediates the relationship of attitude, subjective norms, and PBC with speeding intention [33].

Another variable that can directly affect intention is the personal norm, which was formerly called the moral norm [39]. Personal norms can be described as moral values that are important to people, and they are committed to upholding these values [46]. Many studies have also disclosed marked differences between subjective, descriptive, and personal norms, stating that personal norms can be a separate predictor of speeding intention [33,34,38]. Today, in studies on speeding behavior, personal norms are a major and strong predictor of speeding behavior. For example, Jovanović et al. concluded that personal norms are a stronger predictor of speeding behavior compared to subjective and descriptive norms [33].

Finally, infrastructure-related factors should be mentioned, which were first introduced in the study of Watthanaklang and Ratanavaraha as another important variable added to the TPB model [50]. Given that the impact of factors related to street infrastructure has not been investigated in driving behavior research from a statistical perspective, in this research, the effect of these variables on the intention and behavior of driving at high speed will be investigated.

By incorporating the variable of street facilities in TPB theory, this study seeks to demonstrate that traffic-calming strategies (such as speed bumps, speed cameras, etc.) may affect speeding intention and behavior in residential streets. If they can curb speeding intention and behavior in residential areas, drivers can be persuaded to drive at a speed of 30 kph by providing these strategies. Moreover, the effect of specification on speeding intention and behavior in residential streets was investigated by examining the effect of street quality level (e.g., pavement quality, street width, etc.) on driving speed.

2.3. Present Study

Residential streets describe a road that provides access to adjoining residential properties and navigates local traffic. Since residential streets are the place for pedestrians' commutes and cyclists, who have to use the streets along with motor vehicles, they are of great importance [11]. Hence, the speed limit on residential streets in most parts of the world, including Iran, is set to 30 kph. This reflects the special importance of these streets, especially in Iran, which has a high rate of traffic-related accidents [51]. To date, studies have investigated speeding behavior in various fields, such as the speeding behavior in motorcyclists [52,53], speeding behavior in young drivers [54–56], and speeding behavior on non-urban roads [33,57]. In addition, recent studies have shown how the habit and behavior of drivers can be effective in the accidents of drivers with pedestrians in urban and rural streets [58,59]. Therefore, the habit and behavior of drivers to speeding behavior, especially, has become a serious and dangerous concern in local and residential streets. However, very few investigations have delved into the behavior of drivers on residential streets. Hence, it is one of the subjects that is worth further discussion.

3. Materials and Methods

3.1. General Methodological

This research was a descriptive-analytical survey study that used the content analysis method to answer the main research question. In addition, the sampling method in this research is probable non-random, and the questionnaire method was used to collect the necessary information.

3.2. Questionnaire Design

To achieve this study's goals, the questionnaire's main goal was to discover factors that provoke drivers to exceed the legal speed limit of 30 km/h. Therefore, informed by the research background and the literature, a host of questions were collected in a broad framework of factors that measure speeding intention and behavior in the form of an extended version of TPB. Then, the initial list of questionnaire items was designed. Afterward, all questions were reviewed by five experts in the field of transportation safety, and necessary adjustments were made. Finally, the wording of the questions was revised to ensure their transparency and clarity. After the above steps, a pilot study was carried out on 34 individuals with a driver's license, who were asked to read the questions and single out items that were ambiguous so that any lingering opacities in the questions could be resolved. Finally, the research questionnaire was formulated with 57 items to be used for data collection.

The questionnaire was divided into three general sections: The first part contained demographic questions and general information such as gender, age, year of obtaining the driver's license, driving experience, number of accidents and police stops in the last three years, and the main purpose for which they often used the car.

The second part of the questionnaire describes the research scenario as follows. "Now, to answer the questions, imagine a situation where you are driving on a residential street with a speed limit of 30 km/h. You are driving at 11 am, and the weather is sunny and clear. Whenever in the questionnaire the word "speed" is mentioned, we mean driving over 30 km/h."

Finally, the third part of the questionnaire comprised questions about the theoretical factors of planned behavior, which was the most important part of the questionnaire. This part is explained in the next section.

3.3. Procedure

The main data collection instrument adopted in this study was a questionnaire. Before conducting the main survey, a pilot survey was conducted to gain feedback and make necessary revisions. The data derived from the pilot study were not included in the final analysis. After reviewing and making necessary modifications, the official survey was conducted online from early May to early June 2020 using an online website dedicated to online surveys (Porsline). Online questionnaires have many benefits, including cost-effectiveness, data collection from across the target community, ease of access, etc.

The online survey was distributed to social network groups through social network channels (channels and groups in virtual space whose members were citizens of Qazvin), and they were asked to complete the questionnaire carefully if they met the conditions to enter the study. At the beginning of the questionnaire, the subjects were informed of the criteria required to fill out the questionnaire (having a driver's license, driving experience, and residency in Qazvin). They were also reassured that no personal information was required and the data were only intended for research analysis. Then, the research scenario was clearly explained to participants to make them familiar with the questionnaire sections so that they would answer the questions meticulously. In addition, to encourage participants to complete the questionnaire, 20 participants were randomly awarded a specific gift (T-shirts with the sign 30 km/h).

3.4. Participants

Out of 1222 people who accessed the online questionnaire, 536 completed the questionnaire. After further review and elimination of participants with incomplete data (leaving out one or more questions) or participants with the same score for all items, 480 questionnaires were included in the final analysis. The study sample consisted of 67.1% male drivers and 32.9% female drivers in the age range of 18 to 71 years. A high percentage of drivers (45%) had been stopped by the traffic police once or twice in the last three years, and 41% of drivers had been involved in a traffic crash at least once in the last three years. The participants chiefly used private vehicles for reasons such as commuting to and from work (45%) and, to a lesser extent, touring the city for recreation (20.6%). Descriptive statistics of demographic and driving-related variables are shown in Table 1.

Table 1. Descriptive statistics of demographic and driving-related variables.

No	Variable	Categories	Frequency	Percent (%)
1	Gender	Male	322	67.1
		Female	158	32.9
2	Age	<20	15	3.1
		20s	278	57.9
		30s	122	25.4
		40s	49	10.2
		>49	16	3.4
3	Duration of obtaining a driver's license	Less than three years	130	27.1
		More than three years	350	72.9
4	Duration of driving experience	Less than three years	163	33.9
		More than three years	317	66.1
5	Experience of a car accident as a driver in the last three years	Yes	197	41
		No	283	59
6	Stopped by traffic police in the last three years	Yes	216	45
		No	264	55
7	Most common purpose of car usage	Commuting to and from work	216	45
		Touring the city for recreation	99	20.6
		Otherwise	165	34.4

3.5. Questionnaire Measures

Standard items typically used to measure extended TPB structures are reviewed in this section. In the present study, all items, including those related to self-reported intention and behavior, were measured directly and ranked on a 5-point Likert scale.

3.5.1. Affective Attitude

Affective attitudes toward speeding were assessed by 6 items (for example, "driving 10 km/h over the speed limit on residential streets is more enjoyable for you"). Respondents rated their responses on a 5-point Likert scale, from 1 (strongly disagree) to 5 (strongly agree) (Cronbach's alpha = 0.90).

3.5.2. Cognitive Attitude

Cognitive attitude toward speeding was evaluated by 3 items (for example, "Driving 10 km/h over the speed limit posted on residential streets saves time"). Responses were scored on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree) (Cronbach's alpha = 0.81).

3.5.3. Subjective Norm

The subjective norm of speeding was assessed by 6 items (for example, "My children/parents think I must comply with the speed limit on residential streets"). Responses were measured on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) (Cronbach's alpha = 0.83).

3.5.4. Personal Norm

The personal norm of speeding was assessed by 5 items (for example, "If I drive 10 km/h over the speed limit posted on residential streets, I have done something wrong"). Respondents rated their answers on a 5-point Likert scale, from 1 (strongly disagree) to 5 (strongly agree) (Cronbach's alpha = 0.89).

3.5.5. Descriptive Norm

The descriptive norm of speeding was assessed by four items (for example, "People who matter to me do not respect the speed limit (30 km/h) on residential streets"). Responses were rated on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree) (Cronbach's alpha = 0.79).

3.5.6. Perceived Behavior Control (PBC)

The PBC was assessed by 5 items (for example, "It is difficult to observe the speed limit of 30 km/h on residential streets when there is no car in front of you"). Respondents rated their responses on a 5-point Likert scale, from 1 (strongly disagree) to 5 (strongly agree) (Cronbach's alpha = 0.79).

3.5.7. Habit

Speeding habits were evaluated by 5 items (for example, "Driving at high speeds on residential streets is something I do subconsciously"). Responses were ranked on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree) (Cronbach's alpha = 0.88).

3.5.8. Facilities

The impact of available/unavailable facilities on speeding in residential areas was assessed by four items (for example, "Speed cameras on residential streets force me to observe the speed limit"). Respondents rated their responses on a 5-point Likert scale, from 1 (strongly disagree) to 5 (strongly agree) (Cronbach's alpha = 0.79).

3.5.9. Street Specification

The effect of street specification on speeding was evaluated by 3 items (for example, "The quality of the street pavement affects my driving speed"). Respondents rated their responses on a 5-point Likert scale, from 1 (strongly disagree) to 5 (strongly agree) (Cronbach's alpha = 0.82).

3.5.10. Speeding Intention

The speeding intention was assessed by 2 items. The first question was similar to this, "How likely are you to drive 10 km/h over the speed limit posted on a residential street during the next two weeks?" were rated on a 5-point Likert scale, from 1 (very unlikely) to 5 (very likely). The second question was, "How many times do you think you would drive 10 km/h over the speed limit posted on residential streets during the next two weeks?" The answers were rated on a 5-point Likert scale, from 1 (very few) to 5 (a lot) (Cronbach's alpha = 0.80).

3.5.11. Self-Reported Speeding Behavior

Speeding behavior was evaluated by 3 items (for example, "Do you generally exceed the speed limit of 30 km/h in residential areas?"). Respondents rated their responses on a 5-point Likert scale from 1 (never) to 5 (always) (Cronbach's alpha = 0.87).

The extended TPB model was used for data analysis. Exploratory factor analysis (EFA) and zero-order correlation were performed using SPSS 24 software. The model was drawn and fitted by the IBM SPSS Amos 24 software.

4. Results

First, all questionnaires with missing questions were omitted. Then the KMO test was performed on the samples. KMO and Bartlett's test are methods used to ensure the adequacy of the selected sample in exploratory factor analysis (EFA). The significance of the information in a matrix is calculated through chi-square and Bartlett tests. The significance of these two tests is the minimum necessary condition to perform factor analysis. In Bartlett's test, the null hypothesis is that the variables are correlated only with themselves, and the rejection of the null hypothesis indicates that the correlation matrix has significant information and the minimum conditions necessary to perform factor analysis are present [60]. In general, if the result of Bartlett's test is significant at the 95% level and above, and the numerical value of KMO is greater than 0.6, the data are suitable for factor analysis [61]. Following the EFA and calculation of Cronbach's alpha, four items were removed, and the total number of questions was dropped to 53. The following results were obtained from EFA.

According to Bartlett's test of sphericity, $x^2 = 10285.85$ was estimated at a significance level of $p < 0.001$. The value of the KMO index was estimated at 0.9, which indicated the adequacy of the sample size for factor analysis. The KMO index was also calculated separately for each factor (0.6 for all factors). According to Tabachnick et al. (2007), this is the minimum acceptable value for confirming KMO [62].

All questions, except those related to speeding intention and behavior, were included in EFA. According to the Kaiser criterion, there were nine factors with eigenvalues greater than one, which explained 65.98% of the common variance. To ensure the number of exploratory variables, the scree diagram was also examined, and the results yielded nine different factors with eigenvalues above one. Hence, these nine factors were retained in the research for further analysis. Then, using oblique correlated Promax rotation and setting the absolute value of factor loading to 0.4, the desired and expected outcomes were obtained. These variables, based on the content of questions, include affective attitude, subjective norm, cognitive attitude, habit, personal norm, PBC, descriptive norm, specification, and facilities. Factor loadings of all the items are shown in Table 2.

Table 2. Results of factor analysis with Direct Oblimin rotation (N = 480).

Item	Rotated Factor Loadings								
	Affective Attitude	PBC	Subjective Norm	Personal Norm	Facilities	Descriptive Norm	Habit	Specifications	Cognitive Attitude
Driving fast with the 10 km/h more than speed limit in the residential street gives you a sense of excitement.	0.78	0.02	−0.11	−0.01	0.04	0.02	0.01	0.08	−0.02
Driving fast with the 10 km/h more than speed limit in the residential street gives you energy.	0.81	−0.02	−0.04	−0.04	0.02	0.05	−0.08	0.05	−0.02
Driving fast with the 10 km/h more than speed limit in the residential street gives you self-confidence.	0.85	0.02	−0.03	−0.04	−0.05	0.02	0.00	0.00	0.04
Driving fast with the 10 km/h more than speed limit in the residential street makes you feel independent and free.	0.83	0.02	0.11	0.12	−0.02	−0.04	0.01	0.00	0.01
Driving fast with the 10 km/h more than speed limit in the residential street will fun you.	0.77	−0.06	0.09	−0.03	0.01	−0.04	0.00	−0.08	0.02
Driving fast with the 10 km/h more than speed limit in the residential street for you enjoyable.	0.74	−0.09	0.07	−0.06	0.02	−0.01	−0.08	−0.02	−0.03
My best friends think that I should respect the speed limit in residential streets (reverse coded).	0.04	−0.08	0.69	0.02	−0.03	−0.04	−0.06	0.02	−0.12
My colleagues think that I should respect the speed limit in residential streets(reverse coded).	−0.10	−0.02	0.77	0.00	−0.05	−0.05	−0.07	−0.05	−0.04
My children/parents think that I should respect the speed limit in residential streets(reverse coded).	0.07	0.05	0.79	0.00	−0.03	0.00	0.09	0.00	−0.01
My passengers think that I should respect the speed limit in residential streets (reverse coded).	−0.01	−0.07	0.83	−0.08	0.01	−0.01	0.04	−0.04	0.03
Most people that are important to me think that I should respect the speed limit in residential streets (reverse coded).	0.08	0.02	0.82	0.02	−0.02	−0.03	0.04	−0.07	−0.02
Pedestrians and cyclists encourage drivers who respect the speed limits on residential streets (reverse coded).	0.01	0.12	0.41	−0.12	0.19	0.05	−0.15	0.20	0.13
Driving fast with the 10 km/h more than speed limit in the residential streets enables you to overtake other vehicles more easily.	0.08	−0.08	0.13	0.06	0.04	−0.06	−0.13	0.15	−0.58
Driving fast with the 10 km/h more than speed limit in the residential streets enables you to arrive at your destination more quickly.	0.02	−0.16	0.06	−0.14	0.04	0.05	−0.15	0.14	−0.68
Driving fast with the 10 km/h more than speed limit in the residential streets enables you to save time.	0.12	−0.12	−0.01	−0.08	−0.01	−0.02	−0.09	0.14	−0.68

Table 2. *Cont.*

Item	Rotated Factor Loadings								
	Affective Attitude	PBC	Subjective Norm	Personal Norm	Facilities	Descriptive Norm	Habit	Specifications	Cognitive Attitude
Driving fast in the residential streets range is something I do automatically.	0.10	0.03	−0.09	−0.12	−0.01	−0.18	−0.58	−0.07	−0.23
Driving fast in the residential streets range is something I do without consciously remembering doing so.	−0.01	−0.03	−0.03	−0.11	0.07	−0.04	−0.75	0.04	0.03
Driving fast in the residential streets range is something I do without thinking.	−0.01	0.00	0.02	0.07	−0.05	0.01	−0.88	−0.06	−0.05
Driving fast in the residential streets range is something I start doing before I realize I'm doing it.	0.06	−0.11	0.05	0.01	−0.03	0.03	−0.81	−0.02	0.05
Driving fast in the residential streets range is something I do this all the time.	0.16	0.01	0.02	−0.07	−0.04	−0.10	−0.60	−0.03	−0.15
If I exceeded the speed limit (30 km/h) with more than 10 km/h in the residential streets, I would regret it afterwards (reverse coded).	−0.02	−0.03	0.04	−0.77	0.04	0.02	−0.06	0.06	−0.03
I would feel guilty if I exceeded the speed limit with more than 10 km/h in the residential streets (reverse coded).	−0.07	−0.11	0.01	−0.86	0.06	0.00	0.04	0.05	0.07
Exceeding the speed limit with more than 10 km/h in the residential streets violates my principles (reverse coded).	0.05	−0.02	0.06	−0.83	−0.07	0.01	−0.02	−0.04	0.02
If my speed 10 km/h exceeds the speed limit in residential streets, I would have done the wrong thing (reverse coded).	0.07	0.12	−0.02	−0.76	−0.07	−0.04	−0.01	−0.09	−0.09
If my speed 10 km/h exceeds the speed limit in residential streets, I feel really bad (reverse coded).	0.03	0.00	−0.01	−0.86	0.02	−0.01	0.00	0.00	−0.01
It is difficult to observe the speed limit 30 km/h on residential streets when you are really in a hurry.	−0.08	−0.75	0.01	−0.04	0.06	−0.03	0.04	0.04	−0.03
It is difficult to observe the speed limit 30 km/h on residential streets while driving on a good road (e.g., straight, wide).	0.07	−0.75	−0.01	−0.01	0.03	−0.09	0.02	−0.14	−0.12
It is difficult to observe the speed limit 30 km/h on residential streets when you are excited or nervous.	0.04	−0.69	0.00	0.04	0.01	0.02	−0.08	0.1	0.08
It is difficult to observe the speed limit 30 km/h on residential streets when all others drive too fast.	0.00	−0.64	0.03	0.04	−0.07	0.07	−0.08	0.02	−0.04

Table 2. *Cont.*

	Rotated Factor Loadings								
Item	**Affective Attitude**	**PBC**	**Subjective Norm**	**Personal Norm**	**Facilities**	**Descriptive Norm**	**Habit**	**Specifications**	**Cognitive Attitude**
It is difficult to observe the speed limit 30 km/h on residential streets when you do not have a car in front of you.	0.14	−0.64	−0.01	−0.13	−0.07	−0.11	−0.01	−0.01	−0.05
My best friends don't respect residential streets speed limit (30 km/h).	−0.01	−0.02	0.02	−0.07	−0.02	−0.79	−0.02	−0.03	−0.06
My colleagues don't respect residential streets speed limit.	−0.02	0.05	0.02	−0.03	−0.02	−0.88	0.01	−0.01	−0.06
Other drivers(taxi drivers, Neighbors, acquaintances,...) don't respect residential streets speed limit.	−0.03	−0.13	0.04	0.09	0.13	−0.65	−0.04	0.12	0.26
People who are important to me don't respect residential streets speed limit.	0.06	0.02	0.01	0.00	−0.09	−0.69	−0.05	0.04	−0.05
The presence of speed-monitoring cameras on local and residential streets It causes me to observe the limit of speed (reverse coded).	−0.01	0.10	0.02	0.03	0.44	0.02	0.10	−0.26	−0.31
The presence of bump on local and residential streets It causes me to observe the limit of speed (reverse coded).	0.10	0.13	0.01	−0.02	0.73	−0.07	0.1	−0.12	−0.11
The presence of spiraling streets on local and residential area It causes me to observe the limit of speed (reverse coded).	−0.05	−0.04	−0.06	−0.02	0.89	0.03	−0.04	0.05	0.04
Narrowing parts of the streets on local and residential area It causes me to observe the limit of speed (reverse coded).	−0.04	−0.08	−0.01	0.05	0.84	0.04	−0.02	−0.07	0.05
The quality of surface of the street has an impact on Increasing my speed.	0.04	0.06	−0.06	0.13	−0.10	−0.03	−0.07	0.75	−0.1
The width of the street has an impact impact on Increasing my speed.	0.03	−0.10	0.01	−0.06	−0.06	0.02	0.10	0.82	−0.07
Driving on smooth and straight streets has an impact on Increasing my speed.	0.04	−0.02	−0.03	−0.07	−0.06	−0.13	0.03	0.80	−0.08
Eigenvalues	10.32	3.98	2.66	2.51	2.24	1.64	1.37	1.28	1.05
% of variance	25.17	9.71	6.48	6.12	5.47	4.00	3.34	3.11	2.57
Cronbach's alpha	0.90	0.79	0.83	0.89	0.79	0.79	0.88	0.82	0.81

The internal consistency of the questionnaire and factor questions was determined by Cronbach's alpha. For all factors, the results ranged from 0.787 to 0.902 (as shown in Table 2). According to Kline and Raykov, who proposed a minimum acceptable rate of 0.7 for Cronbach's alpha internal consistency, the internal consistency of all variables (and the questionnaire) was fairly high [63,64].

Before conducting the structural equation modeling (SEM), the relationship between the model's components was investigated using zero-order correlation. The correlation matrix could be seen as a basis for causal analysis. Table 3 depicts the positive and significant relationship between the factors.

Table 3. Descriptive statistics and zero-order correlation between model structures.

	Predictors	M	SD	1	2	3	4	5	6	7	8	9	10	11
1	Affective Attitude	1.91	1.12	-										
2	Cognitive Attitude	2.63	1.26	0.54 *	-									
3	Subjective Norm	2.50	1.11	0.29 **	0.25 **	-								
4	Habit	2.53	1.27	0.57 **	0.57 **	0.29 **	-							
5	Personal Norm	2.53	1.24	0.30 **	0.35 **	0.34 **	0.40 **	-						
6	PBC	3.33	1.19	0.30 **	0.44 **	0.15 **	0.44 **	0.22 **	-					
7	Descriptive Norm	2.92	1.13	0.29 **	0.29 **	0.29 **	0.40 **	0.17 **	0.36 **	-				
8	Facilities	2.62	1.33	−0.16 **	−0.08	0.07	−0.14 **	0.03	0.18 **	−0.14 **	-			
9	Specifications	3.6	1.2	0.26 **	0.30 **	0.05	0.29 **	0.10 *	0.35 **	0.25 **	−0.44 **	-		
10	Intention	2.77	1.22	0.48 **	0.48 **	0.20 **	0.56 **	0.36 **	0.42 **	0.45 **	−0.14 **	0.34 **	-	
11	Behavior	2.4	1.18	0.53 **	0.49 **	0.28 **	0.64 **	0.44 **	0.42 **	0.45 **	−0.14 **	0.29 **	0.74 **	-

Attention: * $p < 0.05$; ** $p < 0.01$.

The results listed in Table 3 illustrate that there is a positive/negative but significant relationship between all factors and speeding intention/ behavior in residential areas. Among these factors, the strongest relationship was observed between speeding intention and behavior in residential areas.

In the next step, informed by the TPB and literature in this field, a hypothetical model was developed within the TPB framework in Amos software. The final model is shown in Figure 1.

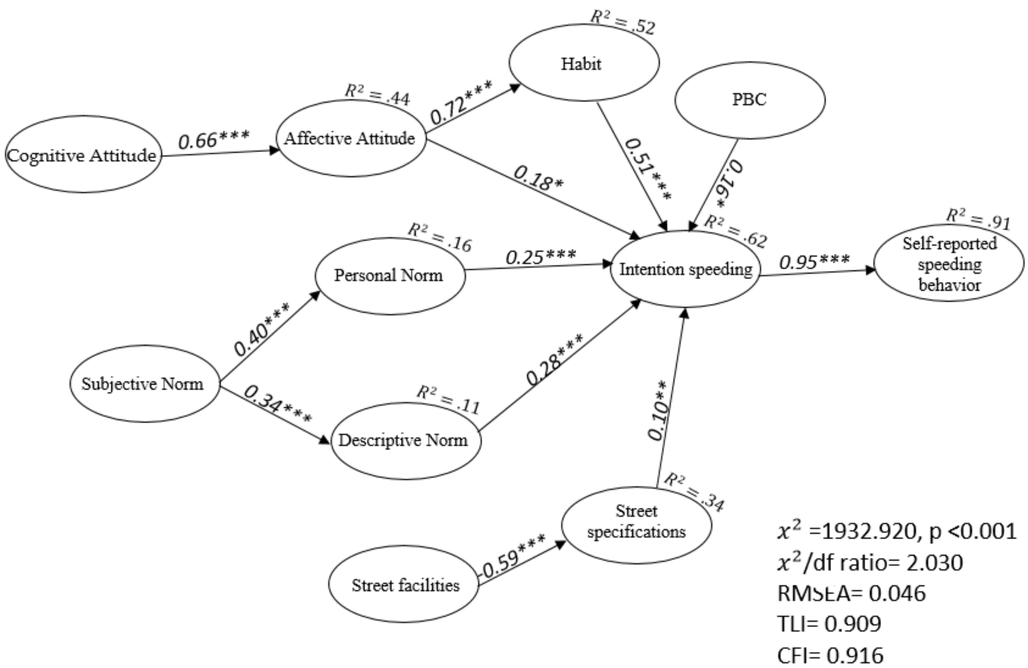

Figure 1. Speeding behavior model in reduced form. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

The analysis of fit indices suggests that the proposed model is adequately fit. The Tucker–Lewis index (TLI) and comparative fit index (CFI) were estimated at 0.909 and 0.916, respectively. These values are higher than the minimum value (0.9) set for a desirable model [63]. In addition, the root mean square error of approximation (RMSEA) value for the proposed model was 0.046, while some sources have reported values below 0.07 [65] and 0.06 [63] as the accepted range for good fitness of the model. Moreover, the value of x^2/df was 2.030, which is acceptable considering that its maximum value is three [66].

According to the model, the coefficient of determination for speeding behavior in residential areas is 91%. This indicates that 91% of variations in speeding behavior (dependent variable) could be explained by independent variables. In addition, as indicated by the model, all standard path coefficients reveal the direct effects of all latent variables. According to the model, subjective norms are a predictor of the descriptive norm and personal norm factors, and cognitive attitude is directly related to affective attitude. In addition, there is a strong direct relationship between affective attitude and habit. The facilities in a residential street are also inversely related to the specification of residential streets.

The only factor that was directly related to self-reported speeding behavior was speeding intention (β = 0.95, $p < 0.001$). The latent variable of speeding intention had a coefficient of determination of 62%. The analysis of standardized path coefficients between other factors and the speeding intention suggested that habit was significantly related to the intention (β = 0.51, $p < 0.001$). Descriptive norm (β = 0.28, $p < 0.001$), personal norm (β = 0.25, $p < 0.001$), affective attitude (β = 0.18, $p < 0.05$), PBC (β = 0.16, $p < 0.05$), and specification of residential streets (β = 0.10, $p < 0.01$) were other latent variables in the model of speeding behavior in residential areas that demonstrate a significant relationship with the speeding intention.

The indirect effects of affective attitude (β = 0.52, $p < 0.001$), habit (β = 0.49, $p < 0.001$), subjective norm (β = 0.18, $p < 0.001$), cognitive attitude (β = 0.35, $p < 0.001$), personal norm (β = 0.23, $p < 0.001$), descriptive norm (β = 0.27, $p < 0.001$), residential street facilities (β = −0.06, $p < 0.05$), PBC (β = 0.15, $p < 0.01$) and residential street specification (β = 0.10, $p < 0.05$) on self-reported speeding behavior is significant but not all of this relationship is strong. All of these factors were only indirectly associated with speeding behavior through speeding intention.

Given the general effects of various factors on speeding behavior, the results show that the major factors explaining speeding behavior are affective attitude, habit, and cognitive attitude, followed by the descriptive norm and personal norm.

5. Discussion

Many traffic fatalities that occur on urban roads are caused by speeding [67]. This study aimed to identify factors associated with exceeding the speed limit of 30 km/h in residential areas and the predictive validity of an extended TPB model was tested for speeding behavior on residential streets.

The results of this study showed that speeding intention is the main predictor of speeding behavior, which mediates the association between other factors and self-reported speeding behavior. According to the proposed model, the only factor that directly contributes to speeding behavior in residential areas is speeding intention. The model formulated in this study combines simpler models [34,39] with more developed models [33,38] of speeding behavior and introduces a new form of a speeding behavior model.

In the present study, there was a clear distinction between the factors of affective attitude and cognitive attitude. In EFA, affective and cognitive attitudes were radically different from each other [33,39]. Moreover, in the CFA, the variables of affective attitude are more important than cognitive attitude in predicting speeding intention and behavior [39]. In other words, drivers who hold a positive affective attitude toward speeding are more likely to drive at higher speeds in residential areas, but this association is weaker in cognitive attitudes. From a broader perspective, this reflects that affective attitude is more important than cognitive attitude [68].

The findings of this study also showed a marked difference between subjective norm and descriptive norm. It is because subjective norms discuss the perceived social pressure to perform or avoid certain behavior, but descriptive norms elaborate on the effects that other users and important people may exert on drivers [34]. In addition, in the present study, the descriptive norm had a stronger effect than the subjective norm on speeding behavior, which is consistent with previous studies [39,47].

Another important variable that is widely employed in TPB studies is the personal norm. The results showed a significant relationship between personal norms and speeding behavior in residential areas, which is aligned with the findings of previous studies on speeding behavior [33,34]. The findings also suggest that personal norms act independently of descriptive and subjective norms because subjective and descriptive norms are inspired by external and environmental issues, and they evaluate the impact of the environment on an individual; however, personal norms are internally driven, evaluating an individual by personal questions (e.g., self-esteem, guilt, and remorse) [33]. The results of this study, along with previous research, highlight the importance of personal norms in predicting intention and subsequent speeding behavior [33,34,39]. Moreover, in this study, personal norm exhibited a stronger relationship than the subjective norm and a weaker relationship than the descriptive norm with speeding behavior in residential areas.

One independent factor that appeared in EFA and CFA was PBC, which reflects the performance of drivers under different conditions in residential areas. PBC was one of the factors that directly and without intermediaries predicted the speeding intention [34,39], but as in Jovanović et al. (2017) research, its direct effect on speeding behavior was not significant [33]. The PBC was directly linked to speeding intention and indirectly related to speeding behavior in residential areas, but the strength of these relationships was low. Several studies on speeding behavior have concluded that there is a weak or no relationship between PBC and speeding intention and, subsequently, speeding behavior [39,57,69,70]. In light of all the evidence, caution should be practiced in interpreting the effect of PBC on speeding intention and behavior in residential areas, as further research is still needed to shed light on the ability of PBC to predict speeding intention and behavior, especially in residential areas.

The model obtained in this study confirms the role of the habit variable. Among all the factors that were directly related to speeding intention in residential areas, such as affective attitude, personal norm, descriptive norm, PBC, and street specification, habit had the strongest relationship with intention. De Pelsmacker and Janssens reported habit as one of the factors that are strongly related to speeding intention and behavior [38].

The strong impact of an affective attitude on habit should also be mentioned. The huge impact of the affective attitude on habit reflects the enjoyable experience of driving at high speeds, which both provokes speeding behavior and fosters the habit in the drivers [33].

In this study, for the first time, two factors of specifications and facilities of residential streets were incorporated into the speeding behavior models. The residential street specifications, which evaluate the relationship between physical appearance and quality of the street (such as pavement quality level, street width, and street appearance) and its effect on speeding, were found to be directly linked to speeding intentions. In addition, the factor of residential street facilities, which investigates the effect of the traffic-calming measures on the speed of drivers on residential streets, was in an indirect inverse relationship with speeding behavior. It should be noted that the two variables of specifications and facilities of residential streets reflected a significant relationship with the speeding intention and behavior on residential streets, but these relationships were weak.

In general, the findings of this study support the effectiveness of extended TPB in investigating speeding behavior in residential areas. Given that speeding in residential areas can be fatal or inflict serious injury on residents of these areas and even the drivers, it is vital to explore the causes of exceeding the 30 km/h speed limit and provide solutions to deal with these misconducts. The adoption of efficient and practical models such as TPB can substantially expand our perception of speeding-related accidents.

Safety Implications for Residential Streets

Nowadays, exploring the behavior of drivers under various conditions, including speeding, is of paramount importance, particularly because it is intended to modify these bad habits [71,72]. For this purpose, models founded on various psychological theories, including TPB, can be highly effective in predicting the misbehavior of drivers.

The results of this study suggest that subjective norms help form personal and descriptive norms because drivers are constantly influenced by environmental factors such as family, friends, colleagues, relatives, and other road users. On the other hand, personal norms also indicate a strong relationship with speeding intention, meaning that drivers do not feel guilty or remorse about speeding in residential areas. However, by implementing a systematic and codified policy by planners and legislators through social media, providing various rewards and punishments, and reminding people of bad driving behaviors, especially in residential areas, the behavioral norms of drivers can be modified [73].

The findings of this study also manifest a difference between affective and cognitive attitudes. On the other hand, the high impact of cognitive attitude on affective attitude was also interesting. Therefore, it can be concluded that drivers with a positive cognitive attitude towards speeding are more likely to display a positive affective attitude when engaging in the same behavior. The strong relationship between affective attitude and habit also suggests that alteration in cognitive and affective attitudes can provoke extensive changes in drivers' habits [33]. This can be of utmost importance to urban planners because, with proper environmental advertising about residential street safety, they can improve drivers 'attitudes about speeding on residential streets, which will be effective in adjusting the bad habits of drivers.

The factor of habit was the most obvious predictor of speeding intention in this study. Now measures must be adopted to break bad habits and nourish good ones. To achieve this, it is essential to investigate factors that may directly facilitate or hinder the growth of the habit [74]. Gardner and Lally [75] concluded that habits are usually formed in an unconventional manner and are potentially diverse in terms of signs and behaviors in people. Therefore, in order to modify drivers' habits (given the difficulty of breaking habits), it is suggested to modify the speeding habits of drivers by applying extensive and costly changes in residential streets (for example, modifying street infrastructure in residential streets or installing expensive and complex speed warning systems).

The PBC was one of the factors that had a direct and relatively weak relationship with the speeding intention on residential streets. A handful of drivers, who claimed to be skilled drivers, tended to drive at high speeds under certain situations (e.g., being in a hurry, being nervous, or driving on deserted streets). Based on the results of this study (and the literature) and the weak relationship of PBC with speeding intention and behavior, it can be concluded that PBC is not a key determinant in the field of speeding behavior. This means that by adjusting other factors, this factor would most likely be modified.

The variable specification, which is weakly related to speeding intention, suggests that if some drivers are on wide, smooth, and well-paved residential streets, they will exceed 30 km/h. As expected, the variable of facilities also had a strong inverse relationship with specifications because by taking traffic-calming measures (such as installing speed bumps, narrowing width, and twisting the street) on residential streets, drivers will be forced to reduce their speed on these streets. This weak and inverse relationship between facilities and speeding behavior could be explained by the coercion of drivers to slow down. It is worth noting, however, that a handful of drivers were still tenacious about speeding on residential streets despite the installment of traffic calming tools.

The present study, informed by the extended TPB model and the results, reveals that the findings can contribute to preventing and reducing car crashes on residential streets. In addition, the results provide a useful framework for designing and planning traffic safety policies in residential areas.

6. Conclusions

In the present study, speeding behavior on residential streets was examined using the TPB framework. A variety of factors have been discovered to predict speeding intention and behavior on these streets. According to the results, the main factors that predict speeding intention and behavior on residential streets are affective attitude, habit, and cognitive attitude, followed by descriptive and personal norms. This is the first study to explore the effect of two variables of residential street facilities and specifications on speeding behavior within the framework of TPB, both of which were found to have a significant but weak relationship with speeding intention and behavior.

According to the study model, general policies to deal with speeding behavior on residential streets have been proposed, which can play a major role in curbing speeding by drivers. Policies aimed at increasing speeding fines on residential streets, imposing stricter rules on speeding, warning about careless driving behaviors through social media and environmental advertisements about the safety of residential streets, making infrastructural and geometric modifications in residential streets, and adopting engineering techniques to reduce speed on residential streets, such as traffic calming (e.g., speed humps, chicanes, and rumble devices, speed bumps and raised intersections, speed tables, etc.), designing and implementing speed warning systems, etc. should be considered by city managers and residential neighborhood managers.

Some limitations of the current study should be noted. First, given that all data were collected from online self-reported questionnaires, the low response rate of online questionnaires and possible data distortions should be considered. To address these issues, incomplete questionnaires, clumsily filled, or questionnaires containing outdated data were excluded from the study. Second, online questionnaires inhibit access to people who have no access to the Internet. Third, our sample only included the citizens of Qazvin. Since Iran is a big country with diverse driving cultures and habits in its different provinces, caution should be exercised in generalizing the results to the whole country. It is also recommended to conduct further research with a larger sample size in other regions to investigate driving behavior on residential streets and verify the results of this study. Moreover, future studies should examine speeding behavior using additional variables of the TPB theory or apply and integrate other theories to fully explore dimensions of speeding behavior in residential streets.

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