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How does talking with passengers threatens pedestrian life? An analysis of drivers' performance based on real-world driving data

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A R T I C L E I N F O

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A B S T R A C T

Talking with passengers while driving may impair driver performance. However, little is known about the extent to which this factor affects driver behavior. Since distracted driving accounts for most pedestrian accidents, the present study seeks to demonstrate the danger posed to pedestrian crossing safety by talking with passengers. Based on a real-world driving approach, the current study examines how talking with a passenger affects a driver's behavior when encountering pedestrians. A study of 41 participants' driving behavior at different locations was conducted, and 2,922 conflicts with pedestrians were coded according to four conditions (without or with passengers, and at marked crossings or at other locations). Using binary regression, it was found that this factor near pedestrian crossing areas causes significant dysfunction in driving yielding behavior. Distraction negatively affects driver-yielding behavior when drivers engage in speeding, resulting in a fivefold decrease in evasive maneuvers. In addition, a multinomial regression model indicated that drivers would reduce their evasive maneuvers by more than 60%, with lane changes accounting for most of these maneuvers. Also, the present study concluded that pedestrian crossing gaps should be at least two times larger when drivers converse with passengers than when they do not do so. This study may contribute to the development of legislation, policy, countermeasures, and future research aimed at reducing distracted driving.

1. Introduction

Driving distractions prevent drivers from maintaining safe vehicle control (Parnell et al., 2020; Regan et al., 2008, 2011). Based on a conceptual analysis of common elements in various definitions of distraction, Regan et al. (2008) provide the following general definition: "Driver distraction is a diversion of attention away from activities critical for safe driving toward a competing action" (Regan et al., 2008). Accordingly, some research (Caird et al., 2018; European Commission, 2018; Ferdinand & Menachemi, 2014; Huisingh et al., 2015; Vollrath et al., 2002) indicates that passengers can be a source of distraction that contribute to driver distraction in various ways, including visual distraction (e.g., looking away from the roadway), auditory distraction (e.g., responding to a conversation), and cognitive distraction (e.g., being lost in thought). It has been reported that passengers in the vehicle can distract the driver and increase the risk of crashes. Pradhan et al. (2014) argued that the presence of a passenger may pose a threat because peripheral events may be overlooked (Pradhan et al., 2014). In support of this point, some research has found that the presence of passengers made it difficult for drivers to detect hazardous events during driving, which increased their risk of becoming involved in a

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crash (Ouimet et al., 2015; Williams et al., 2010, Williams et al., 2012). There is also evidence that drivers are distracted by talking to passengers, and drivers spend between 11% and 15% of their time talking to passengers (Caird et al., 2018; Farmer et al., 2015; Huisingh et al., 2015). Although several studies have reported that passengers contribute to driver distractions, no comprehensive study has yet explored how talking with passengers affects driver behavior on different roads. Focusing on different areas and roadways may reveal where drivers are more likely to be involved in a crash while talking with passengers.

There is some evidence that driver distraction leads to multiple pedestrian crashes every year, resulting in the injury or death of many pedestrians (Nasar et al., 2008; National Highway Traffic Safety Administration, 2021; Stavrinos et al., 2018; Sundfør et al., 2019). Hence, many pedestrian fatalities are directly attributable to distracted drivers. The Centers for Disease Control and Prevention (CDC) reported that distracted drivers contribute to at least 2,800 pedestrian deaths and 400,000 pedestrian injuries in the United States (National Highway Traffic Safety Administration, 2021). In Norway, pedestrians were involved in about a third of all inattention-related crashes where drivers failed to detect pedestrians due to distraction (Sundfør et al., 2019). In Iran, distracted driving accounts for more than 40% of pedestrian fatalities and causes the death of more than 1,800 pedestrians annually (Iranian Legal Medicine Organization, 2022).

Despite the extensive research conducted on driving distraction and its associated risks, there exists a noticeable research gap regarding the conversation between drivers and passengers in the context of driving distraction. While numerous studies have explored the impact of various sources of distraction, such as mobile phone use (Liu et al., 2021; Rahmillah et al., 2023), navigation systems (Ma et al., 2022; Yared & Patterson, 2020), and external stimuli (Mollu et al., 2018; Sheykhfard & Haghighi, 2020), little attention has been given to the specific influence of conversational interactions within the vehicle. Although conversations with passengers are a common occurrence during driving, the potential effects on driver attention and performance remain largely unexplored. Understanding the dynamics of driver-passenger conversations and their implications for driving distraction is crucial for developing effective countermeasures and guidelines to enhance road safety. Closing this research gap will not only contribute to the existing body of knowledge on driving distraction but also help policymakers, automotive manufacturers, and road safety advocates make informed decisions regarding the design of in-vehicle systems and the promotion of safe communication practices for drivers and passengers alike. As distracted driving contributes significantly to pedestrian crashes worldwide due to talk between drivers and passengers, a comprehensive study is required to identify how distracted driving threatens pedestrian safety. Therefore, the present study aims to explore pedestrian crossing safety by analyzing vehicle–pedestrian conflicts where drivers are talking to passengers. Accordingly, the risk of pedestrian crashes can be estimated through videography from a driver's perspective approach based on the driver's yielding behavior (DYB) and the type of driver's evasive maneuver (DEM). Moreover, the present study considers driver behavior to determine how much talking with passengers affects the risk of pedestrian crashes. There is a hypothesis that drivers' yielding rates differ across areas, causing the risk of a crash with a pedestrian to be different. Furthermore, evasive maneuvers by drivers are associated with the risk of pedestrian crashes.

The study consists of four sections. Data collection and methods are discussed in the second section. Section three presents the research results and compares them with previous research. The fourth section is the conclusion section, summarizing the research findings and proposing topics for further research.

2. Materials and methods

2.1. Data collection

The present study used a real-world driving approach to examine DYB and pedestrian crash risk to analyze their behaviors in continuous time and space intervals. Initially, 44 people expressed interest in participating in the research after publishing the request for cooperation. Before starting the study, a meeting was held with participants to instruct them on how to participate. The current research objectives were not presented to the participants to prevent any possible effect of prior knowledge on their behavior and performance. The participants were informed, however, that their travel information would be recorded during the study, including selected routes, vehicle speeds, as well as pictures inside and outside the cabin. As part of the contract, they were also assured that the information would only be used for research purposes and would be kept confidential. The project used a sample size of 41 people (21 men, 20 women, age range 18 to 65 years) after three people were excluded for declining to participate. A valid driver's license was required for all participants. The participants drove an average of more than 6,000 km per year with an average of 7.4 years of driving experience. During the studies, vehicle-mounted video cameras (i.e., the CARPA-120 Dual Dashcam) that recorded both the inside and outside of the vehicle were installed in the participants' vehicle for seven days. To control the influence of vehicle features on the research, it was stipulated in the cooperation form that a Peugeot 206 car was required, so all participants drove the same vehicle model. The camera also recorded the interior audio and had a playback resolution of 640 × 480 DVD quality. In these studies, data were collected from June 2019 to March 2020, and then a three-person expert team examined the videos of the studies at the university's traffic lab for a month. The DYB of participants in various areas was carefully observed, and their information was coded in conflicts with pedestrians through four following conditions:

- Condition #1: The driver doesn't talk with passengers near marked crossing areas
- Condition #2: The driver talks with passengers near marked crossing areas
- Condition #3: The driver doesn't talk with passengers in various areas
- Condition #4: The driver talks with passengers in various areas

There were 2,922 conflicts that occurred between drivers and pedestrians. Approximately 70% of the data (2,046 samples) were used for modeling and 30% (876 samples) were used for model validation (Fig. 1).

2.2. Study sites

The Mazandaran Province (population: 3,283,577) in the north of Iran is one of the top three provinces with the highest crash rate. Over 500 people died in road crashes in this province in 2021, and more than 13,000 were injured (Iranian Legal Medicine Organization, 2022). A quarter of these fatalities and injuries occurred in Babol County (population: 540.571; 119 dead, 3,117 injured), where driving distraction and speeding were the most common factors contributing to these crashes. Babol County is also the most dangerous place for pedestrians in the Mazandaran province, as half of the casualties are pedestrian-related (Iranian Legal Medicine Organization, 2022). Considering the high number of crashes caused by driver distraction and the high vulnerability of pedestrians on roads in Babol County, various areas in this region were chosen for study. Table 1 shows the traffic and geometrical characteristics of different areas along the studied conditions (Fig. 2).

2.3. Ethics approval

The Babol Noshirvani University of Technology human research ethics committee approved the research and ensured participant safety. Additionally, all participant data was kept confidential and anonymous. Following an announcement of cooperation requests, the participants were hired by the Traffic Research Laboratory of the Babol Noshirvani University of Technology. Newspapers and social media were used to share the announcement.

2.4. Data coding and analysis

Video recordings were viewed, coded, and analyzed to examine the driver's behavior and pedestrian crossing behavior (see Table 2). GPS map data was also collected from the vehicle-mounted camera, including the exact location of the participant as well as the vehicle's speed and acceleration rate in G's. Video data were coded as a traffic conflict if there was "an observable event that could lead to a crash unless one of the involved parties changed its movement by slowing down, changing lanes, or accelerating to avoid a collision" (Cafiso & Di Silvestro, 2011; Tageldin & Sayed, 2016). It was observed that the drivers attempted to avoid collisions by performing evasive maneuvers such as accelerating, decelerating, changing the vehicle's movement path, or stopping.

The binary regression models in SPSS software (v.26) were used to assess the potential conflict between the participants' vehicles and pedestrians. The binary logistic regression model's dependent variable is whether a conflict occurred (YES = 1; NO = 0). Equations (1) and (2) represent the model:

$$\mathrm{log}it(p) = \ln\left(\frac{p}{1-p}\right) = \alpha + \beta_1 x_{1,i} + \beta_2 x_{2,i} + \cdots + \beta_k, i = 1, 2, \cdots, n \quad (1)$$

$$\Pr(Y_i = 1|x) = \frac{e^{\mathrm{log}it(p)}}{1 + e^{\mathrm{log}it(p)}} \quad (2)$$

Fig. 1. The geographical location of Babol in Mazandaran Province, Iran.

Table 1
Geometric and traffic characteristics of the studied Conditions.

Feature	Condition #1	Condition #2	Condition #3	Condition #4
Speed limit	40 km/hr	40 km/hr	30–60 km/hr	30–60 km/hr
Total of lanes	3	3	3	3
Lane width	3.75 *m*	3.75 *m*	3.75 *m*	3.75 *m*
Direction of traffic	Two-way	Two-way	Two-way	Two-way

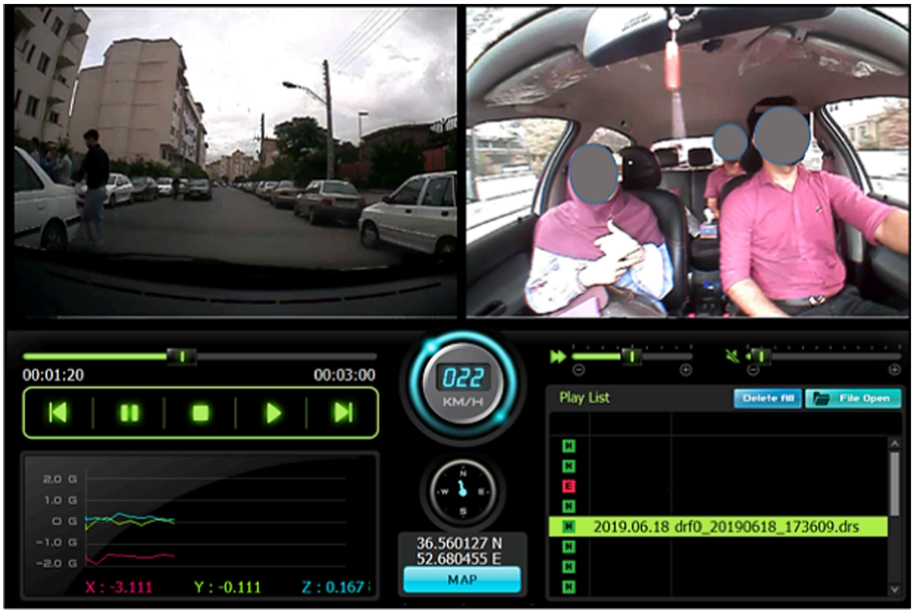

Fig. 2. Driver encountering pedestrian while talking with the passengers in the present study.

Table 2
Variable coding and definitions.

Code	Variables	Definition and calculation
S.M	Safety margin	The time interval between a pedestrian crossing a point and the next vehicle reaching that point
		Crossing in a zigzag motion by pedestrian
Zigzag	Zigzag movements	Pedestrian speed
S_PX_PGroup	S_PX_PGroup	The distance from the pedestrian to the potential collision point
P. Attention	Pedestrian attention	Whether the pedestrians cross the group or alone; Group: 1, Alone: 0
P. Gender	Pedestrian Gender	Whether the pedestrian is looking at an approaching vehicle
C. Path	Crossing path	Male: 1; Female: 0
P. D	Pedestrian Distraction	Perpendicular: 0; diagonal:1
		A pedestrian is distracted by a secondary task while crossing (using phones, eating, luggage, etc.) Yes: 1,
Cross.Req	Pedestrian request	No: 0
P.crossing	Pedestrian crossing	Whether the pedestrian requests crossing by raising a hand; Yes: 1, No: 0
P.SEEN	Place of conflict	Whether pedestrian could cross or not; Yes: 1; No: 0
P.crossing	Pedestrian crossing	Place of pedestrians when seen by driver: on left side:0; on right side;1; in middle:2
S_VDistance	S_VDistance	Whether pedestrian could cross or not; Yes: 1; No: 0
H.T.C	How to cross	Vehicle speed
D. Gender	Driver Gender	The distance from the vehicle to pedestrian
Speeding	Speeding	Running: 1; Walking: 0
D. Attention	Driver attention	Male: 1; Female: 0
D. Yielding	Driver Yielding behavior	Whether the driver is exceeding the speed limit; Yes: 1, No:
T.D.	Type of driver evasive	Whether the driver is looking at a pedestrian; Yes: 1, No: 0
Maneuver	maneuver	Whether driver yields or not; Yes: 1; No: 0
		Deceleration (releasing accelerator/gas pedal):1; Acceleration:2; Braking:3; Changing lane:4

Which is the probability of conflict when the participants interact with pedestrians at the ith event (Y_i), the independent variables affecting the probability of conflict (x_k), and the independent variable coefficient (β_k).

Following the logistic regression analysis used in this study, multinomial logistic regression was used to evaluate the influence of variables on the type of driver's evasive maneuver. The behavior of drivers when they encounter pedestrians can be divided into different types, such as stopping, decelerating, accelerating, and changing lanes. Equation (3) represents the general form of a multinomial logistic model:

$$\Pr(Y = i|x) = \frac{e^{[h_i(x)]}}{1 + \sum_{i=1}^{n} e^{[h_i(x)]}} \tag{3}$$

Where, $h_i(x)$ is the function of independent variables and Pr (Y = i|x) is the probability of evasive maneuver types.

3. Result and discussion

3.1. Driver yielding behavior

In the review of the recorded videos, 2,046 vehicle–pedestrian conflicts were identified, consisting of 1,248 occurring in Condition #3 and 798 in Condition #4. The share of conflicts reported for Condition #3 and Condition #4 was 60.9% and 39.1%, respectively. Table 3 provides descriptive statistics about these conflicts. Analyses of the data showed that driver and pedestrian behavior patterns in Condition #3 and Condition #4 routes differed in different time intervals and places before and during encounters. The number of aggressive pedestrian behaviors was higher in Condition #4 compared to Condition #3. In Condition #4, pedestrians were observed doing zigzag movements more than 1.5 times as often as in Condition #3. Speeding occurred about three times more frequently in Condition #4 than in Condition #3. The driver pays less attention to the road in Condition #4 while talking to passengers than in Condition #3. Table 3 provides additional information about conflicts in Condition #4 and Condition #3.

Of the 2,046 vehicle–pedestrian conflicts detected on different roads, 1,457 took place in Condition #2 and 589 in Condition #1. Thus, the number of conflicts in Condition #2 was almost 2.5 times higher than in Condition #1. Data analysis showed that 1,049 cases (72%) of the 1,457 conflicts found in Condition #2 occurred away from intersections. A similar pattern was observed for Condition #1, where more conflicts took place away from the intersection than near/at the intersection (67% vs. 33%). Consequently, conflicts are more likely to occur in places far from intersections than in areas near or at the intersection. Drivers often drive at high speeds between two intersections, which may explain this. Furthermore, in Condition #2, since drivers don't expect pedestrians to cross suddenly, more conflicts are created than in Condition #1 (88% vs. 74%). According to Table 3, drivers in Condition #2 generally behave less safely while talking to passengers than in Condition #1. Table 3 shows additional relevant information separated by study areas.

3.1.1. Yielding behavior models

Table 4 shows the results from modeling DYB in SPSS software (version 26). The first step involved identifying non-significant variables in the independent variable. These variables were eliminated from the original model, and the modeling process was restarted with the remaining variables. Pearson and Chi-square tests were also used to determine the correlation between continuous and discrete variables. The variables did not show any significant correlation. Besides, the variance inflation factor variable indicated non-collinearity between the variables. The Hosmer-Lemeshow test was used to evaluate the model's goodness of fit. This test

Table 3
Descriptive statistics of the behavior of drivers and pedestrians.

Variable		Condition #1		Condition #2		Condition #3		Condition #4	
		Proportion	Count	Proportion	Count	Proportion	Count	Proportion	Count
Zigzag movement	Yes	38.20	225	77.89	1135	41.26	515	62.90	502
	No	61.79	364	22.11	322	58.74	733	37.10	296
Speeding	Yes	65.53	386	84.00	1224	68.99	861	74.06	591
	No	34.47	203	16.00	233	31.01	387	25.94	207
Pedestrian attention	Yes	82.85	488	52.09	759	76.04	949	66.91	534
	No	17.15	101	47.91	698	23.96	299	33.09	264
Driver attention	Yes	87.26	514	59.78	871	83.57	1043	72.80	581
	No	12.74	175	40.22	586	16.43	205	27.20	217
Pedestrian request	Yes	66.38	391	87.71	1278	69.15	863	77.94	622
	No	33.62	198	12.29	179	30.85	385	22.06	176
Pedestrian Distraction	Yes	71.64	422	76.04	1108	77.00	961	66.67	532
	No	28.36	167	23.96	349	23.00	287	33.33	266
Place of conflict	In middle	19.86	117	40.35	588	19.79	247	35.33	282
	Left side	37.52	221	29.51	430	42.14	526	24.44	195
	Right side	42.62	251	30.04	439	38.07	475	40.23	321
Group	Yes	58.91	347	71.58	1043	60.49	755	66.04	527
	No	41.09	242	28.42	414	39.51	496	23.96	271
How to cross	Running	34.46	203	78.72	1147	37.01	462	63.53	507
	Walking	65.54	386	21.28	310	62.99	786	36.47	291
Pedestrian Gender	Male	59.08	348	52.91	771	58.41	729	58.39	446
	Female	40.92	241	47.09	686	31.59	519	41.61	352
Driver Gender	Male	50.77	299	67.67	986	59.37	741	65.03	519
	Female	49.23	290	33.33	471	40.63	507	34.97	279

Table 4
Estimation logistic regression of DYB.

Variable	(βi)		p-value		(βi)		p-value	
	Condition #3	Condition #4	Condition #3	Condition #4	Condition #1	Condition #2	Condition #1	Condition #2
S_v	−1.715	−2.124	0.002	0.003	−2.105	−3.753	0.001	0.001
Distance	1.025	1.542	0.020	0.015	1.828	2.593	0.015	0.009
Zigzag	−0.712	−0.216	0.016	0.010	−0.279	−0.422	0.005	0.007
H.T.C	−0.578	−0.335	0.030	0.015	−0.127	−0.498	0.012	0.038
Group	0.431	0.612	0.019	0.035	–	–	–	–
D. Attention	1.065	1.322	0.020	0.015	1.885	1.671	0.001	0.000
CrossReq	0.362	0.124	0.032	0.017	–	–	–	–
Constant	0.018	−0.063	0.001	0.00	−0.269	−0.117	0.032	0.020

compares the observed and expected number of events. A p-value above 0.05 indicates that the model fits the data well.

Condition #3 vs. Condition #4.

Of the 1,248 conflicts observed in Condition #3, 927 (74%) were associated with DYB. The percentage of drivers willing to yield to pedestrians in Condition #4 was 44% (359 out of 798). Table 4 shows that only seven variables influence the driver's yielding behavior model at the desired confidence level out of all the variables evaluated. The influential variables on DYB are similar in Condition #3 and Condition #4, but their severity varies. DYB is affected by similar variables; however, the degree of their influence differs.

According to the regression model, vehicle speed and distance between vehicles and pedestrians are the most critical factors influencing drivers' decision-making behavior when approaching pedestrians. A negative coefficient of speed in Condition #3 and Condition #4 indicates that the probability of the DYB increases by 5.5 times for each unit increase (odds ratio $= \frac{1}{e^{\beta}=e^{-1.715}}$) and decreases by 8.36 times (odds ratio $= \frac{1}{e^{\beta}=e^{-2.124}}$). Negative coefficients indicate a reduction in the probability of DYB. As a factor influencing DYB, distance is the second most crucial variable. Condition #3 and Condition #4 exhibit a positive coefficient for this variable that indicates a direct relationship between this variable and an increased likelihood of DYB when confronting pedestrians. By increasing this variable by one unit, the probability of DYB in Condition #3 and Condition #4 increases by 2.8 times and 4.7 times, respectively. As a result, the driver is more likely to yield to the pedestrian in this situation because he/she has enough time to analyze the situation and make a decision.

DYB is also influenced by a driver's attention to the road. This increases the likelihood of a yielding reaction by 2.90 times and 3.75 times, respectively, in Condition #3 and Condition #4. Distracted driving can negatively impact this variable, decreasing the probability of DYB. In critical situations where the driver must react quickly, this issue can lead to collisions with pedestrians.

Model results also suggest that pedestrian situations can affect the decision-making behavior of drivers in two different ways. Firstly, pedestrian aggressive behavior, such as running and zigzag movements, can cause drivers to reduce their yielding reaction. In Condition #3 and Condition #4, the beta coefficients of these two indicators indicate a decrease in DYB probability of 1.8 times and 2.1 times, respectively. Secondly, the pedestrian behavior-related factors affecting drivers' yielding behavior are crossing requests by pedestrians and crossing in groups. Positive beta coefficients in Condition #3 indicate that asking permission to cross and crossing in groups increases the probability of DYB by 1.45 times and 1.55 times, respectively.

Condition #1 vs. Condition #2

There were 589 conflicts identified in Condition #1, and the DYB was observed in 88% of them (518 cases) compared to the 36% of 1,457 identified conflicts in Condition #2 that showed DYB (524 cases). The coefficients of the influencing variables on the DYB in Condition #1 and Condition #2 are presented in Table 4. DYB behavior in condition #1 has proven to be safer than in condition #2. Table 4 shows five main factors influencing drivers' yielding/not yielding behaviors when facing pedestrians on different study routes. Compared to the DYB obtained in Condition #3 and Condition #4, DYB in Condition #1 and Condition #2 were not significantly affected by pedestrian requests and crossing in-groups.

The vehicle's speed is the most crucial variable in DYB's model. Each unit of speed increase reduces the probability of the driver yielding in Condition #1 by 8.20 times (odds ratio $= \frac{1}{e^{\beta}=e^{-2.105}}$). In Condition #2, this variable reduces the likelihood of the driver yielding by 42.60 times. This significant difference can be attributed to the high speed of drivers in Condition #2, as well as other causes like aggressive pedestrian behavior that deprives the driver of the necessary time to make sense of the situation and make the appropriate decision. Secondly, the distance between the car and the pedestrians played a role in the decision of the driver of whether or not to yield. Condition #1 and Condition #2 reported that the probability of DYB increased by 6.22 and 13.36 times, respectively, indicating that variable distance significantly impacts their decision-making. This variable has two times more significant effects in condition #2 than in condition #1. Drivers' attention to the other road was identified as a substantial influence on DYBs. In Condition #1 and Condition #2, the likelihood of drivers yielding increased by 6.58 times and 5.31 times, respectively, suggesting the importance of driver attention. Drivers were less likely to yield to pedestrians crossing in zigzag movements or running in Condition #2, which was more prevalent when pedestrians ran when crossing. In zigzag crossings by pedestrians, the probability of DYB is reduced by 1.32 times in Condition #1 and 1.52 times in Condition #2.

The models were validated by analyzing 876 conflicts identified in the studies, which were separated during the data extraction step. There were 307 conflicts in Condition #4 and 569 conflicts in Condition #3.

Furthermore, 281 conflicts were identified in Condition #1 and 595 conflicts in Condition #2. According to Table 5, over 88% of

Table 5
Result of model validation.

Observed		Predicted											
		Does yielding behavior/Doesn't yielding behavior								Correct percentage			
		Doesn't				Does							
		Condition #2	Condition #1	Condition #4	Condition #3	Condition #2	Condition #1	Condition #4	Condition #3	Condition #2	Condition #1	Condition #4	Condition #3
Does yielding behavior/Doesn't yielding behavior	Does	42	19	16	38	304	191	126	393	88.11	90.95	88.73	91.18
	Doesn't	209	61	148	123	29	10	17	15	88.40	85.91	89.69	89.13
Total		–								88.25	88.43	89.21	90.15

the models are accurate across different routes (Table 5).

3.1.1.1. Speed/distance diagram. Condition #3 vs. Condition #4

Two variables influencing yielding driver behavior were vehicle speed and the distance between the vehicle and the pedestrian. In this section, we examine the influence of indicators on drivers' decision-making from the perspective of pedestrian crossing risks. As shown in Figure 3, 79% of drivers react to pedestrians in Condition #3 when their speed is below 30 km/h. Since vehicle and pedestrian conflicts are at the lowest level of risk (Low-risk conflict; green circle), pedestrians could cross the street as they walk. As the speed of vehicles increases, the rate of DYB declines to about 46% at 60 km per hour. The maximum speed limit in Condition #3 is 60 km/h. This situation makes pedestrian crossing relatively risky (Medium-risk level of conflicts; orange circle), so pedestrians are forced to run to cross the street. As a result, pedestrians choose to run across the road rather than walk because walking may cause a crash.

Moreover, Fig. 3 illustrates that at speeds over 60 km/h, DYB decreases drastically, so pedestrians cannot cross in this condition due to the high risk of crossing. Fig. 3 also shows the probability rate of DYB based on speed/distance in Condition #4. The distance speed diagram in Condition #4 shows that pedestrians must act aggressively even at speeds lower than the speed limit when crossing the road. At speeds below 60 km/h, orange circles indicate moderate pedestrian crossing risks. As a result, despite the relatively high DYB rate, pedestrians must run to avoid colliding with approaching vehicles because of their high speed. Additionally, pedestrian crossings are impossible because of the high-risk level of conflicts (red circle).

DYB probability is also displayed in Fig. 3 based on speed/distance in Condition #4. Distance-speed diagrams in Condition #4 generally show that pedestrians have to choose aggressive behaviors such as running to cross the road even at speeds lower than the speed limit. For example, a pedestrian is at moderate risk of being struck by a vehicle when its speed is below 60 km/h. As a result, even though the rate of DYB is relatively high in this situation, pedestrians must run to avoid collisions with approaching vehicles because of their high speed. The high-risk level (red circle) also prevents pedestrians from crossing. At a given speed and distance, Fig. 3 shows that drivers tend to yield more in Condition #3 than in Condition #4. Conversely, pedestrian crossings are not very safe despite drivers' willingness to yield to pedestrians in Condition #4, forcing pedestrians to respond aggressively by running. As a result, Condition #4 requires safe pedestrian crossing facilities, such as non-level crossings or pedestrian bridges.

Condition #1 vs. Condition #2.

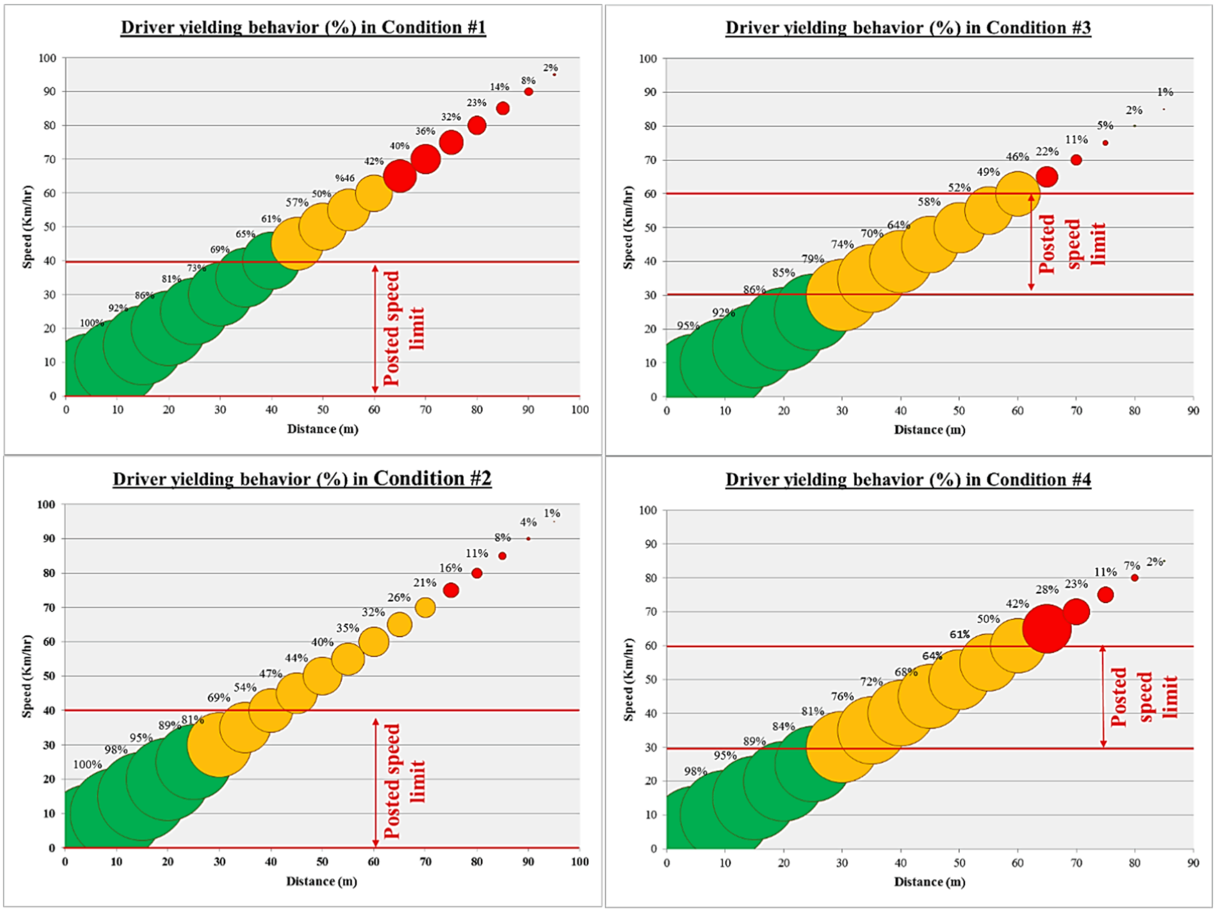

Fig. 3. Probability rate of DYB according to the speed/distance diagram.

According to Fig. 3, the probability of DYB in condition #1 and Condition #2 varies with distance and speed. Condition #1 has a higher probability of DYB than Condition #2 for an equal condition, as shown in Fig. 3. In Condition #1, approximately 61% of drivers who faced pedestrians at a distance of about 40 m yielded to them. At the same distance, 47% of drivers took action in Condition #2. In low-risk conflicts, pedestrians may walk across the road. Condition #1 provides completely safe pedestrian crossings, and at least 65% of drivers displayed yielding behavior in these conditions. A relative risk is associated with pedestrian crossings even within the speed limit range in Condition #2. Although more than 54% of drivers tried to yield at speeds of 30 to 40 km/h, pedestrians had to perform aggressive behavior such as running to avoid collisions. More pedestrians displayed aggressive behavior in Condition #2 compared to Condition #1. According to this, pedestrians should receive safe crossing training regarding Condition #2 to reduce their risk of crossing. A standard and controlled crossing may be effective in this situation, but preliminary studies and evaluations are necessary.

3.2. Driver evasive maneuver

Following the decision to yield to pedestrians crossing the road, this section discusses the various types of driver evasive maneuvers (DEMs). The key factors contributing to different DEM types are identified using multinomial regression models. A comparison of the probability of drivers' reactions is presented in this section to provide a more comprehensive understanding of the different types of DEM used to prevent pedestrian collisions in various areas, including Condition #1, Condition #2, Condition #3, and Condition #4.

Table 6 shows the number and percentage of DEMs when drivers encountered pedestrians in different areas. As shown in Table 6, evasive maneuvers elicited four different reactions. The most common reaction of drivers performing an evasive maneuver was to slow down (deceleration) and brake to stop the vehicle. Deceleration as the employed DEM was observed in about 40% of conflicts, while braking was observed in 30%. Based on the videos, it was found that slowing down and braking resulted in safe pedestrian crossing (by walking) by 57% and 71%, respectively. The other typical DEM was changing the lane of the vehicle's movement direction, which was observed in 19% of the DYBs. The maneuver provided a safe crossing for pedestrians in 42% of conflicts. DEM patterns differed between Condition #4 and Condition #3. In these conditions, 30 to 46 percent of conflict situations involved drivers increasing their speed and changing lanes to yield to pedestrians. It was found that pedestrians were able to cross safely in 53% of conflicts when drivers changed lanes, whereas speed increased the probability of aggressive behavior by pedestrians (running). As a result, pedestrians were 52% more likely to cross through zigzag movements or running. There was also speed reduction and braking in 17% and 8% of DYB, resulting in a decrease of 23% and 21%, respectively, compared to Condition #3. Table 6 provides descriptive statistics of DEM according to Condition #1 and Condition #2.

Data analysis also reveals that drivers exhibit different behaviors in Condition #1 and Condition #2. Most drivers in Condition #1 slowed down or stopped when they saw pedestrians in 53% and 37% of conflicts, respectively. In Condition #1, speeding up and changing lanes were other reactions adopted by the drivers and were observed in approximately 4% and 7% of the yielding behaviors. According to the results, drivers in Condition #2 tend to speed up and change lanes more often than in Condition #1. In Condition #2, 26% and 43% of evasive maneuvers were performed by speeding up or changing lanes. In addition, in Condition #2 only 21% and 13% of yielding behaviors such as slowing down and braking took place.

3.2.1. Models of drivers' evasive maneuvers

According to preliminary modeling, the probability of the reaction of a speed increase is not significant at 95% confidence. This evasive maneuver was therefore excluded from the model. The final DEM models were then re-executed with three types of DEMs (Table 7).

Condition #3 vs. Condition #4

Table 7 presents four types of DEMs and their coefficients for the studied areas. We utilized changing lanes as a base evasive maneuver in modeling, then modeled other evasive maneuvers in comparison with it. The model fit information in Table 7 compares the full model with the null hypothesis (i.e., with no independent variables) for all available conditions. Based on the statistical significance of all three models, the full model represents a significant improvement over the null model (p-value less than 0.05). Furthermore, Pearson's chi-square tests for all models show they are well-fitted to the data (p-value greater than 0.05). At a significant level of 95% (p-value = 0.05), variables such as speed, distance, driver's attention, and step movements of pedestrians could influence a driver's decision and create different evasive maneuvers.

The chance ratio of other evasive maneuvers to this type of DEM is determined by changing lanes as the base maneuver. Table 7 shows the regression coefficients for speed reduction and braking to change lanes. Positive coefficients indicate drivers are more likely to slow down and brake rather than change lanes. Conversely, the negative coefficients indicate that drivers choose to change lanes over evasive maneuvers when they perform yielding behavior. The following are the results of the models:

Table 6
Descriptive statistics of DEM.

Variable	Condition #1		Condition #2		Condition #3		Condition #4	
	Proportion	Count	Proportion	Count	Proportion	Count	Proportion	Count
Deceleration	52.89	274	20.06	154	39.69	368	16.71	60
Acceleration	3.67	19	25.52	196	11.65	108	29.80	107
Braking	36.49	189	12.24	94	29.77	276	7.52	27
Changing lane	6.95	36	42.18	324	18.89	175	45.97	165

Table 7
Coefficients of DEM based on multinomial logistic regression (changing lane as reference).

Condition	Variable	Probability of DEM as deceleration $h_1(x)$			Probability of DEM as braking $h_2(x)$		
		βi	p-value	Odds ratio	βi	p-value	Odds ratio
Condition #3	S_v	0.751	0.002	2.11	0.906	0.000	2.47
	Distance	0.513	0.012	1.67	0.596	0.010	1.81
	Zigzag	−0.214	0.000	0.80	−0.139	0.015	0.87
	Running	−0.305	0.004	0.73	−0.251	0.002	0.77
	D. Attention	0.662	0.000	1.93	0.745	0.000	2.10
	Constant	0.029	0.016		0.013	0.008	
Condition #4	S_v	−0.211	0.015	0.80	−0.768	0.009	0.46
	Distance	−0.430	0.027	0.65	−0.467	0.015	0.62
	Zigzag	-	-	-	-	-	-
	Running	-	-	-	-	-	-
	D. Attention	0.339	0.034	1.40	−0.609	0.017	0.54
	Constant	−0.092	0.041		0.035	0.002	
Condition #1	S_v	1.108	0.035	3.02	1.313	0.010	3.71
	Distance	0.454	0.021	1.57	0.769	0.000	2.15
	Zigzag	-	-	-	-	-	-
	Running	−0.180	0.012	0.83	−0.497	0.020	0.61
	D. Attention	0.603	0.005	1.82	1.068	0.032	2.90
	Constant	−0.086	0.009		−0.055	0.025	
Condition #2	S_v	−0.365	0.010	0.69	−0.661	0.001	0.51
	Distance	−0.772	0.036	0.46	−0.980	0.002	0.37
	Zigzag	-	-	-	-	-	-
	Running	-	-	-	-	-	-
	D. Attention	0.496	0.042	1.64	−0.517	0.005	0.59
	Constant	0.020	0.002		0.013	0.001	
Model	Likelihood Ratio Tests		Condition #4 Condition #3	Condition #2 Condition #1			
	df		28 44	23 44			
	sig		0.003 0.023	0.027 0.038			
Goodness-of-Fit	Pearson (Chi-Square)		109.405 166.219	175.462 111.708			
	sig		0.429 0.716	0.505 0.392			

i. A speed and distance variable with positive coefficients indicates that drivers are more likely to reduce speed than to change lanes at low speeds and longer distances. The probability of reducing speed compared to changing lanes at low speeds is 2.72.
ii. Aggressive behavior was not significant at the 95% level in Condition #4, but in Condition #3, it affected evasive maneuver choices. In Condition #3, aggressive behavior leads to drivers changing lanes rather than slowing down or braking. Based on the data analysis, high vehicle speeds with short distances from pedestrians often force drivers to change directions to avoid colliding with them. When pedestrians cross the road in zigzagging movements or running, drivers are more likely to change lanes than to decelerate by 1.25 and 1.36 times, respectively. Besides, when drivers encounter pedestrians crossing the road by zigzagging or running, they are more likely to perform a lane change than brake by 1.14 and 1.19 times, respectively.
iii. In all models, the variable of driver attention to the road and speed and distance significantly influenced the probable DEM model. For this variable, beta's positive effect in Condition #3 indicates that drivers are more likely to slow down and brake than change lanes. In Condition #3, drivers are more likely to choose to reduce speed than to change lanes by 64%. Also, the more significant beta coefficient indicates that if drivers recognize the pedestrian, they will be more inclined to brake since they will have more time to react. The driver's attention variable significantly influences DEM in SAUs. During these situations, drivers are more inclined to change lanes, and high vehicle speeds play an essential role in their decision-making.
iv. Generally, DEM models indicate that slowing down, braking, and changing lanes are the three major evasive maneuvers that are selected by drivers depending on their driving conditions. In addition, speed and distance indicators have the most influence on drivers' evasive maneuver choices.

Condition #1 vs Condition #2.

A preliminary model found that the acceleration was insignificant at a 95% confidence level. Table 7 presents the goodness of fit test and the probability ratio obtained after excluding the data related to acceleration in the modeling process. Generally, in the proposed models, speed, distance, pedestrian running, and the driver's attention were mentioned as factors influencing DEM. Using the lane change variable as a reference, the probability of speed reduction and braking based on influencing factors was estimated. Beta coefficients show that the variables affect drivers under different conditions. The results of the models of studies in Condition #1 can be summarized as follows:

i. The two factors of speed and distance significantly affect the driver's tendency to slow down and brake rather than change lanes. Compared to changing lanes, speed changes lead to the adoption of evasive maneuvers such as speed reduction and braking 3.0

Table 8
Result of Multinomial model validation.

Observed	Predicted															
	Stop				Deceleration				Change lane				Correct percentage			
	Condition #3	Condition #4	Condition #1	Condition #2	Condition #3	Condition #4	Condition #1	Condition #2	Condition #3	Condition #4	Condition #1	Condition #2	Condition #3	Condition #4	Condition #1	Condition #2
Stop	159	16	96	69	11	3	14	8	7	1	3	1	89.83	0.80	84.95	88.46
Deceleration	19	6	17	9	182	54	110	90	10	3	5	4	86.25	85.71	83.33	87.37
Change lane	5	6	0	16	12	9	3	21	84	107	16	206	83.16	87.70	84.21	84.77
Total													86.41	84.47	84.16	86.86

times and more than 3.70 times more than lane changes, respectively. Data analysis indicates that at low speeds and farther distances between the vehicle and the pedestrian, the driver first brakes before reducing speed to allow pedestrians to cross.

ii. In most cases, it was pedestrians' aggressive crossing behavior (like running) that caused drivers to change the lane of their vehicle's movement. A sudden pedestrian behavior forces drivers to react quickly by turning the vehicle's steering wheel before a collision occurs. When pedestrians behave in such a way, the probability of changing lanes increases by about 20% compared to reducing speed and 63% compared to braking.

iii. The decision of the driver to reduce speed and brake increased by 1.8 times and 2.9 times compared to the behavior of changing lanes, indicating that the driver's attention variable significantly affects the reaction time required by the driver to perform an evasive maneuver.

In Condition #2, it is essential to note the following findings:

i. The drivers were not expecting pedestrians on the road, which resulted in many conflicts at high speeds and short distances. Therefore, drivers were unable to make the necessary decision to slow down or brake in time, and as a result, changing lanes became the primary priority for them. According to Table 7, lane changes were 44% and 96% more likely than slowing down and braking, respectively. Compared with evasive reactions such as slowing down and braking, the probability of a driver changing lanes is higher by 2.17 times and 2.70 times, respectively, for short distances.

ii. Alert drivers (paying attention to the road) are more likely to slow down and brake than to change lanes. It is evident from these results that most of the driver's lane-changing behaviors occur when the driver is not paying attention to the road.

Table 8 shows the results of the validation of the obtained models. For each reaction, there are correct and incorrect maneuvers predicted. The prediction percentage of the models is about 85%, which indicates that they can reliably predict the DEM.

3.2.2. Speed/distance diagram

Fig. 4 shows the study's speed/distance diagrams for Condition #3 and Condition #4. The green, yellow, and red colors represent three situations of pedestrian crossing risks. Low-risk conflict, where crossing can be done by walking (green area), describes where a pedestrian can cross the road without engaging in aggressive behaviors such as running or zigzagging. All pedestrians fail to cross the road in the red area (High-risk conflict, where crossing is not possible). A yellow area indicates pedestrians crossed the road by running

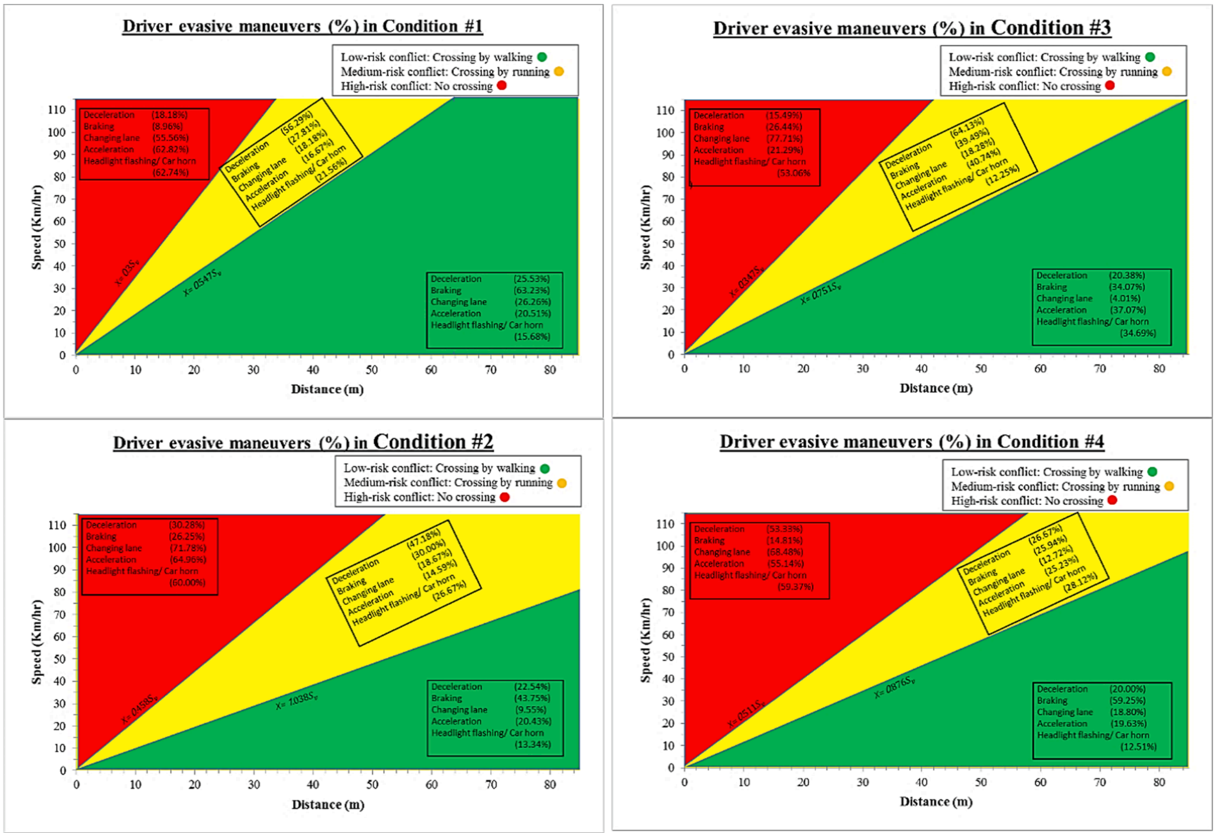

Fig. 4. Speed-Distance diagram for DEMs.

(Medium-risk conflict). This figure shows the crossing situation of pedestrian safety in different areas according to different types of DEMs. Using speed/distance diagrams for various pedestrian crossing modes, Table 9 shows the critical safe gap for pedestrian crossings.

MATLAB software was used to cluster conflicts based on two measures (speed and distance). Three classes emerged as the best clustering model based on the Silhouette criterion and the results of the ANOVA analysis of variance. The overall silhouette criterion of the clusters varied between 0.71 and 0.83, which indicates that it is desirable to select three different classes (Subbalakshmi et al., 2015). Table 9 presents each cluster's thresholds concerning the safe gap values. Moreover, Table 9 shows the variance values for the safe gap at 95% significance. The F-test determines whether the measure is significantly proportional to its clusters based on its relative weight. At a significance level of 95%, F values for both measures are statistically significant, and appropriate clusters are assigned. Conflicts can be categorized into three clusters based on severity: Low-risk conflict, Medium-risk conflict, and High-risk conflict.

The minimum critical gap required for pedestrians to cross safely in Condition #3 is 2.7 s. In Condition #4, however, this gap was estimated to be 3.15 s. Based on the comparison of the two modes, it can be concluded that in Condition #3 driving at lower speeds results in a more significant safety margin for pedestrians.

According to Fig. 4, more than 34% (94 cases) and 20% (75 cases) of DEM in the form of braking and slowing down occurred in the low-risk conflict area in Condition #3. Approximately 60% (16 cases) and 20% (12 cases) of the evasive maneuvers of drivers leading to safe pedestrian crossings involved braking and slowing down. Additionally, Table 9 shows that pedestrians failed to cross the road in less than 1.25 s in Condition #3 and less than 1.84 s in Condition #4. The data analysis shows that pedestrians failed to cross the road due to drivers' choice of lane change. More than 77% of evasive maneuvers performed in Condition #3 (136 cases) and 68% in Condition #4 (113 cases) occurred in conflict areas with high risks (no crossings). However, despite drivers slowing down and braking to yield to pedestrians crossing the road, there were insufficient safety margins (gaps of less than 1.25 s in condition #3 and 1.84 s in condition #4) and the pedestrian could not cross. In Condition #3, approximately 16% and 27% of slowing down and braking behaviors, respectively, occurred in high-risk conflict areas. Drivers slowed down and braked in 54% and 15% of DEM, respectively, to prevent collisions with pedestrians. The pedestrian failed to cross the road due to the gap being less than the minimum required value. Table 9 shows the minimum and maximum gaps for the medium-risk crossing area (yellow area) in Condition #3 and Condition #4. Based on the data analysis, the most frequent evasive maneuvers in these areas were slowing down and braking to yield to pedestrians. In Condition #3, nearly 64% of drivers reduced their speed, while 26% in Condition #4 did the same (Medium-risk conflict area). The driver's braking behaviors were observed in 40% and 26% of total evasive maneuvers, respectively, in Condition #3 and Condition #4.

3.2.3. *Pedestrians crossing/not crossing areas with changes in speed/distance*

Fig. 5 shows the probability of pedestrian crossing/not crossing depending on speed and distance. A continuous red and green line shows Condition #3, where the green area is the pedestrian crossing area and the red area is the non-crossing area. Based on the data analysis, pedestrians successfully crossed the road in 723 of the 1,248 conflicts that occurred in Condition #3 (58%). The approaching vehicle reached the possible collision point before pedestrians could cross the road in another 522 conflicts. More than 36% (261 cases) of the conflicts in which pedestrians could cross the road occurred when the vehicle's speed was less than 30 km/h (below the minimum speed limit).

Furthermore, in 462 cases (64%) of the conflicts, pedestrians were allowed to pass while drivers were driving at speeds over 30 km/hr. Approximately 407 failed crossings (77%) occurred when the vehicle approaching the pedestrian exceeded 60 km/h (above the maximum speed limit). There were 115 cases (22%) of unsuccessful crossings in which the vehicle speed was less than 60 km/h.

Data analysis shows that 27% (196 cases) of successful crossings in Condition #3 occurred at speeds greater than 60 km/h. By performing an appropriate evasive maneuver in this situation, the DYB gave pedestrians enough time to cross. Drivers who did not yield or delay increased the chance of pedestrian collisions. The red and green dashed lines indicate the areas of not crossing and crossing in these areas, respectively. Of 798 conflicts, 32% (225 cases) were successful crossings, and 68% (543 cases) were not. There were 138 successful crossings (54%) in the speed range of vehicles less than 60 km/h, while other successful crossings (117 cases; 46%) occurred at speeds above 60 km/h. In contrast, more than 81% (439 cases) of unsuccessful crossings occurred when the vehicle exceeded the maximum speed limit. Considering the speed limits in Condition #4, 16% (41 cases) of pedestrian crossings were successful when vehicles were approaching at speeds over the maximum speed limit. As a result of yielding behaviors such as changing lanes, reducing speed, and applying brakes, pedestrians could cross safely.

In Condition #2, 525 of the 1,457 conflicts involved pedestrians successfully crossing the road (36%). A pedestrian crossing/not-crossing situation in these areas can be divided into two areas above and below 56 km/h, as shown in Fig. 5. In Condition #2, more than 39% (205 cases) of successful pedestrian crossings occurred when over 50% of drivers yielded by performing an evasive maneuver. More than 61% of successful crossings (320 cases) occurred under conditions where the probability of DYB was less than 50%. As a result, pedestrians in these areas accept a high risk when crossing roads over short distances.

Table 9
Critical safe gap for pedestrian crossing.

Risk	Condition #3	Condition #4	Condition #1	Condition #2
Low-risk conflict	$t_c \geq 2.70$	$t_c \geq 3.15$	$t_c \geq 1.97$	$t_c \geq 3.74$
Medium-risk conflict	$1.25 < t_c \leq 2.70$	$1.84 < t_c \leq 3.15$	$1.08 < t_c \leq 1.97$	$1.65 < t_c \leq 3.74$
High-risk conflict	$t_c \leq 1.25$	$t_c \leq 1.84$	$t_c \leq 1.08$	$t_c \leq 1.65$
Sig:0.014	F-test:48.519		Mean square: 0.195	

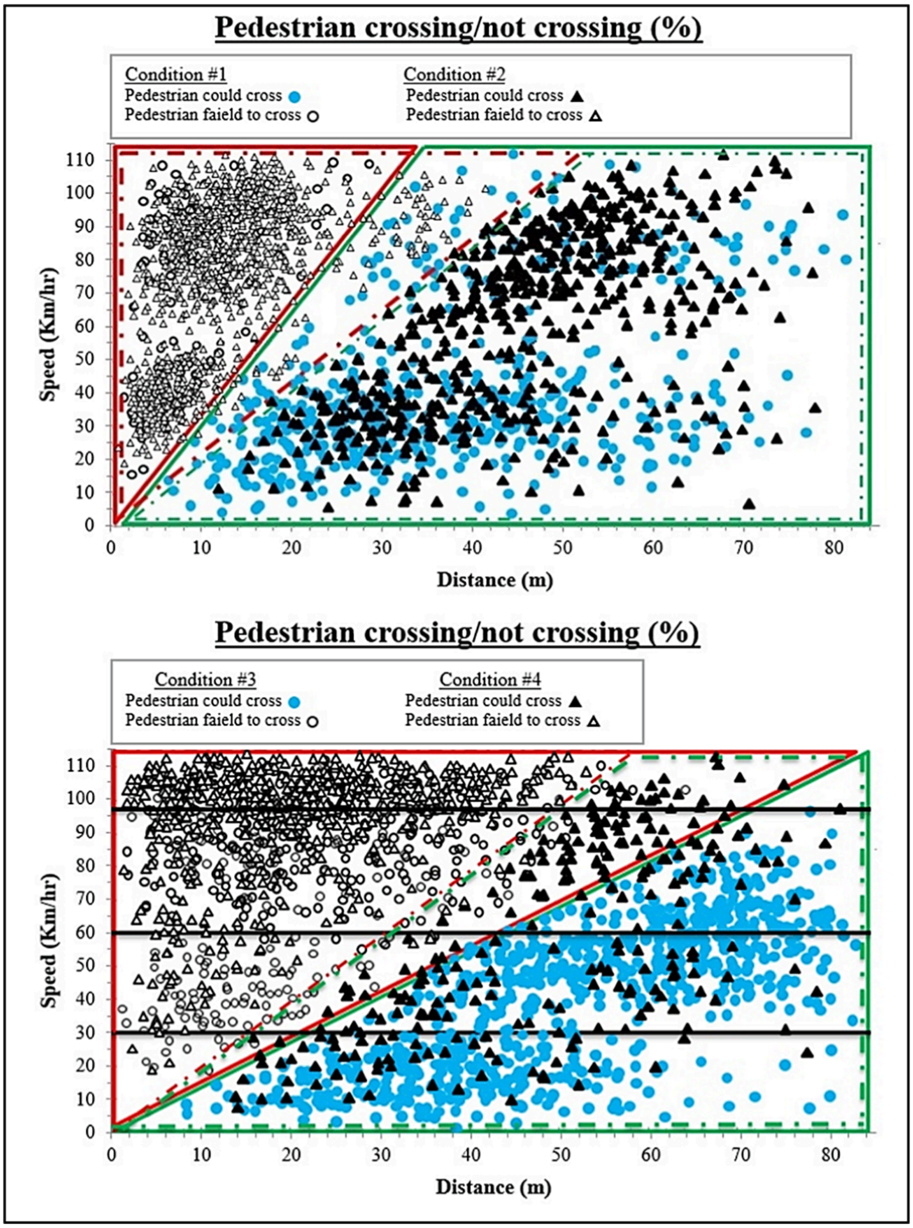

Fig. 5. Pedestrian crossing and not crossing probabilities based on distance and speed.

Fig. 5 shows that of the 453 successful crossings in Condition #1, about 80% (362 cases) occurred below the speed of 62 km per hour. Furthermore, other successful crossings in Condition #1 occurred when the vehicle was traveling over 62 km/h. In these areas, the probability of drivers reacting was less than 50%, but pedestrians could still cross in 91 of the conflicts. 261 of the 932 conflicts where pedestrians failed to cross occurred in areas below 56 km/h (28%), according to Fig. 3. Although DYB was more than 50% likely in these areas, data analysis showed pedestrians did not cross the road due to the short distance between the vehicle and them. In addition, 671 unsuccessful crossings occurred at speeds greater than 56 km per hour, and these situations occurred in Condition #2 because drivers failed to yield. About 66% (89 cases) of unsuccessful crossings occurred at speeds above 62 km/h in Condition #1. These areas experienced a large share of unsuccessful crossings due to the high speed and short distances.

4. Conclusion and further research

The present study aimed to evaluate the influence of talking with passengers on the DYB through real-world driving data in different areas. Since most pedestrian crashes result from driving distractions including those caused by talking between driver and passenger, the present research examined the danger of driving while talking to passengers at various time intervals and places before colliding with pedestrians. To determine how talking with passengers affects the DYM, real-world driving data was divided into Condition #1, Condition #2, Condition #3, and Condition #4. Additionally, to determine which areas are safer to cross the road while encountering drivers who are talking with passengers, DYB models were developed for each area.

Based on binary regression analysis of the DYB models, the driver's probability of yielding behavior to pedestrians when talking to passengers in Condition #4 was reduced by about 70% compared to the drivers in Condition #3, which may be a result of an increase in the perception and reaction time of drivers. Research has examined the relationship between driver reaction time and talking with passengers. Some research suggests that talking with passengers increases the reaction times of drivers (Burns et al., 2003; Hunton & Rose, 2005; Stelling-Konczak & Hagenzieker, 2013). There is, however, some evidence that conversing with a passenger does not affect reaction times differently (Consiglio et al., 2003; Horrey & Wickens, 2006).

According to the research findings, most drivers in Condition #4 are more likely to change lanes and even speed up instead of slowing down or braking to avoid collisions with pedestrians. The results show that drivers change lanes and increase their speed when they encounter pedestrians in Condition #4 more than 2.5 times compared to Condition #3, reducing pedestrian safety. Also, drivers who fail to make proper evasive maneuvers when traveling over the speed limit in Condition #4 are two times more likely to be involved in a collision. In addition, the critical safe gap for pedestrian crossings in Condition #4 is about 20% larger than in Condition #3. The current study also examined how talking to drivers affects the DYB when encountering pedestrians in condition #1 and Condition #2.

The study found that talking to passengers reduces DEM by more than 60% in Condition #2. In addition, distraction negatively affects Condition #2 when drivers operate their vehicle at an illegal speed (speeding), so the rate of evasive maneuvers decreased by 1.5 times. Drivers' evasive maneuver rate decreased with steeper slopes as speed increased in this situation. To prevent pedestrian collisions with approaching vehicles, the safe pedestrian crossing gap in Condition #2 should be at least twice that in Condition #1. According to the present study, talking to passengers significantly impacts DYB in Condition #4, indicating reduced pedestrian crossing safety. While behaviors such as requesting pedestrian crossings or even increasing the number of pedestrians waiting on the edge of the curb to cross the road may reduce distractions caused by talking to passengers, these factors do not significantly impact drivers. Another factor that may reduce the rate of DYB is speeding. In such a situation, pedestrian crossings may be less safe, especially those in the middle of the road.

The findings in the present study may provide safety policymakers with a more specific understanding of the influence of talking between drivers and passengers, which could be used to reform policies regarding traffic tickets. Additionally, it may be helpful to develop awareness campaigns to educate drivers and passengers about the risks of distracted driving, including the potential impact on pedestrian safety. This may include social media campaigns, billboards, and public service announcements. Awareness campaigns are needed to inform drivers about the risks associated with talking with passengers while driving, especially near pedestrian crossing areas. Furthermore, it is important to implement infrastructure improvements, such as wider pedestrian crossing gaps, to accommodate distracted drivers and reduce the risk of pedestrian accidents. For instance, pedestrian crossing signals may be extended to allow more time for drivers to react. Road safety audits and assessments may also be conducted to identify high-risk pedestrian crossing areas, and necessary measures taken to enhance safety. Despite using the best possible facilities available in the present study, future studies should consider some new factors. The eye-tracking measurement of the point observed by the driver and the length of the conversation are essential factors to consider in future studies. Also, future extensions of this study might provide more detail on the impact of drivers' cognitive and vision distractions by passengers on the occurrence of pedestrian crashes, including medical and behavioral-cognitive skills evaluation, as well as psychological assessments using computer tests and driving simulations. It is also recommended that future studies include a larger, more representative sample of drivers' populations to develop behavioral models of drivers. In this way, researchers can examine socio-demographic factors, such as driving experience, age, and gender, and determine whether they play a significant role. Future research into designing an advanced driver assistance system that assists if the conversation length between a driver and a passenger exceeds a particular value may also be of interest. Therefore, in this regard, the development of technologies that advise passengers not to talk to the driver (for example, displaying a warning message on the monitor) may reduce this type of distraction among drivers.

Declaration of Competing Interest

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

Data availability

Data will be made available on request.

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Author statement

The authors confirm contribution to the paper as follows: study conception and design: Abbas Sheykhfard; analysis and interpretation of results: Abbas Sheykhfard, Farshidreza Haghighi, and Subasish Das; draft manuscript preparation: Abbas Sheykhfard, Farshidreza Haghighi, and Subasish Das. All authors reviewed the results and approved the final version of the manuscript.

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