Original Article

Pedestrian Injuries and the Relevant Burden in Shanghai, China: Implications for Control

ELSEVIER

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Abstract

Objective To study the associations of pedestrian injuries with age, income and educational level in Shanghai and to analyze the relative disease burden.

Methods Information on pedestrian-related cases and deaths were collected from 494 hospitals and mortality registry systems from 1992 to 2010, and a multistage cluster sampling survey conducted in 2006. Logistic regression model was used in the analyses.

Results The age group of 5-9 had the highest mortality and morbidity among children. Mortality increased obviously among those aged 60 or above. Individuals with an educational level under the primary school and with the lower family average income were more likely to suffer pedestrian-related injuries. Multivariate Logistic analysis demonstrated that lower income and lower educational level increased the risk of pedestrian injuries with the odds ratio of 1.40 (95% CI: 1.15-1.71) and 1.70 (95% CI: 1.20-2-40), respectively. About 13.54% of the share of GDP for the healthcare, social security and welfare industries in Shanghai was occupied by the burden of pedestrian-related injuries in 2006.

Conclusion Pedestrian-related injury has inverse association with victims' income and educational level. Children of 5-9 years old and adults over 60 with lower educational level and lower monthly income are the target persons to be intervened.

Key words: Pedestrian; Injury; Mortality; Education; Costs

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INTRODUCTION

Pedestrian-related injuries in traffic crashes are an expanding public health threat. It causes annually over 4200 pedestrians died, which contributes to approximately 12% of all traffic-related deaths in the United States, and more than 270,000 people died worldwide each year, accounting for 22% of all road deaths. The magnitude of non-fatal injuries has been increasing rapidly in recent years, with over 70,000 pedestrians injured in the United States and almost 10 million worldwide annually. Studies indicated that these injuries will rise dramatically by the year of 2020, particularly in countries which are rapidly motorizing^[1-5].

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In China, mortality of injuries has increased over the past decades. The three leading causes of injury mortality are traffic injuries, fall-related injuries, and suicide. The traffic-related mortality continued to be the first leading cause of injury death (12.45 per 100,000 populations) in 2011^[6-9], and about 25% of the total fatalities were pedestrians^[10]. Shanghai is the metropolitan city in China. The motorization rates [V/P (vehicles per 1000 populations) varied from 14 to 129 during 1987-2003. In the same period, traffic fatality risks (fatalities/populations)] increased along with the rate of growth of motorization (V/P), changed from 7.78 to 14.18 per 100,000 populations^[11-12]

Pedestrians are one of the most vulnerable road users. The increasing healthcare cost due to pedestrian-related injuries is becoming a big challenge faced by the healthcare system. Although some characteristics of pedestrian-related injuries documented in population-based have been settings^[4-5,10,13], global data on injured pedestrians are not readily available and crashes involving pedestrians are poorly reported in official statistics in many countries^[4,10]. There is few evidence about the actual magnitude, nature and extent of pedestrian fatalities and injuries for all ages in China. Therefore, it is necessary to study and identify the and disease burden actual pattern of pedestrian-related deaths and injuries.

We conducted a study which aims to identify the risk factors of pedestrian-related injuries focused mainly on different income, age, gender, and education level; and analyze the costs of pedestrian-related injuries. It is helpful in providing scientific evidences for comprehensive injury risk management and implementing pedestrian safety interventions.

MATERIAL AND METHODS

Definitions

The definition of a pedestrian refers to WHO's conception. Briefly, a pedestrian is any person involved in a transport accident who was not at the time of the accident riding in or on a motor vehicle, railroad train, streetcar, animal-drawn or other animal^[4]. bicycle vehicle, or on а or А defined pedestrian-related injury is as any pedestrian's physical damage resulting from accident^[14]. transport In our study, pedestrian-related deaths and non-fatal injuries were coded as V01-V09 according to International Classification of Disease-10 (ICD-10). The cases of collision of pedestrian (conveyance) with other pedestrian (conveyance) and collision of pedestrian (conveyance) with other pedestrian (conveyance) with subsequent fall were excluded^[14-17]. The underlying cause of pedestrian-related death is the injuries that initiate events leading directly to death. Evidence for the diagnosis of cause-of-death includes physical and chemical tests, surgery, autopsy, pathology, clinical diagnosis, and verbal autopsy^[18].

The total cost of pedestrian-related injuries was composed of direct medical treatment costs and costs of productivity loss. The costs of direct medical treatment refer to the payment provided by patients and insurance companies for treating pedestrianrelated injuries. Costs of productivity loss are the payment of labor earnings caused by the result of pedestrian-related injuries outcome, including the lost earnings and productivity of both patients and their family members who take care of them. For the indirect cost of premature death is the loss of potential wages and benefits^[19].

Data Sources

Information on cases of hospitalization and fatalities due to pedestrian-related injuries was obtained from 494 hospitals and mortality registry systems from 1992 to 2010 in Shanghai. Shanghai has established the mortality registry systems covering about 100% of all Shanghai registered permanent residents since 1953. The registration system has used ill-defined categories according to ICD-10. The data of pedestrian-related injuries incidence and costs were abstracted from a retrospective survey which was conducted to analyze the disease burden of injuries in all 19 of Shanghai in 2006. Standardized districts questionnaires were designed to collect information on demography, date of injuries, treatment type (in-patient or out-patient), hospitalization and costs. Data on local-level economic accounting, demography, and labor force from 1992 to 2010 were collected from Shanghai Municipal Statistics Bureau and were used to analyze of the disease burden of pedestrian-related injuries.

The instruments for the survey were developed according to the instruments of the WHO injury survey at the community level. Quality control was implemented in this study as described previously^[9]. Briefly, the sample size and standardized questionnaires were ascertained after a pilot study.

Investigators were trained to be eligible for this study. Finished questionnaires during the survey were checked daily in order to ensure the integrality and accuracy. In the process of analysis, data were checked carefully and 10% of the input data were double examined for controling the quality of the data.

Sampling Technique

A multistage cluster sampling was used for sampling in all 19 districts in Shanghai, as described previously^[9]. Briefly, three sub-districts of each district were firstly sampled randomly and three communities were randomly selected from each sub-district. Then, 100 households were selected randomly from each community. A total of 45,857 recruited for the participants were survey. Participants were interviewed by trained investigators after obtaining a written informed consent from each participant.

Statistical Analysis

All cases were categorized according to the international classification of external causes of morbidity, mortality, and injury, poisoning, and certain other consequences of external causes^[15-17]. Variable of age was categorized into different age-groups with 5-year interval. Morbidity and mortality rates were calculated for both genders and different age groups. We combined all-year data into one dataset. For the calculation of average age-specific mortality during 2001-2010, data of 4902 individuals died of pedestrian-related injuries from 2001 to 2010 was divided into different age-groups; data of total number of registered permanent residents during the same period was divided into correspondent age-groups. Chi-square test was adopted in the analysis of the difference in categorical variables and variation trend in rates of mortality and morbidity by income, years and age. Pedestrian-related injuries costs of direct medical treatment and productivity loss were also calculated. Multivariate logistic regression was applied to analyze the independent association of factors related to pedestrian injury. SPSS (Version 15) was used in this study. P<0.05 was taken to indicate statistically significant.

RESULTS

During the period of 1992 to 2010, a total of

129

9363 individuals died of pedestrian-related injuries in Shanghai, which accounted for 7.97% of all injury related deaths and 28.58% of traffic injury-related deaths. Of 45,857 individuals surveyed in 2006, 101 were injured from pedestrian traffic accidents, and the pedestrian-related morbidity was 220.62 per 100,000 populations.

Figure 1 shows the changes of the pedestrian-related mortality rate and per capita disposable annual income from 1992 to 2010. The pedestrian-related mortality rate changed from 2.55 per 100,000 populations in 1992 to 3.48 per 100,000 populations in 2010, while average per capita disposable annual income increased by 958.09%, from 3009 CNY (US\$ 2043) to 31,838 CNY (US\$ 5050) during this 19-year period (Chi-Square is 17.07, $P_{trend} < 0.001$).

Figure 2 shows pedestrian-related morbidity in 2006 and mortality rates by age from 2001 to 2010 in Shanghai. The morbidity and mortality rates increased progressively among people aged 15 years old and above (Chi-Square is 41.86, P_{trend} <0.001 for morbidity; Chi-Square is 5178.80, P_{trend} <0.001 for mortality). And there was an increased dramatically trend in the group of aged 45 or above for the morbidity rate and in the group of aged 60 or above for the mortality rate.

Among different age groups of children (age of 0 to 14 years old), the age group of 5-9 has the highest morbidity and mortality. The morbidity rates in the age groups of 0-4, 5-9, and 10-14 years old were 54.95, 59.79, and 30.04 per 100,000 populations respectively. Meanwhile, mortality rates of the age groups of 0-4, 5-9, and 10-14 were 0.96, 1.05, and 0.53 per 100,000 populations respectively.

The rates of mortality and morbidity of labor force groups (age of 15 to 64 years old) were 1.96 per 100,000 populations which accounted for 41.17% of the mortality of all age groups and 187.87 per 100,000 which accounted for 65.21% of the nonfatal injuries of all age groups, respectively. For the age groups of 15-44 and 45-64, the mortality rates were 1.06 and 3.09 per 100,000 populations, accounting for 12.40% and 28.76% of the mortality of all age groups respectively; the morbidity rates were 59.83 and 301.22 per 100,000 populations, which presented 9.75% and 55.46% of the morbidity of all age groups correspondingly. Among different labor force groups, the age group of 60-64 had the highest mortality (5.10 per 100,000 populations) and morbidity (469.31 per 100,000 populations).

Of all pedestrian-related deaths, about 56.79% occurred in the age group of 65 years or above, with the mortality of 13.61 per 100,000 populations. Mortality rates in the age groups of 65-69, 70-74, 75-79, 80-84, and aged 85 or above were 8.70, 12.33, 15.86, 19.02, and 20.38 per 100,000 populations, respectively. Meanwhile, the morbidity rates were 364.30, 480.95, 419.41, 443.95, and 426.44 per 100,000 populations, correspondingly.

Table 1 shows the distribution of pedestrianrelated morbidity rates in 2006 and mortality rates by gender during 2001-2010. The mortality rate of the male was 3.80 per 100,000 populations, about 11.51% higher than that of the female. The morbidity rate of the male was 162.71 per 100,000 populations, and was 69.64% lower than that of the female.

Table 2 presents the distribution of pedestrianrelated injuries in 2006 and deaths during 2001-2010 of people with different educational levels. Pedestrian-related mortality and morbidity had inverse association with victims' educational levels.



Figure 1. Change in income and pedestrian-related mortality, 1992-2010.



Figure 2. Changes in pedestrian-related injuries in 2006 and mortalities by age in Shanghai, 2001-2010.

Those with an educational level under primary more likely to suffer school were from pedestrian-related injuries, accounting for 57.96% of all deaths and 36.36% of the nonfatal cases respectively. This group of people had the highest mortality and morbidity (15.40 per 100,000 populations and 383.78 per 100,000 populations, respectively), compared other with groups (Chi-Square is 68.18, P<0.001 for mortality, Chi-Square is 13.52, P<0.05 for morbidity). Individuals with an educational level of junior middle school or senior high school contributed to 33.35% of all fatalities and 54.55% of the nonfatal cases,

respectively. Individuals with a college or higher degree presented lower rates of pedestrian-related injuries, and only accounted for 6.59 % of fatalities and 9.09% nonfatal cases respectively.

Table 3 presents the association between pedestrian injuries and family average per capita monthly income. There was a significant difference among injured pedestrians with different income. Pedestrians with the family per capita average monthly income lower than 1000 CHY were more likely to suffer from pedestrian-related injuries with the highest morbidity rates (302.97 per 100,000 populations), accounting for 70.00% of all cases.

Fatalities			Non-fatalities			
Gender	n	Proportion (%)	Mortality (per 100,000)	п	Proportion (%)	Morbidity (per 100,000)
Male	2593	52.9	3.80	37	36.36	162.71
Female	2309	47.1	3.41	64	63.64	276.03
Total	4902	100	3.60	101	100.00	220.25

Note. Chi-Square is 14.560, P<0.001 for mortality; Chi-Square is 6.420, P<0.05 for morbidity.

		Fatalities			Non-fatalities		
Educational Level	п	Proportion (%)	Mortality (per 100,000)	n	Proportion (%)	Morbidity (per 100,000)	
Under primary school	2841	57.96	15.40	37	36.36	383.78	
Junior middle school/senior high school	1635	33.35	2.09	55	54.55	207.91	
College degree or above	323	6.59	1.08	9	9.09	132.32	
unknown	103	2.10	1.07	0	0.00	0.00	
Total	4902	100.00	3.60	101	100.00	220.25	

Table 2. Distribution of Pedestrian-related Injuries by Different Educational Level, Shanghai

Note. Chi-Square is 68.18, *P*<0.001 for mortality; Chi-Square is 13.52, *P*<0.05 for morbidity.

Table 3. The Distribution of the Family Average per Capita Monthly Income ofInjured Pedestrians in 2006, Shanghai

Average Per Capita Monthly Income of the Family	n	Proportion (%)	Morbidity (per 100,000)
≤500	15	14.85	277.32
501-1000	55	54.46	308.00
1001-2000	26	25.74	172.73
2001-3000	4	3.96	78.77
3001-5000	1	0.99	64.23
≥5001	0	0.00	0.00

Note. Chi-Square is 570.61, *P*_{trend}<0.001.

Table 4 presents the results of multivariate logistic regression analysis for the factors related to pedestrian injuries. The risk of pedestrian injuries was higher in lower educational level, with the average increase of 1.70-fold OR (95% CI: 1.20-2-40) from higher educational level to lower educational level. Furthermore, the value of average increase of OR for income was 1.40 (95% CI: 1.15-1.71) from higher income to lower income.

Table 5 shows the total costs of pedestrian-related injuries in Shanghai in 2006. In general, the total annual cost was approximately 1,371,239,829 CNY (US\$ 217,478,637). Health care costs were borne directly by victims and/or public agencies/organizations for the medical treatment and relevant care, and were estimated using information of the five different conditions of severity of cases. Total direct medical treatment cost approximately 181,809,030 was CNY (US\$ 28,834,912). In addition, the cost related to lost or impaired ability to work due to pedestrian-related Injury was also estimated. The total productivity loss cost 1,189,430,799 CNY was about (US\$ 188,643,725). During this period, the total of GDP on the healthcare system, social security and welfare industries was 10.125 billion CNY (US\$ 1,605,825,003) in Shanghai, 13.54% of which was allocated and spent to ease the burden of total pedestrian-related injuries.

DISCUSSION

Data from this study indicate that the proportion of pedestrians died of road traffic crashes in Shanghai is higher than the average level of China (25%) and worldwide (22%)^[4]. The pedestrian mortality in Shanghai is 2.45 times as much as that in the United States (1.42 per 100,000 populations, 13.7% of road user death)^[20]. And pedestrian injuries and deaths are not on the decline with the change of time. The burden of total pedestrian-related injuries the individual, families and society on is overwhelming, which contributes to 13.54% of the GDP on the healthcare system, social security and welfare industries in Shanghai. It requires much more attention from emergency medicine physicians, public health experts and policy makers.

Our results suggested that the age of 5-9 years old was the group with the greatest risks for pedestrian-related injuries among children aged 0-14

Table 4. Multivariate Logistic	Regression	Analysis of Fac	ctors Related to	Pedestrian Injuries
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Variables	в	OR (95% CI)	Wald χ^2	P Value
Gender	-0.025	0.98 (0.69-1.37)	0.021	0.886
Age-groups	0.011	1.01 (0.96-1.07)	0.149	0.699
Income	0.338	1.40 (1.15-1.71)	10.940	0.001
Education level	0.530	1.70 (1.20-2.40)	9.011	0.003

Note. Value assigned to variables: for Education, it is that 0, 1, and 2 represent 'College degree or above', 'Junior middle school/Senior high school', and 'Under Primary School'; for Income, 0, 1, 2, 3, 4, and 5 represent '5001 or above', '3001-5000', '2001-3000', '1001-2000', '501-1000', and '≤500', respectively.

Table 5. Estimated Pedestrian-related Ir	njury Costs	in 2006,	Shanghai
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Items	Fees (CHY)	
Total direct medical treatment costs	181,809,030	
Total productivity loss costs	1,189,430,799	
Not go hospital	2,266,440	
From moderate cases who sought medical care but were not admitted in a hospital	75,492,033	
Form serious cases-Hospitalized without permanent disability	142,421,960	
From severe cases with permanent disability	31,058,620	
Inpatients in fatal end	262,878	
From fatal and permanent disability cases aged 15-64 years	937,928,869	
Total costs	1,371,239,829	
The total of GDP of the health, social security and welfare industries	10,125,000,00	
Pedestrian-related injury costs/The total of GDP of the health, social security and welfare industries (%)	13.54	

years. Therefore, more effective programs in keeping child pedestrians safe are needed to be initiated and implemented for this group. Recently, some studies have demonstrated the effectiveness of education approaches for increasing child pedestrian safety. A majority of child pedestrian education utilizes brochures, videos and classroom instruction to teach young children. Often, these programs find an increase in children's knowledge of pedestrian safety but do not show similar gains in increasing children's safety behaviors^[21-25]. One possible explanation for this consistent finding is that psychological theories of learning and more updated child development theories are not often used when developing programs. However, even with training, children under the age of 10 years old should not be unsupervised when they are on or near roads, largely because they do not had the ability to control their impulses and base decisions long-term consequences^[26]. Future on child pedestrian safety education program in China should incorporate motor skill acquisition, which combined instruction about safely crossing the street with enough practice; some supervised and structured experience in real traffic situations, which include positive reinforcement for correct behaviors to ensure that the habit is developed; Vigotsky's zone of proximal development, both peers and adults help children grasp concepts that cannot be achieved alone or through a lecture-type format.

The age distribution of killed or injured pedestrians varies widely in different countries, underscoring the necessity of local data collection and analysis in order to achieve a thorough understanding of the problem at the local level. In the United States in 2010, the fatality rates for pedestrians in the age groups 15-64, and older than 65 years were 0.34 per 100,000 populations and 0.58 per 100,000 populations, and the proportions were 65.08% and 21.79% respectively^[27]. About 57% of pedestrians killed in road traffic crashes in four South African cities were found to be aged from 20 to 44 years^[28]. In Hyderabad, India, 61% of pedestrians involved in road traffic crashes were between 21 and 40 years old^[29]. Our findings indicated that the proportion of pedestrian fatalities among the 15-64 years old adults in Shanghai was lower than the United States (41.17%), but the relevant mortality was 5.80 times as much as that in the United State. The risk of pedestrian-related injuries or deaths began to increase dramatically from the age of 60 for both genders, which

suggested that people in this age group would be the target group of being intervened. In this study, in the calculation of pedestrian-related morbidity, there are only 101 injured persons who were divided into 18 age groups. So the relatively small sample size in some age groups caused the instability of morbidity across age. It is appropriate to enlarge the sample size in study in future.

Pedestrians aged 65 or older are significantly more likely than younger people to be severely injured or death as a result of a collision with an automobile. And it is partly explained by age-related physical changes and their effect on functional abilities of older adults to safely walk and cross the street. With aging, the complexity of the road environment becomes more difficult; in particular, complicated intersections become more risky^[30-36]. Our study identified that older pedestrians were particularly vulnerable. The relevant mortality rate was almost 7 times higher than that in the age groups 15-64. By the end of 2012, the number of the population aged 60 and above in Shanghai increased to 3,673,200, accounting for 25.70% of all age group of people^[37]. If the current fatality rate remains constant, older pedestrians will make up an even larger proportion of all pedestrian fatalities and will impose a commensurate burden on families and health-care systems in the coming years. Positive intervention methods including signal-controlled crossings, area-wide speed reduction, improving the road environment and reflective pedestrian clothing are likely to be effective for older pedestrians^[38].

Our data demonstrated that the trends for pedestrian crashes by gender are somewhat different. Men are more likely to experience fatalities than women, while women are more likely to experience non-fatalities. Male pedestrians have been found to be over-represented in pedestrian collisions^[4,38]. The fatality rate of male pedestrians was 2.84 times as much as that of female pedestrians in 2010, while the nonfatal injury rate of male was 1.60 times as much as that of female in 2000 in the United States^[27,39]. Differences in pedestrian injury rates between genders can be partly explained by differences in exposure; Increase of exposure may lead to the increment of injury rates in lower socio-economic groups. It may also be explained by the fact that more elder women suffer from vision loss due to cataract or macular degeneration, which may contribute to accident risk, or do have a high risk of falling while walking^[40]. However there is virtually lack of available global

data on injured pedestrians.

Our findings showed that the frequency of pedestrian-related injuries was inversely related to victims' educational levels and income, which may be a significant determinant of pedestrian injury in China. Pedestrian injuries affect all people, but have a greater negative impact on those of lower socioeconomic condition specially. Individuals with these backgrounds are easily to be affected in a greater percentage, and have fewer social supports in place and less frequency in the use of emergency services^[4,41-46]. The over-representation in pedestrian injuries among those from lower socioeconomic standing may be explained by the limitations in their access to health promotion and care, less supervision for their children, cultural-related differences and perceptions related to safety and public health. Some Chinese people have not accepted the perception that pedestrian collisions (like other road traffic crashes) are evitable and preventable. Although increasingly being recognized, there is little research focus on investigating the relationship of the educational level, income and pedestrian-related injuries in China.

In the prevention and control of pedestrianrelated injury, community-based comprehensive and more effective programs need to be initiated and implemented. In China, a responsibility system of family doctors is integrated into the current health system reform. The family doctor offers personalized care and whole-process health management through setting up a long-term relationship with contracted families. This platform can provide better public health services in a unique way. Therefore comprehensive programs for prevention and control can be added to this platform to reduce the related risk factors of pedestrian-related injury.

CONCLUSIONS

Age, gender, educational Level, and income are the significant risk factors for the morbidity and mortality of pedestrian-related injuries in Shanghai. Children aged of 5-9 years old, adults over 60 with an educational level lower than primary school and with lower family income are the target populations which should be implemented preventive strategies in order to reduce the pedestrian injuries. One-seventh of the GDP on the healthcare system, social security and welfare industries is allocated to ease the burden of pedestrian-related injuries in Shanghai. More effective programs in keeping pedestrians safe should be integrated into the service system of family doctors for implementing intervention activities and reducing the risk of pedestrian injuries.

CONFLICT OF INTEREST STATEMENT

None declared.

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