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The Role of Social Networks in Mobile Phone Use among Pedestrians: A Pilot Study in China

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Abstract: Pedestrian safety is alarming worldwide, and it is well validated that distracted walking/crossing involving mobile phone use would significantly compromise pedestrian safety. Some existing studies demonstrated that distracted pedestrians would spend more time to cross street, miss more safe opportunities to cross and pay less attention to the road environment, etc. As a result, they are more likely to be hit by an oncoming vehicle. Specifically, with respect to the distraction results from mobile phone use for communication in road user groups, previous research has examined the relationship between social networks and mobile phone use among drivers and motorcyclists. However, very little similar research was found in the field of pedestrian study. This study performed an online survey to investigate with whom pedestrians were most likely to communicate with while crossing street in a Chinese sample. The association between social networks and self-reported injury/ near miss event was also examined. To provide an insight into the difference in communication pattern between scenarios, the results were compared with the patterns while driving, motorcycling and the general patterns. Results indicate that pedestrians are most likely to communicate with friends (31.2%), followed by spouses (24.5%). Additionally, participants who frequently talk to parents/children have a greater likelihood of being involved in injury/ near miss events than those talk to the others. Compared with the prevalence of mobile phone use among drivers and motorcyclists reported in previous studies, mobile phone use is more prevalent among pedestrians, especially as they are more likely to communicate with colleagues. In sum, the results demonstrate that social networks play an important role in mobile phone use during street crossing, and pedestrians are more likely to communicate with people who are socially closest to them. The effect of social networks on mobile phone use (especially for communication) among pedestrians should be considered in the development of traffic safety countermeasures.

Keywords: pedestrian safety; distracted street crossing; mobile phone; social networks; communication partner

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1. Introduction

1.1. Background

Social connection with others is a fundamental human need, especially the need for connecting with family members, friends and intimate persons [1,2]. In fact, the need for connection and communication between individuals across all ages has not changed in nature over years, only the way or medium we use for connection has changed due to the development of new technologies. In such a digital age, mobile/smart phone is the most popular and indispensable tool for contemporary people to communicate with each other, rather than letters via the post office. Moreover, the smart phone is no longer a regular communication tool, it provides users with more powerful and diversified functions, such as music, video, and social media apps. In 2019, it was estimated that more than 5 billion have mobile devices, and over half were smart phones. Particularly, compared to the people in emerging economics, those in advanced countries are more likely to have smart phones and use the internet as well as social media [3].

As the most important communication tool nowadays, making phone calls and text messaging via smart phone or instant messaging (IM) apps installed in device are prevalent usages for the users. For example, in China, there were 1.599 billion mobile phone users by the end of October, and the amount of mobile phone call time was 2003.4 billion minutes during the first ten months in 2019 [4]. Furthermore, it was reported that the number of IM users based on mobile phone reached 0.890 billion by the end of March 2020, which made up 99.2% of mobile phone netizens, and mobile phone users spent the largest proportion of time (14.8%) on IM apps [5]. In addition, text messaging is increasingly becoming a more preferred communication channel among Chinese device users, particularly those younger user groups. Compared with the first ten months of 2018 in China, the total time of voice calls via mobile phone and landline in the same period in 2019 declined 6.3% and 19.1%, respectively, whereas text messaging service volume increased 40.8% [4]. Similarly, it was reported that the amount of time spent on talking via the smart phone decreased 25% between 2012 and 2015 in the USA [6]. According to the survey conducted by Pew Research Center, text messaging (55%) was the dominant way that teens communicate with their friends on a daily basis, followed by instant messaging (27%), while 19% of teens indicated that they interact with friends through talking on the phone [7].

In order to explain what makes texting such a hit, Burke [8] argued that texting is easy and quick, the users could send text messages via short messaging service (SMS) or apps. On the other hand, it is also easier to reach most people through text, since only 20% people answer calls that they are not expecting [8]. To provide a more scientific and solid explanation, Weinschenk [9] stated that addictive behavior including texting is associated with the release of dopamine, which is a kind of chemical created in the brain, and it is critical in all sorts of brain functions. Dopamine could make people want, desire and seek out, it increases people's goal-directed behavior. Specifically, the users would have almost instant gratification of their desire to seek through texting, and then it makes people seek more, finally they have fallen into a dopamine-induced loop [9].

1.2. Drivers and Mobile Phone Distraction

As the most important way through which the people can be connected with each other in today's society, communication via smart phone is quite ubiquitous in our daily life. Additionally, in general, such communication behavior is common and unproblematic, in other words, it at least will not result in personal safety problem. However, communication based on such a medium in some specific situations would place the users at risk of injury or even worse. From the point of view of traffic safety, distracted behavior of using a smart phone among road users (e.g., drivers, motorcyclists, pedestrians) has concerned the researchers and practitioners. According to the evidence from a naturalistic driving study in Brazil [10], mobile phone use occurred in 58.71% of the driving trips (n = 201), indicating an average frequency of 8.37 interactions per hour. The time of using a mobile phone averagely accounted for 7.03% of the trip time, while calling/voice message (14.46%) and texting (7.39%) made up 21.85% of the total usage time. It is now well established that using a mobile phone while driving will compromise driving performance and consequently increase crash risk, including talking and text messaging [11–16]. For instance, a number of previous studies have confirmed that communication behavior involving mobile phone use while driving significantly increases cognitive workload [13,17,18]. With regard to mobile phone conversation while driving, it is associated with attention blindness [19], decreased reaction time [11]. Compared with talking on the phone, texting while driving is demonstrated to be even more worse [18], and it is associated with loss of visual attention and increased brake reaction time [20], along with increased variability of vehicle speed and lane position [20,21], etc. In particular, Fu et al. [22] found that handheld texting lead to a delayed response to the sudden braking events as compared to no phone use, while speech-based texting did not slow down the response. In addition, in the presence of simple and complex handheld texting, the rear-end accident probability increased by 2.41 and 2.77 times, respectively, while the effects of speech-based texting were not significant.

To prevent distracting communication activities concerning smart phone use among road users while performing traffic tasks (e.g., driving a vehicle, crossing street) and thus enhance traffic safety, it is necessary to understand the behavior at first. Specifically, as a kind of communication behavior, to consider about the person (i.e., communication partner) with whom he/she is talking or texting during that specific period is crucial. From this point of view, several previous studies have investigated the effect of social networks (or social distance) on distracted behavior (i.e., communication behavior here) in the context of traffic activity. With regard to distracted drivers, LaVoie et al. [23] indicated that social distance is a key factor in talking and text messaging while driving. Their results indicated that teens (15–18 year-olds) were more likely to talk with parents while driving, while adults (40–60 year-olds) were more likely to talk with their spouse. With regard to text messaging, the results indicated that teens were more likely to text with friends rather than girlfriend/boyfriend or parent, while adults said that they were more likely to text with friends or their children while driving [23]. Furthermore, Mirman et al. [24] found that the association between adolescent technology addiction and communication frequency via mobile devices while driving was significantly stronger for contacting their peers than it was when the communication partners were their parents. As for parents, they engaged in communication via mobile devices while driving with their children as frequently as adolescents engaged in communication while driving with peers [24].

1.3. Motorcyclists and Mobile Phone Distraction

A number of studies have investigated mobile phone use while riding a motorcycle. Through a survey of 602 app-based motorcycle taxi drivers in Vietnam, 52% of the drivers reported using a mobile phone while driving, which was found to be the most common risky driving behavior among the sample [25]. Using a sample of university students in Vietnam, the results indicated that calling while motorcycling had the highest prevalence (74%) among risky riding behaviors, and the prevalence of texting was 49.9% [26]. However, an observational study conducted in Malaysia showed that the prevalence of mobile phone use while riding a motorcycle was much lower (only 0.2% of 72,377 observations) [27]. Additionally, mobile phone use increases among female riders, riders wearing industrial uniforms, or carrying passengers [27]. Furthermore, some existing studies indicated that there are associations between distracted riding and traffic crashes [28]. Truong et al. [29] indicated that the motorcyclists who frequently use mobile phones while riding had a higher chance of being involved in a crash/fall.

Similarly, De Gruyter et al. [30] have examined the association between social networks and mobile phone use among motorcyclists in a sample of Vietnam college students, and the results indicated that the majority of students were most likely to communicate with a friend while riding, as is case for both talking (56.5%) and text messaging (62%) via mobile phone. In addition, they found that participants who frequently communicate with their boyfriend/girlfriend/spouse (or friend) via voice call (or text message) while riding were more likely to experience crash/fall involvement than those who frequently talk with others while riding [30].

1.4. Pedestrians and Mobile Phone Distraction

In addition to distracted driving and riding, some literature paid attention to the detrimental effect of mobile phone use on pedestrian safety in recent years. Given that pedestrian is the road user group which without any protective equipment (e.g., seatbelt, airbag, helmet), they thus may be more vulnerable to accident risk result from distracting activities in relation to mobile phone use for communication or other purposes. In 2012, a survey found that 23% cell phone owners have bumped into another person or an object because they were distracted by using their devices, and 50% of the owners responded that they have been bumped into by another person who was busy paying attention to his/her phone. As for young adults, among 18–24 year-olds, the figures were even more significant, meeting 51% and 70%, respectively [31]. In New Zealand, researchers stated that the rate of pedestrians who use digital devices (e.g., mobile phones, headphones) while crossing street is increasingly high, and such unsafe traffic behavior may divert the users' attention away from their primary task (i.e., crossing street) even at appropriate crossing facilities [16]. Additionally, it was found that pedestrians who were distracted by a cigarette, cell phone or music player accounted for 20% of pedestrian fatalities and serious injuries caused by road users' attention being diverted [16]. In Australia, Horberry et al. [32] found that, on average (including eight city sites, a total of 4129 observations), 20% of pedestrians were using smart phones when crossing roads, headphone use (auditory only, 38%) and texting/interacting with the device (37%) were the most popular functions used by those distracted pedestrians. Besides, Hou et al. [33] found that over half (53%) of 387 participants reported using a mobile phone while crossing street in China, and the younger participants were more likely to be distracted by their devices, they also had a more positive attitude towards the device use while crossing street. Furthermore, the most prevalent usage was calling (49.5% of males, 54.7% of females), followed by operations of social apps (23.4% of males, 31.6% of females). In fact, considering that mobile phone use especially for communication is necessary and ubiquitous in day-to-day life, and on the other hand, a person may be not a driver (i.e., a driving license holder), but generally she or he must be a pedestrian. Hence, it is not surprising that mobile phone use during walking or crossing street is prevalent in both developed and developing countries, especially among young pedestrians due to the fact that they are more susceptible to the new technologies.

A number of existing studies have provided evidence regarding the negative effect of problematic mobile phone use on pedestrian safety, as well as the associations between mobile phone use and unsafe pedestrian behavior [34]. According to the data from the US Consumer Product Safety Commission on injuries in hospital emergency rooms from 2004 through 2010, mobile-phone related injuries among pedestrians increased relative to the total pedestrian injuries, with the proportion increasing from 0.58% in 2004 to 3.67% in 2010 [35]. In another study based on the data drawn from National Electronic Injury Surveillance System (NEISS) database, 310 injuries between 2000 and 2011 were identified as cases of cell-phone-induced distraction, and the result revealed a significant increase in distraction injury rates over the years of study [36]. Specifically, when pedestrians were simultaneously using mobile internet and crossing street, their behavior was greatly altered and considerably riskier as they looked left and right less often, took longer to initiate crossing [37], etc. Interestingly, Chen et al. found that unsafe crossing behaviors (e.g., sudden movement, fewer head-turning frequencies) were more prevalent among those playing "Pokemon Go" game on their devices, texting via instant-message apps and/or web surfing appeared to be the second risky distraction event [38,39]. With respect to mobile phone use for communication among pedestrians, it was found that when texting while walking, pedestrians need a longer time to visually detect the critical roadside events [40]. In an observational study, Thompson et al. [41] indicated that text messaging while crossing increased crossing time, and these distracted pedestrians were 3.9 times more likely than undistracted pedestrians to display at least one unsafe crossing behavior, such as failing to look the both ways and running the lights. In another field study, Pešić et al. [42] found that compared with pedestrians who did not use mobile phones, the distracted pedestrians behave less safely while crossing street. They stated that mobile phone talking has the greatest effect on unsafe pedestrian behavior, followed by texting/viewing content on the device, while the effect of listening to music is the smallest [42]. Slightly different from the results of Pešić et al., through an outdoor-environment experiment, Jiang et al. [43] argued that the greatest effect was from text distraction, followed by phone conversation distraction and music distraction. The results demonstrated that pedestrians distracted by texting look left and right less often, they also switch, distribute and maintain less visual attention on the traffic environment. Moreover, pedestrians distracted by phone conversation cross the street more slowly, direct fewer fixation points to the right traffic area, and spend less fixation time and lower average fixation duration on the left traffic area [43]. Furthermore, Schwebel et al. [44] found that participants distracted by texting were more likely to be hit by a vehicle when crossing a semi-immersive virtual street, both talking and texting participants were more likely to look away from the street environment than those undistracted ones. In addition, findings from some other studies also back up the perspective that talking on the phone and texting while walking/crossing may jeopardize pedestrian safety [45–47].

Although previous studies have examined the association between social networks and mobile phone use while driving/motorcycling, and a number of meaningful findings are achieved, which contribute to the understanding of communication behavior among drivers and motorcyclists. However, to the authors' knowledge, no study has examined the effect of social networks on mobile phone use among pedestrians, probably the largest group of road users, while crossing street which is a typically risky traffic scenario for them. In addition, it is not clear whether there is difference in communication partners across different scenarios (e.g., driving a car, riding a motor, crossing street and in daily life), for example, whether the road users are most likely to communicate with the same partner in the context of crossing street and driving a car. To sum up, more research is needed to investigate the role that social networks play in communication behavior among pedestrians.

Therefore, the first aim of present study is to explore if and how social networks are associated with mobile phone use among pedestrians while crossing street. The second aim is to explore the relationships among pedestrian injury/near miss events, social networks and communication behavior while crossing. Additionally, the third aim is to compare the communication patterns (i.e., calling and text messaging pattern) while crossing the street with the patterns of other scenarios reported in previous studies (i.e., in the scenario of driving, motorcycling and in general). It should be noted that the mobile phone use while crossing in the following parts refers to communication via a smart phone, such as talking, text messaging, and video chatting.

The present study is structured as follows: Survey design and analytic methods for the data are presented in Section 2. The results of data analysis are detailed in Section 3, including descriptive statistics, relogit modelling and difference analysis between scenarios. Section 4 discusses these results, and implications for practice are also provided in this section. At last, conclusions, limitations and directions for future research are provided in Section 5.

2. Method

2.1. Survey Design and Data Collection

An online survey based on a self-administered questionnaire was performed in 2019 to investigate the mobile phone use for communication while crossing the street in a sample of Chinese pedestrians. The questionnaire was published on a professional online survey website in China (www.sojump.com), and the participants were recruited via convenience sampling method. The questionnaire developed for this study was comprised of 19 questions, a brief introduction to the survey was provided in front of these items, privacy, security, and anonymity of the response were promised, and informed consent was obtained from all of the respondents. Additionally, in order to improve the validity and reliability of response, the participants were encouraged to respond to the questions in terms of their actual experience. This survey was promoted by emails, social apps and personal contacts to recruit more participants. After completing the questionnaire, the participant would receive a red envelope worth 10 RMB in return.

At the beginning of survey, participants were asked about socio-demographic questions, including gender, age, whether they were a smart phone user, etc. Only the individual who responded that he/she was a smart phone user would be included, then the survey would be continued, and the remaining questions related to frequency of communication behavior via smart phone while crossing street and who they are most like to communicate with would be presented. These questions were developed on the basis of Chinese user habit. Finally, there are 6 items regarding frequency of mobile phone use while crossing, each represents a specific kind of communication method or channel, including regular voice call, regular text messaging via short messaging service (SMS), text messaging via IM apps installed in the smart phone (e.g., Wechat, Tencent QQ), voice messaging via IM apps, voice call via IM apps, video chatting via IM apps. For example:

How often do you initiate, answer or have a regular voice call via your smart phone while crossing street?

- never
- a few times a year
- at least once per month
- at least once per week
- at least once per day

In the other 5 items, only the communication method descriptions were changed. Moreover, the options were coded from 1 (never) to 5 (at least once per day) in the subsequent data analysis, namely 5-point Likert scale, the higher figure represents the more frequent behavior.

In order to investigate who the participants were most likely to communicate with, 6 items regarding the potential communication partner were developed, which corresponded to the 6 communication methods. For example:

If you are using a smart phone for a regular voice call while crossing street, who are you most likely to talk to on your phone?

- colleague or someone at work
- friend
- parent
- girlfriend/boyfriend/spouse
- sibling
- child (adult only)
- other

Similarly, in the other 5 items, only the communication method descriptions were changed. In addition, the category "parent" and "child (adult only)" were combined into the category "parent/child" in latter data analysis procedure, and "girlfriend/boyfriend/spouse" was simplified as "spouse" hereinafter.

Lastly, participants would be asked to indicate if they were injured or experienced a near miss event while crossing due directly to distraction resulted from communication behavior via smart phone in recent two years; if the individual responded "Yes", then she/he would be further asked to indicate the communication method which was adopted at that time.

2.2. Participants

A casual non-probabilistic sample of 400 Chinese participants responded to the online survey. After the eligibility inspection of survey data, 39 participants were excluded from data analysis due to their unreliable responses (e.g., inconsistent responses). Thus, the final sample size in the present study is 361, including 161 males (44.6%) and

200 females (55.4%). As for age distribution, 145 participants (40.2%) are 25 years or younger, 128 participants (35.5%) are between 26 and 30 years old, and 88 participants (24.4%) are over 30 years old.

2.3. Data Analysis

The data analysis steps and techniques for this paper are as follows: to meet the first aim, a series of chi-square analyses were performed to examine the difference in communication partner between participants grouped by demographic variables (i.e., gender and age), and if the potential partner would vary across communication methods. As for the second aim, a relogit regression model with self-reported injury/near miss event as dependent variable was carried out to examine its possible relationships with the independent variables, including age, the frequency of mobile phone use for communication via specific channel and social networks. Finally, to achieve the third aim, a number of chi-square analyses were conducted to examine the difference in communication pattern between the scenario of street crossing and the other three scenarios reported in previous studies, namely driving a vehicle, riding a motorcycle and in daily life.

3. Results

3.1. Descriptive Statistics

The present study investigated 6 communication methods via smart phone device in total; Table 1 details who the participants responded that they were most likely to communicate with via the specific channel. First, chi-square analysis was conducted to examine the difference in partners between males and females within each communication method. For regular voice call, males and females differed in their communication partner ($p = 0.100$), with males being most likely to converse with a colleague (31.9%) on the phone, followed by a friend (24.8%), while most females chose parent/child (27.6%) and friend (22.1%). There was no significant gender difference when participants communicate via regular text messaging ($p = 0.739$), although males reported they were most likely to text a colleague (28.9%) while most females prefer to text a friend (27.6%), and participants were less likely to communicate with a parent/child via this channel (7.9% and 11.5%). With regard to text messaging via IM apps ($p = 0.039$), participants were most likely to text with a friend, both for males (39.7%) and females (33.6%), but females were significantly more likely to text with a parent/child than males (10.9% vs. 2.5%). Of the participants who reported that they contact others via voice messaging while crossing ($p = 0.048$), both males and females were most likely to communicate with a friend (38.1% and 34.5%), but significant more females reported communicating with a parent/child (12.0% vs. 5.6%) or sibling (9.9% VS 4.0%) than males through this communication method, while males were more likely to contact a colleague than females via such channel (25.4% vs. 18.3%). With regard to voice call via IM apps ($p = 0.013$), a friend was the most possible interlocutor for participants (37.9% and 32.4%), while significantly more males contacted a colleague than females (24.2% vs. 13.2%); in turn, females were more likely to contact a parent/child than males (16.9% vs. 5.6%). Finally, the communication pattern of video chatting differed between males and females, the former ones were most likely to chat with a spouse (33.7%) followed by a friend (31.6%), while the latter gender group chose a parent/child (25.7%) or a friend (25.7%) as their potential interlocutor during crossing.

Second, the results of chi-square analysis indicated that the difference in communication partner among three age groups within each method was significant with $p < 0.010$. For example, as the most common communication channel ($p < 0.001$), the younger participants (≤25 years old) were most likely to talk to a parent (34.3%) via regular phone call while crossing, followed by a friend (33.3%) and a spouse (15.2%), whereas participants in the two elder groups were most likely to talk with a colleague (32.2% and 36.4%) or a spouse (20.9% and 18.2%). Interestingly, for the younger participants (≤25 years old), the communication patterns were similar among the other five communication methods; it was found that they were most likely to communicate with a friend through these channels, followed by a spouse. For those between 26 and 30 years old, the percentage of participants choosing colleague, friend or spouse as their most possible interlocutor was comparable in each of the remaining five methods. With respect to participants over 30 years old, in addition to the channel of video chatting (i.e., spouse accounted for the largest proportion with 28.2% here), the participants were most likely to interact with a colleague when using smart phone for communication while crossing street. These divergences may be attributable to their difference in social role, the participants over 25 years old needing to deal with more work-related as well as home affairs, while the younger participants under 25 years were largely university students or unmarried, so they were more likely to contact a friend or a romantic partner for social or private affairs.

Table 1. Who participants are most likely to communicate with while crossing street in China.

Interlocutor	Regular Voice Call		Regular Text Messaging		Text Messaging (IM Apps)		Voice Messaging (IM Apps)		Voice Call (IM Apps)		Video Chatting (IM Apps)	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Work	72	25.2	39	23.9	57	22.9	58	21.6	48	18.5	29	14.8
Friend	67	23.4	41	25.2	91	36.5	97	36.2	91	35.0	56	28.6
Parent/child	68	23.8	16	9.8	17	6.8	24	9.0	30	11.5	37	18.9
Spouse	52	18.2	41	25.2	68	27.3	67	25.0	66	25.4	55	28.1
Siblings	16	5.6	7	4.3	12	4.8	19	7.1	19	7.3	14	7.1
Other	11	3.8	19	11.7	4	1.6	3	1.1	6	2.3	5	2.6
Total	286	100	163	100	249	100	268	100	260	100	196	100

Notes: only the participants who use their devices at least several times a year were presented. The category “Work” refers to colleague or someone at work. The category of “Spouse” refers to girlfriend/boyfriend/spouse.

Third, in terms of an overall chi-square test ($p < 0.001$), there was significant difference in communication partner among the six channels based on smart phone device. Overall, participants were most likely to communicate with friend (31.2%) while crossing street, and they almost made up the largest proportion in each of the six communication methods. Then, spouse accounted for the second largest proportion with a percentage of 24.5%, followed by colleague (21.3%). It was worth noting that parent/child communication only accounted for 13.5% of the mobile phone use while crossing, and participants were more likely to engage in parent/child communication via regular voice call (23.8%) or video chatting (18.9%), while they were significantly less likely to text with parent/child while crossing, including regular texting and text messaging via IM apps. In addition, IM apps-based communication channel was the preferred way for participants in present sample to contact a friend and/or a spouse in such traffic scenario, it may be due to the fact that the majority of participants in the present study were relatively young adults.

3.2. Relogit Regression Models

A total of 40 injury/near miss events due to mobile phone use while crossing street were reported, Table 2 details the proportion of participants who had been involved in such cases by communication method. To examine the potential relationship among the behavior of mobile phone use, social networks and self-reported injury/near miss events, a series of binary logit models were developed. Given that injury/near miss rates were relatively higher in text messaging (IM apps) and voice messaging group compared to the other four groups, in particular, as the rates in these four groups were lower than 2%, maybe it was reasonable to view injury/near miss event in these groups as a rare event

[48]. Hence, binary logit models were developed for text messaging (IM apps) along with voice messaging (IM apps) group, while relogit models [49] were used in the remaining four groups.

Table 2. Proportion of participants who have been involved in injury/near miss event.

	Regular Voice Call	Regular Text Messaging	Text Messaging (IM Apps)	Voice Messaging (IM Apps)	Voice Call (IM Apps)	Video Chatting (IM Apps)
n (N)	5 (286)	2 (163)	18 (249)	9 (268)	4 (260)	2 (196)
%	1.75	1.23	7.23	3.36	1.54	1.02

Notes: N refers to the number of participants who communicate with someone while crossing via the specific method, n refers to the number of participants who had been involved in injury/near miss events.

Finally, only a significant relationship between injury/near miss event due to mobile phone use for regular voice call during street crossing and social networks was found ($p < 0.10$). Table 3 presents the result of relogit regression model. The results indicated that participants who frequently talk to parent/child on smart phone while crossing street would have a higher probability to be involved in injury/near miss event than those who talk to other interlocutors (coefficient = 2.186, $p < 0.10$). In addition, although the frequent use of device for regular phone call while crossing was associated with a higher chance of being involved in injury/near miss event, this positive relationship between the two variables was weak and not statistically significant for the sample of current study (coefficient = 0.080, $p > 0.10$).

Table 3. Relogit regression model for injury/near miss events due to regular voice call (n = 286).

Variable	Coefficient	S.E.	p	95% C.I.
Constant	−7.879	2.758	0.004	
Age	1.031	0.800	0.197	0.585–13.459
Frequency of regular voice call while crossing	0.080	0.704	0.910	0.273–4.304
Most likely to talk to parent/child	2.186	1.254	0.081	0.762–103.833

Notes: S.E. = Standard error, p = Significance p value, 95% C.I. = Confidence interval. Variable most likely to talk to parent/child while crossing is significant at 90% confidence level.

3.3. Communication Pattern in Different Scenarios

As aforementioned, a few previous studies have examined the role of social networks in unsafe traffic behavior, including distracted driving [23] and motorcycling [30]. In order to provide a preliminary insight into communication pattern in different scenarios, along with the difference between scenarios, current research compared the mobile phone use among pedestrians while crossing the street with its use while driving, motorcycling and in general life that was reported in previous studies. For comparison, only the shared interlocutor types as well as communication channels in these studies were included in the following analysis. Table 4 details the partner that individuals were most likely to communicate with while crossing, driving, motorcycling and in general. Additionally, given that regular text messaging is much less used among Chinese smart phone users in day-to-day life as well as during street crossing, and text messaging via IM apps is more prevalent nowadays, regular text messaging was replaced by texting via IM apps in Tables 4 and 5 to make the data to be more representative and comparable.

Table 4. Who device users were most likely to communicate with in different scenarios.

		Crossing	Driving [a]	Motorcycling [b]	In General [c]
Talk	Friend	20.0% (26.0%)	18.2%	42.0%	33.7%
	Parent	20.0% (26.0%)	32.3%	13.0%	26.7%
	Spouse	16.0% (20.0%)	15.2%	10.0%	28.7%
	Work	22.0% (28.0%)	1.0%	4.0%	10.9%
	Do not talk	22.0%	33.3%	31.0%	
Text	Friend	26.7% (39.7%)	24.0%	33.0%	44.6%
	Parent	4.0% (5.9%)	8.0%	1.0%	18.8%
	Spouse	19.8% (29.4%)	12.0%	12.0%	26.7%
	Work	16.8% (25.0%)	1.0%	2.0%	9.9%
	Do not text	32.7%	55.0%	52.0%	

Notes: Text in Crossing scenario refers to text messaging via IM apps, the others refer to regular texting which were reported in previous studies. Talk refers to regular voice call. The Data in brackets was used for the comparison between Crossing and In general scenario. The data for driving, motorcycling and in general was summarized and recalculated on the basis of data reported in previous research. [a] LaVoie et al.[23], [b] De Gruyter et al. [30], [c] Lenhart et al. [50] and Wajcman et al. [51]. The data for In general scenario originally derived from Lenhart et al. [50] and Wajcman et al. [51], but for convenience and comparison, the current study used the data which was summarized in LaVoie et al. [23].

A set of chi-square tests were performed to examine voice call and text messaging pattern while crossing with the pattern in three other scenarios, and the results were detailed in Table 5. The overall chi-square analysis suggested that communication pattern while crossing was significantly different from the pattern either while driving, motorcycling or in general. Overall, pedestrians use mobile phone more often than drivers and motorcyclists (Talk 78.0% vs. 66.7% vs. 69.0%, Text 67.3% vs. 45.0% vs. 48.0%). For calling, pedestrians were more likely to contact a colleague while crossing, but this was not the case for drivers and motorcyclists (22.0% vs. 1.0% vs. 4.0%). Additionally, participants were more likely to talk to a friend while motorcycling than crossing street (42.0% vs. 20.0%). Moreover, pedestrians were less likely to talk to a parent than those who use their devices while driving a vehicle (20.0% vs. 32.3%). Additionally, compared to device use in general, participants were significantly more likely to talk on the phone with a colleague while crossing (28.0% vs. 10.9%). For texting, similarly, pedestrians were more likely to communicate with a colleague than drivers and motorcyclists (16.8% vs. 1.0% vs. 2.0%). Additionally, compared to pedestrians, drivers and motorcyclists were less likely to text with a spouse while their travel (19.8% vs. 12.0% vs. 12.0%). Compared to voice call, fewer participants reported texting with a parent either while crossing street, driving a car or riding a motorcycle (4.0% and 8.0% and 1.0%). Furthermore, compared to device use in general, pedestrians were more likely to text a colleague while crossing street (25.0% vs. 9.9%), while they were less likely to text a parent in such traffic scenario (5.9% vs. 18.8%).

As the most common and representative group in social networks, further chi-square analysis was performed between friend and parent category. Interestingly, as shown in Table 5, voice call pattern while crossing was significantly different from its pattern while riding a motorcycle ($p < 0.010$), the result indicated that participants were more likely to talk to a friend while motorcycling, rather than during street crossing. With regard to texting pattern, it was somewhat different between scenario crossing and in general ($p < 0.10$), suggesting that participants were relatively more likely to text a friend in crossing scenario than in day-to-day life. The differences in communication partner between remaining comparison pairs were not statistically significant with $p > 0.10$.

Table 5. The results of chi-square test for communication patterns in different scenarios

		Overall Chi-Square Test	Friend VS Parent
Talk	Crossing vs. Driving	$p < 0.010$	$p = 0.181$
	Crossing vs. Motorcycling	$p < 0.010$	$p < 0.010$
	Crossing vs. In general	$p < 0.050$	$p = 0.572$
Text	Crossing vs. Driving	$p < 0.010$	$p = 0.222$
	Crossing vs. Motorcycling	$p < 0.010$	$p = 0.132$
	Crossing vs. In general	$p < 0.050$	$p = 0.073$

4. Discussion

Although it is common to use a smart phone in contemporary people's day-to-day life, using the device in some traffic scenarios would be problematic and risky. Previous studies have examined the relationship between social networks and mobile phone use while driving a car or riding a motorcycle, which contributed to a better understanding of distracted behavior in relation to mobile phone use in the context of traffic activity. This paper seeks to investigate the potential link between social networks and mobile phone use for communication while crossing the street by using a sample of Chinese participants. In particular, we are curious about whom the pedestrians are most likely to contact in such a traffic scenario. Additionally, the relationship between injury/ near miss event, frequency of communication behavior and social networks is examined to provide more insights. In addition, communication patterns in several scenarios are compared in this study to explore the role that social networks play in different situations, as previous studies show that social distance between road user (i.e., driver, motorcyclist) and his/her interlocutor is a strong predictor of cell phone use while driving/motorcycling.

Consistent with previous research [23,30,52], the results indicated that social networks play an important role in pedestrian mobile phone use while crossing street, they are more likely to communicate with those who are socially closest to them, such as a friend or boyfriend/girlfriend/spouse. That is to say that although the most likely interlocutor may differ between communication channels or scenarios, but the underlying mechanisms of communication are not changed: device users generally prefer to communicate with the person who is significant to them, in particular, a closer social distance between device user and interlocutor may increase the possibility of responding to a mobile phone signal [52]. LaVoie et al. [23] hypothesized that drivers choose to only take the most important calls given the risk associated with mobile phone use while driving; it seems that such a hypothesis is also valid for pedestrians in a street crossing scenario.

In terms of overall chi-square analysis, there was significant difference in communication pattern between males and females ($p < 0.10$), except for regular text messaging ($p = 0.739$). Consistent with previous research (e.g., [51]), males were more likely to communicate with a colleague than females. In particular, as for communication via regular voice call, males reported that they were most likely to interact with a colleague (31.9%). On the other hand, compared with males, females were more likely to contact parents/children. Particularly, as for regular phone call and video chatting, a parent/child was the most likely interlocutor for females (27.6% and 25.7%). Maybe the gender division of labor in society could be responsible for such divergence [53,54]. From the traditional view of breadwinner-homemaker pattern, males are encouraged to devote more effort to career development, and females are more focused on family, such as taking care of children and the elderly [55]. Hence, it is not surprising that the communication pattern differs between males and females. In addition, friend and spouse were important interlocutors with whom both males and females were likely to interact while crossing, indicating that socializing is one of the main purposes of communication, even in such a traffic scenario.

Some differences regarding communication partner among age groups were found as well. Specific to regular phone call, younger individuals (≤25 years old) were more likely to talk to a parent or friend than their elders, whereas the older individuals (>25 years old) more frequently engaged in conversation with colleagues while crossing. Overall, the communication patterns of specific age group among the channels were similar, younger participants (≤25 years old) were more likely to communicate with friends than participants over 25 years, in turn, participants over 25 years old had significant more communication with colleagues than the younger cohort (≤25 years old). Of the participants under 25 years old, most are students or workplace newcomers, this is a golden period for them to make more friends and expand their social circle. For teens and youngsters in the digital age, making friends and social interactions are not confined to school, neighborhood or playing field, smart phone along with installed apps (e.g., IM apps, social media) provide them with a convenient digital platform for communication and socializing. Similarly, previous research also found that teens/college students were more likely to contact a friend while driving [23,24] and motorcycling [30], rather than a parent or boyfriend/girlfriend. Moreover, considering that participants over 25 years old had more opportunities to deal with work-related affairs, it was possible that they would more frequently contact someone at work.

The overall chi-square analysis indicated that communication patterns were not always the same among channels. Overall, pedestrians were most likely to communicate with a friend (31.2%), followed by a spouse (24.5%); in total they made up 55.7% of the mobile phone use. In particular, compared to the other channels, pedestrians were more likely to communicate with a parent/child via regular voice call (23.8%), followed by video chatting (18.9%). Similar results were also reported in previous studies that a higher proportion of device users said that were more likely to talk on the phone with parents, rather than text them [56]. Maybe it was habitual to communicate with parent/child via this channel; Lenhart et al. [50] and Smith [57] suggested that text messaging was more common among young adults than older adults. Given that most of the participants (273 of 361 participants) in current sample were under 30 years old and were more adaptable to new technology, and the interlocutor on the other end of phone more likely to be a parent of them, not a child who was mature enough to independently use the device. Thus, the perspective of Lenhart et al. [50] and Smith [57] also seemed to be suitable for our study. In addition, the characteristic that voice call and video chatting were more direct and efficient than texting may also contribute to such a preference. Furthermore, compared to the other communication partners, participants were more likely to contact a friend or spouse via video chatting, maybe the private and intimate nature of video chatting should account for such preference.

Self-reported prevalence of injury/near miss due to mobile phone use while crossing was 7.23% for text messaging (IM apps), which was the highest among six communication channels. Given that texting while crossing street was associated with higher level of difficulty than the other channels, it would cost more physical, cognitive and visual resources, therefore, the highest rate was as expected. According to the result of relogit regression, pedestrians who frequently interact with a parent/child via voice call while crossing were more likely to be involved in an injury/near miss event than those who talk to the other interlocutors (e.g., a friend or spouse). Similarly, De Gruyter et al. [30] found that motorcyclists who frequently talk to a boyfriend/girlfriend/spouse while riding were more likely to experience a crash/fall, as well as those who frequently text a friend. A possible explanation for this phenomenon is that individuals may have a longer call or text messaging conversation with those specific interlocutors who are socially closest to them, and they may be more immersed in these conversations [30]. As a result, less attention is paid to their primary task (e.g., crossing street or riding a motorcycle), and safety performance is jeopardized greatly.

However, it was difficult to draw an indisputable conclusion concerning the relationship between social networks and injury/near miss event from these results. First, the present study asked participants to indicate who they were most likely to communicate with while crossing, not who they were actually communicating with at the moment that such an event occurred. In fact, given that we collected data through an online survey, not hospital records (e.g., emergency room) or accident records of police, it was difficult to ensure the interlocutors recalled by respondents were indeed those who they were communicating with at the time (i.e., recall bias). Second, the sample size of current study was relatively small (N = 361), and of the participants reporting using mobile phone for voice call, only five injury/near miss events were obtained, it was not solid enough to conclude a direct relationship between social networks and injury/ near miss event. Finally, social network was a variable which was statistically significant at 90% confidence level, not 99%. As a whole, further research is needed to examine the direct link between social networks and behavioral outcome (i.e., injury, near miss) of road users due to mobile phone use while performing traffic task.

Based on the pattern of regular voice call and text messaging reported in previous research, this study has made a series of comparisons between crossing and the other scenarios. First of all, compared to drivers and motorcyclists, mobile phone use was more prevalent among pedestrians while crossing street. Interestingly, the proportion of drivers and motorcyclists who said that they have never used mobile phone were comparable, including for voice call (33.3% VS 31.0%) and texting (55.0% VS 52.0%). Given that distracted driving and riding were more risky than distracted crossing, and the distraction would result in difficulties in vehicle control, especially for novice drivers, it was not hard to understand why mobile phone use was more prevalent among pedestrians. In addition, participants were more likely to talk to someone than text him/her within each of the three traffic scenarios. This result may be due to device users need to pay more attention to the screen when texting with someone, in order to reduce the potential risk results from mobile phone use, road users prefer to talk rather than text in a traffic scenario (i.e., a kind of compensatory strategy). In contrast to crossing, individuals were less likely to communicate with colleagues when driving a car or riding a motorcycle. To some extent, this finding may support the theory of cell phone distraction and social relationships proposed by LaVoie et al. [23]; they suggested that perhaps in an effort to compensate for the possible risk of using a cell phone while driving, drivers only take the most important calls, especially those who are socially closest to them, such as a parent or spouse. In other words, compared to using a mobile phone while crossing, participants may experience greater potential risk when doing so while driving or motorcycling, and given that a friend/spouse/parent was socially closer than a colleague to the individuals, to have fewer calls and text messages with colleagues when driving or riding a motorcycle seemed to be a strategy. Moreover, it was worth noting that device users were more likely to communicate with parents through voice calls than texts, either in traffic scenarios or in general. Additionally, it may reflect the fact that text messaging is more popular among young adults [50,57], while voice call is a more preferred communication channel between child and parent.

Distracted behavior related to mobile phone use is prevalent among road user groups, and a better understanding of who they are most likely to contact while crossing street is helpful in developing countermeasures and preventing such unsafe behavior. Although the communication partner may vary across groups (e.g., age groups) and scenarios, the underlying mechanism is the same, namely pedestrians are more likely to contact people who are socially closest to them. Hence, safety interventions should target pedestrians as well as their communication partners. First, traffic safety campaigns should be promoted to highlight the risk related to mobile phone use while crossing street. For example, putting up pedestrian safety posters on billboards at nearby busy intersections in business districts while handing out leaflets at these intersections may also work. It is also a good way to make some short videos and promote them on social media. Moreover, from this point of view, some new technology and tools are useful and promising in changing such unsafe pedestrian behavior, such as virtual reality [58,59]. By using a virtual pedestrian environment system to implement a behavioral intervention, Schwebel et al. [58] provided opportunities for community members to experience the risks of distraction caused by text messaging while crossing a virtual street. The results demonstrated that individuals exposed to text messaging within the virtual environment reported changes in intentions to cross streets while being distracted by their mobile phone and in perceived vulnerability to risk while crossing streets. In addition, as an emerging solution to address the distraction of mobile phone use while walking/crossing, embedded illuminated lights installed in the footpath can effectively attract the attention of distracted pedestrians, then they may play as warning signals for pedestrians distracted by their mobile phones [60]. Second, Piazza et al. [61] found that subjective norm (SN) significantly predicted pedestrians' intention to use mobile devices while crossing street, SN being a psychometric construct determined by normative beliefs concerning the expectations of important referents (e.g., friends, family members). Intervention strategies in relation to the effect of SN can focus on how to discourage individuals from using their mobile phone while simultaneously performing traffic tasks. For instance, the message that those significant others in your social networks will not approve distracted crossing should be delivered to the public. Educational campaigns focusing on SN might be more effective in the population of students, given that they are generally heavy users of mobile phone, and their desire for approval from society and others [62]. Finally, interventions might be more effective when both pedestrians and their communication partners are included.

5. Conclusions and Future Research

In sum, the current study revealed that social networks were associated with mobile phone use while crossing in a sample of Chinese pedestrians. The communication pattern may differ in some conditions, but the same underlying mechanism was responsible for the mobile phone communication in a street crossing scenario, namely pedestrians were most likely to communicate with those who are socially closest to them, such as a friend, boyfriend/girlfriend/spouse. The results contribute to the understanding of relationship between social networks and pedestrians' mobile phone use for communication while crossing the street. When developing interventions to prevent the distracted crossing among pedestrians, the effect of social networks cannot be ignored, particularly, interventions would be more effective when both pedestrians and their communication partners are considered. Moreover, developing a subjective norm (or social norm) that distracted crossing is risky and unaccepted by the public may be helpful in reducing inappropriate device use as well as the crash risk. In addition, given that the prevalence of portable devices and their problematic use is still rising in this age of information, it is possible that the situation of pedestrian safety may be further exacerbated due to the distraction of such device use. Therefore, in order to better understand the distracted behavior of using a mobile phone while crossing street among pedestrians, and ultimately reduce its prevalence, more research is needed.

Several limitations of the current research must be acknowledged. First, this study was based on a self-reported questionnaire, and we asked participants about who they were most likely to communicate with via smart phone while crossing street, rather than who they were actually talking to or texting with during such a period; this limitation should be considered when interpreting the results. The future studies are encouraged to collect data through a field survey at urban intersections, and to have a face-to-face interview with those distracted pedestrians. Second, although a total of six communication methods were investigated in this study, we did not consider who generally initiated the conversation in such a traffic scenario (i.e., is the pedestrian an initiator or respondent of the conversation), and the content of conversation. Future research should explore the influence of these factors. Third, we used the data derived from previous research to examine the difference in communication pattern between crossing and the other scenarios (i.e., driving, motorcycling and in general). These studies were carried out in different countries (i.e., China, USA, Vietnam), and the characteristics of samples were not exactly the same (e.g., age distribution). Hence, the results regarding differences between crossing and the other scenarios should be interpreted with caution. Future research should further investigate the communication pattern of distracted road users in developed and developing countries to provide more insights. Finally, to the authors' knowledge, this is the first study which investigated the association between social networks and mobile phone use among pedestrians while crossing street, thus, this topic deserves further study. Additionally, the future studies are encouraged to expand the sample size to derive more reliable and robust conclusions.

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