Study on the Trend and Disease Burden of Injury Deaths in Chinese Population, 2004–2010

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Abstract

Injuries are a growing public health concern in China, accounting for more than 30% of all Person Years of Life Lost (PYLL) due to premature mortality. This study analyzes the trend and disease burden of injury deaths in Chinese population from 2004 to 2010, using data from the National Disease Surveillance Points (DSPs) system, as injury deaths are classified based on the International Classification of Disease-10th Revision (ICD-10). We observed that injury death accounted for nearly 10% of all deaths in China throughout the period 2004–2010, and the injury mortality rates were higher in males than those in females, and higher in rural areas than in urban areas. Traffic crashes (33.79–38.47% of all injury deaths) and suicides (16.20–22.01%) were the two leading causes of injury deaths. Alarming, suicide surpassed traffic crashes as the leading cause of injury mortality in rural females, yet adults aged 65 and older suffered the greatest number of fatal falls (20,701 deaths, 2004–2010). The burden of injury among men (72.11%) was about three times more than that of women’s (28.89%). This study provides indispensable evidence that China Authority needs to improve the surveillance and deterrence of three major types of injuries: Traffic-related injury deaths should be targeted for injury prevention activities in all population, people aged 65+ should be encouraged to take individual fall precautions, and prevention of suicidal behavior in rural females should be another key priority for the government of China.

Introduction

Various types of injuries collectively are a growing public health issue which has become an important cause of death throughout the world. Injuries kill more than five million people worldwide in 2000, accounting for nearly one of every 10 deaths [1]. Around the world, about 16,000 people die every day as a result of an injury [2,3]. Among the causes of injury are acts of violence, road traffic crashes, assault, drowning, falls and poisoning. The deaths caused by injury have a serious impact on the families and communities, where life is often irrevocably changed by these tragedies. According to the World Health Organization (WHO), over 90% of injury-related deaths occurred in low- and middle-income countries in 2004 [4].

China is a developing country with the largest population in the world. Meantime, China’s rapid economic growth has been accompanied by substantial changes in modes of transport, lifestyle and so on, all of which cause many unexpected issues and problems. For instance, in the past two decades, the main transportation mode has changed from animal carts and bicycles to motor vehicles, it is estimated that about 55 thousand new motor vehicles are registered in China every day [5]. The population is ageing; as the proportion of the population aged 65 and above grew from 7.0% to 8.9% throughout the period of 2000–2010 [6]. Moreover, the gap between the rich and the poor is widening; by 2004, the gross domestic product per person in the richest province was 13 times greater than that in the poorest province [7]. All these contribute to the astonishing reality that injury has silently grown to be the fourth leading cause of death in China [8]. Injuries now are an additional public health threat in China, causing at least 800,000 deaths and 50 million non-fatal damages each year, of which 2.3 million cases lead to disability with varying degrees of severity [9,10] and the hefty medical expenses that cost the taxpayers 65 billion RMB every year [11]. In addition, injury is also the leading cause of death in China from age 1–39 [12], causing annual loss of 12.6 million potentially productive years of life, a loss greater than for any disease group [13]. The estimated annual economic cost of injury is almost 4 times the total public health services budget in China. Considering the status quo of China’s injury scenarios and its rapid societal change, the drive for injury prevention and safety promotion need to be further strengthened, and there is an urgent need for the development of a national injury prevention/safe community program.

This study was designed to look at the distribution and trend of injury deaths from 2004 to 2010 in China by criterions such as age, gender, urban/rural residence and regions. We further performed a detailed analysis of China-specific characteristics of the leading causes of injury-related mortality, providing some scientific basis for preventing injury and death incidences. The results will serve to national injury prevention strategies, and,
Results

Basic Information of Injury Deaths in China, 2004–2010

In the DSPs system, the rates and proportions of death from injuries in China are categorized by gender, age and geographical region, respectively. In this investigation, among 73 million people investigated per year from 2004 to 2010, more than 400,000 people died of all causes every year except for the year 2006 (Table 1). The number of deaths caused by injuries accounted for about 10% of all deaths in China during the study period and the total number of injury deaths was 25,858–32,281 in rural areas and 8,645–11,815 in urban areas (2004–2010). The number of injury deaths among rural males was 18,029–22,195 persons/year, which was the highest among groups of different areas, followed by rural female and urban male groups. The number of injury deaths in urban female group was the lowest, 2,912–4,081 persons/year.

Demographic Trend of Injury Mortality Rates (/100,000/year) by Gender and Urban/Rural Residence in China, 2004–2010

The injury mortality rate in males was consistently high during the 7 years (Figure 1), in the range of 70.21–82.18 deaths per hundred thousand per year. This was much higher than the rate in females, more than twice as high (Table 2). The injury mortality rate in rural areas was also consistently high in the same time period (Figure 1), in the range of 60.06–68.03 deaths/100,000/year, about 1.37–1.64 times higher than the rate in urban areas (Table 2).

Linear regression analysis showed a gradual decline in both males and females during the study period, with the regression coefficient was −1.70 and −1.41, respectively (p<0.05). However, the differences were not statistically significant between the rates of rural male and female groups (p>0.05) (Table 2).

The Proportion Dissection of Standardized Injury Mortality by Leading Causes in the Overall Injury Deaths in China, 2004–2010

The number one leading cause of death from injury was road traffic crashes, accounting for 33.79 to 38.47% of all injury deaths during the period 2004–2010 in China; the second was suicide, accounting for 16.20% to 22.01%; and the third was fall, accounting for 11.98% to 14.22%. These top three causes are jointly responsible for 61.97% to 74.02% of all injury deaths. Other leading causes, including drowning, poisoning and assault account about 17% of injury deaths. Proportions of all the leading causes in the gross injury deaths have not significantly changed throughout the study period (p>0.05) (Table 3).

We further assessed the differences among different groups from respective urban/rural areas (Table 4). Overall, the top six leading causes were: traffic crashes, suicide, fall, drowning, poisoning and assault, both in urban and rural areas. Traffic crashes caused the most serious life loss with the highest standardized mortality rates, ranging 12.05–15.73 (deaths/100,000/year) in urban areas and 19.78–22.91 in rural areas. Surprisingly, there was a tendency of a decreasing demographic features from 2004 to 2010 for traffic, drowning, poisoning and assault deaths in urban areas, with the regression coefficients ranging from −5.60 to −3.08 (p<0.05). However, in rural areas, though a decreasing trend of suicide and assault was observed (p<0.05), flat trends of the standardized injury mortality rates generated by road traffic crashes, fall, drowning and poisoning only contributed a non-significant rate decrease throughout the period 2004–2010 (p>0.05).

Top Three Leading Causes of Average Injury Mortality by Urban/Rural Areas and Gender, China 2004–2010

The injury mortality rate was 62.89±3.90 in rural areas and 42.24±4.76/100,000/year in urban areas throughout the period 2004–2010. Injuries killed 85.53±4.48 rural residents per 100,000 people a year, approximately 1.5 times higher than the rate of urban residents. Traffic crashes was the number one leading cause of injury deaths in urban areas; followed by fall and suicide for urban males; for urban females, the suicide was the second leading cause of injury deaths, followed by falls. For rural males, traffic crashes killed 34.35±1.86 per 100,000 people a year, 1.5 times higher than the rate of urban males. Nevertheless, the rate of suicide surpassed the rate of road traffic crashes, claiming the number one leading cause of injury mortality in rural females (Table 5).

Demographic Trend of Injury Mortality Rate by Age in China, 2004–2010

We further assessed the demographic trends of the diverse injury mortality rates by the criterion of age (Figure 2A and B). The injury mortality rate was 14.68–18.03 deaths/100,000/year in 5–14 year-old age group, the lowest among all age groups. The

| Table 1. Basic information of injury deaths in China, 2004–2010. |
|-----------------------------------------------|
| Year  | 2004  | 2005  | 2006  | 2007  | 2008  | 2009  | 2010  |
|-------|-------|-------|-------|-------|-------|-------|-------|
| Total people surveyed(*million) | 71.17 | 71.49 | 73.78 | 71.48 | 75.14 | 75.67 | 75.67 |
| Total number of death | 430994 | 437490 | 347058 | 401008 | 424683 | 437550 | 453211 |
| Death caused by injury | 43979 | 43774 | 34503 | 39114 | 40581 | 40447 | 40321 |
| Urban | 11815 | 11493 | 8645 | 10459 | 10041 | 10597 | 10922 |
| Male | 7734 | 7573 | 5733 | 7069 | 6782 | 7181 | 7346 |
| Female | 4081 | 3920 | 2912 | 3390 | 3259 | 3416 | 3576 |
| Rural | 32164 | 32281 | 25858 | 28655 | 30540 | 29850 | 29399 |
| Male | 22195 | 22162 | 18029 | 20210 | 21290 | 21008 | 20862 |
| Female | 9969 | 10119 | 7829 | 8445 | 9250 | 8842 | 8537 |

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rates were similar between 1–4 and 15–24 year age groups. During the study period, the injury mortality rate was 35.49–56.39 deaths/100,000/year in the zero-year-old age group and 33.79–44.00 deaths/100,000/year among 25–34 year-old adults. The rates then further increased to 48.33–64.64 and 59.47–75.38 deaths/100,000/year for 35–44 year-old and 45–64 year-old age groups, respectively. The injury mortality was 164.24–210.32 deaths/100,000/year in the 65+ year age group, the highest among all age groups (Figure 2A). Injury accounted for 58.35% of all deaths in the 5–14 year-old age group; meanwhile, injury deaths accounted for some 43.48% of all deaths among 1–4 year-old children and 42.41% among 15–44 year-old individuals, respectively. However, only about 3.92% of deaths were caused by injuries in the group of people aged 65 and beyond (Figure 2B).

Top Six Causes of Death for Assorted Age Groups in China, 2004–2010

Drowning, road traffic crashes and falls represented the top three leading causes of injury deaths for children under one-year-old. For 1–4 year-olds, the three leading causes of injury deaths were traffic crashes, falls and drowning, while drowning surfaced as the leading cause of injury mortality for 5–14 year-old youths. For 15 to 64 year-old people, the number one leading cause of injury deaths was due to road traffic crashes. Starting at age 65, fall and suicide were the two most prominent causes of injury deaths (Table 6).

Table 2. Injury mortality rates (100, 000/year) by gender and urban/rural residence in China, 2004–2010.

| Year | Regression coefficient \( \beta \) | \( t \) | \( p \)-Value |
|------|----------------------------------|-------|----------|
| Total | 61.79 | 61.23 | 52.27 | 54.72 | 54.89 | 53.91 | 51.19 | 1.52 | 3.04 | 0.029 |
| Gender | | | | | | | | | | |
| Male | 82.18 | 81.35 | 70.49 | 74.76 | 74.34 | 73.63 | 70.21 | 1.70 | 2.67 | 0.044 |
| Female | 40.42 | 40.19 | 33.25 | 33.84 | 34.59 | 33.37 | 31.39 | 1.41 | 3.67 | 0.014 |
| Region | | | | | | | | | | |
| Urban | 49.44 | 47.88 | 40.60 | 42.61 | 38.83 | 39.75 | 36.63 | 2.02 | 5.10 | 0.004 |
| Male | 63.77 | 62.21 | 53.23 | 56.83 | 51.91 | 53.28 | 48.74 | 2.30 | 4.52 | 0.006 |
| Female | 34.68 | 33.14 | 27.67 | 28.00 | 25.46 | 25.91 | 24.26 | 1.71 | 0.93 | 0.002 |
| Rural | 68.03 | 67.98 | 57.82 | 61.06 | 63.54 | 61.73 | 60.06 | 1.10 | 1.71 | 0.148 |
| Male | 91.38 | 90.90 | 78.60 | 84.03 | 86.21 | 84.69 | 83.10 | 1.06 | 1.33 | 0.242 |
| Female | 43.37 | 43.80 | 35.95 | 36.91 | 39.59 | 37.54 | 35.80 | 1.13 | 2.33 | 0.067 |

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Demographic Trend of Injury Rates by Geographic Characteristics Analysis of Injury Deaths in China, 2004–2010

In general, injury mortality rates increased gradually from east to west (Figure 3). The injury mortality rate in eastern region was 51.76 ± 4.74 deaths/100,000/year, which was lower than that of western region (61.04 ± 5.28 deaths/100,000/year) (p < 0.01). Similarly, the injury mortality rate in central region was 55.79 ± 3.28 deaths/100,000/year, which was also lower than that in western region (p < 0.05). The injury mortality rate in western urban region was 48.66 ± 5.28, in central urban region 44.25 ± 4.87 and in eastern urban region 37.74 ± 4.38 deaths/100,000/year. The injury mortality rate in western rural region was 66.05 ± 5.67 deaths/100,000/year, which was the highest among all the subgroups differed by geographical divisions.

Life Lost Caused by Injuries

In this survey, 218,763 persons died of injuries in China throughout the period 2004–2010, but males suffered almost triple the PYLL as females did. Injuries caused 5,036,969 PYLL in males and 1,949,464 PYLL in females. For each fatal injury, AYLL was 31.14 years in males and was 34.20 years in females, respectively (Table 7).

Discussion

According to World Health Organization (WHO) prediction, by the year 2020, injuries will be responsible for even more morbidity, mortality and disability, with significant socioeconomic impact on the developing countries [14]. As a developing country, it is essential for China to measure injury losses for the productive working population [13]. This study investigated the injury deaths in China from 2004 to 2010 and found important prototypes, disparities and trends in injury mortality rates and patterns by the criteria of urban/rural residency, gender, age and geographic location. Furthermore, this report also provided scientific evidences for the strategic policies and blueprints designed to restrain injury deaths in future.

Our results showed that about 10% of all deaths had resulted from injury-related causes, and 7.5% occurred in rural China, which was lower than the rate 8.9% in rural South Africa 2000–

Table 3. The proportion dissection of standardized injury mortality by leading causes in the overall injury deaths during 2004–2010 in China.

| Cause     | 2004 Rank | %      | 2005 Rank | %      | 2006 Rank | %      | 2007 Rank | %      | 2008 Rank | %      | 2009 Rank | %      | 2010 Rank | %      | p-value |
|-----------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|--------|
| Traffic   | 1         | 33.83  | 1         | 33.79  | 1         | 34.89  | 1         | 38.47  | 1         | 36.99  | 1         | 37.89  | 1         | 38.00  | 0.387  |
| Suicide   | 2         | 22.01  | 2         | 20.39  | 2         | 19.34  | 2         | 18.40  | 2         | 17.28  | 2         | 17.09  | 2         | 16.20  | 0.205  |
| Fall      | 3         | 11.98  | 3         | 12.86  | 3         | 14.34  | 3         | 13.57  | 3         | 13.49  | 3         | 13.95  | 3         | 14.22  | 0.698  |
| Drowning  | 4         | 8.74   | 4         | 8.92   | 4         | 8.63   | 4         | 7.97   | 4         | 7.93   | 4         | 8.10   | 4         | 7.96   | 0.683  |
| Poisoning | 5         | 5.49   | 5         | 5.58   | 5         | 5.38   | 5         | 4.91   | 5         | 5.43   | 5         | 5.87   | 5         | 5.94   | 0.803  |
| Assault   | 6         | 2.78   | 6         | 2.62   | 6         | 2.31   | 6         | 2.24   | 6         | 1.78   | 6         | 2.10   | 6         | 1.81   | 0.528  |
| Others    | -         | 15.17  | -         | 15.84  | -         | 15.21  | -         | 14.44  | -         | 17.10  | -         | 15.00  | -         | 15.87  | 0.875  |
| Total     | -         | 100.00 | -         | 100.00 | -         | 100.00 | -         | 100.00 | -         | 100.00 | -         | 100.00 | -         | 100.00 | -       |

Table 4. Standardized injury mortality rates (/100,000/year) by leading causes of death in China, 2004–2010.

| Causes of death | Year | Regression coefficient B | t   | p-Value |
|-----------------|------|--------------------------|-----|---------|
| Urban Traffic   | 2004 | 15.73                    | 15.07 | 12.69    | 14.55 | 13.31 | 13.01 | 12.05 | -0.52 | -3.28 | 0.022 |
|                 | 2005 | 8.71                     | 7.36 | 5.87    | 5.61 | 4.75 | 5.12 | 4.46 | -0.66 | -5.43 | 0.003 |
|                 | 2006 | 6.17                     | 6.17 | 5.61    | 5.33 | 5.02 | 5.46 | 5.52 | -0.14 | -2.31 | 0.069 |
|                 | 2007 | 3.45                     | 3.34 | 2.73    | 2.81 | 2.43 | 2.57 | 2.30 | -0.19 | -5.60 | 0.003 |
|                 | 2008 | 2.95                     | 2.78 | 2.25    | 2.17 | 2.03 | 2.38 | 2.01 | -0.14 | -3.08 | 0.027 |
|                 | 2009 | 1.93                     | 1.61 | 1.30    | 1.18 | 0.85 | 0.96 | 0.73 | -0.26 | -4.50 | 0.006 |
|                 | 2010 | 22.59                    | 22.63 | 19.78    | 22.91 | 22.26 | 22.16 | 21.72 | -0.04 | -0.18 | 0.868 |
| Suicide         | 2004 | 8.71                     | 15.11 | 14.11    | 11.08 | 11.11 | 10.55 | 10.05 | 9.16 | -0.95 | -5.98 | 0.002 |
|                 | 2005 | 6.92                     | 7.46 | 7.02    | 7.00 | 6.95 | 7.60 | 7.33 | 0.05 | 0.98 | 0.370 |
|                 | 2006 | 6.42                     | 6.49 | 5.35    | 5.12 | 5.30 | 5.55 | 5.25 | -0.19 | -2.42 | 0.060 |
|                 | 2007 | 3.38                     | 3.49 | 4.10    | 2.68 | 3.11 | 3.22 | 3.25 | -0.07 | -0.82 | 0.449 |
|                 | 2008 | 1.56                     | 1.55 | 1.11    | 1.19 | 0.98 | 1.21 | 1.05 | -0.84 | -2.78 | 0.039 |

*Standardized to China standard population for the year 2000.

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The demographic trends of the diverse injury mortality rates by the criterion of age. (A) The demographic trends of injury mortality by the criterion of age; (B) The proportional mortality rate caused by injury by the criterion of age.
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number of vehicles, road traffic injury has become a serious public health concern in China [11]. Although in 2007, the Development and Research Center of Chinese State Council published a report that identified several major shortfalls that were responsible for road traffic injury in China, including lack of safety standards in road construction, and ambiguities in road safety laws and regulations [27]. In particular, the mortality rate caused by road traffic crashes failed to show any tendency of decline. In summary, careless male drivers in rural areas, vehicle overloading, speeding, drink/drunk driving, obsolete safety regulations, limited access to urgent care and/or poor quality of care in the rural areas imply lift up the risks of traffic injury mortality.

Overall, the number one leading cause of injury death was road traffic crashes, followed by suicide and falls. Suicide injuries emerged as the most common injury category for rural areas. During 2004–2010, suicide injury mortality rate for rural males and females was $13.08\pm2.07$ and $11.42\pm1.93$ deaths/100,000/year, respectively. Although the rate in rural females was lower than that of rural males, suicide has become the number one causes of injury mortality for rural females. In this report, the suicide rate of rural females was 1.76 times higher that of urban females, distinctively different from the panoramas in high-income countries, where differences in urban and rural suicide rates are marginal and vary only by locations [28]. China and India are the two biggest political entities where absolutely top numbers of suicides exist [29]. Young women in rural areas in both countries are at especially high risk of dying by committing suicide, accounting for about a third of all mortality cases of the age group; and the common methods of suicide is self poisoning with pesticides [30]. In China, the demographic, social, and psychological issues have been assumed as universal risk factors for suicide, much different from the findings in the high-income countries where suicidal behavior is almost always associated with a mental illness, such as depression [31]. Furthermore, there are no strong religious or legal prohibitions against suicide, so people with serious mental disorders or chronic life stressors might commit suicide to relieve themselves from misery and emotional burden [32]. Shan et al have indicated that reasons for attempted

| Rank | 0 year | 1–4 years | 5–14 years | 15–24 years | 25–34 years | 35–44 years | 45–64 years | 65+ years |
|------|--------|-----------|------------|-------------|-------------|-------------|-------------|-----------|
| 1    | Drowning | Traffic crashes | Drowning | Traffic crashes | Traffic crashes | Traffic crashes | Traffic crashes | Falls      |
| 2    | Traffic crashes | Falls | Traffic crashes | Suicide | Suicide | Suicide | Suicide | Suicide |
| 3    | Falls | Drowning | Falls | Drowning | Falls | Falls | Traffic crashes |
| 4    | Poisoning | Poisoning | Suicide | Falls | Poisoning | Drowning | Poisoning |
| 5    | Assault | Assault | Poisoning | Poisoning | Drowning | Poisoning | Poisoning |
| 6    | Suicide | Suicide | Assault | Assault | Assault | Assault | Assault |

| Total | Urban | Rural |
|-------|-------|-------|
|       |       |       |

Figure 3. Demographic trend of injury mortality rates (/100,000/year) by geographical divisions in China, 2004–2010. Mortality rates in eastern, central and western regions are compared, respectively. Compared to eastern regions, *p<0.05, **p<0.01; Compared to central regions, # p<0.05.
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Table 7. Person Years of Life Lost and Average Years of Life Lost of injury by gender in China, 2004–2010.

| Year | PYLL (person years) | AYLL (years) |
|------|---------------------|--------------|
|      | Male | Female | All | Male | Female | All |
| 2004 | 796,621 | 333,444 | 1,132,065 | 31.95 | 34.96 | 33.46 |
| 2005 | 780,859 | 318,894 | 1,099,753 | 31.77 | 34.92 | 33.34 |
| 2006 | 619,903 | 238,028 | 857,931 | 31.48 | 34.09 | 32.79 |
| 2007 | 710,180 | 264,718 | 974,898 | 31.34 | 34.21 | 33.78 |
| 2008 | 715,094 | 275,448 | 990,542 | 30.73 | 33.97 | 32.35 |
| 2009 | 714,550 | 263,665 | 978,215 | 30.59 | 34.11 | 32.35 |
| 2010 | 697,762 | 254,266 | 952,028 | 30.12 | 33.15 | 31.64 |
| Total | 5,036,969 | 1,949,464 | 6,985,432 | 31.14 | 34.20 | 32.67 |

Our results show that lack of awareness of traffic regulations, poor road conditions, suicide and drowning are leading risk factors of fatal injuries in China. Males, rural area, and western region should be the key targets for injury prevention policies. More psychological counseling and health education should be performed for rural females. Also, there is an earnest need for injury prevention policies for elderly residents, regarding falls and suicide. Moreover, it is critically important to develop policies and programs that can deliver effective measures in the high risk populations and areas.

Data and Methods

Data Source

Data of this study obtained from Death Surveillance Data Sets, which were summarized in the National Disease Surveillance Point (DSPs) system and compiled by Chinese Center for Disease Control and Prevention (CDC). The DSPs system covers 1% representative sample of China’s population in 31 provinces, autonomous regions and municipalities, which is epitomizes the characteristics of Chinese population. Causes of death were classified according to the International Classification of Diseases-10th Revision (ICD-10) (World Health Organization, 1992). We disaggregated the data by age (≤0, 1–4, 5–14, 15–24, 25–34, 35–44, 45–64, ≥65+) [37], gender and major geographic focus (East, Central, West). We also portrayed rate trends for the six leading causes of injury throughout the study period. The age-adjusted mortality rates were cited from the DSPs, whose direct standardization procedure employed China standard population of the year 2000 as the referent.

Geographical Divisions and Population Geography

According to the classification of the National Statistics Bureau, China is divided into 22 provinces, 4 municipalities (Beijing, Shanghai, Tianjin and Chongqing), 5 autonomous regions (Guangxi, Ningxia, Xizang, Xinjiang and Neimenggu), and 2 special administration regions (Hong Kong and Macau). Moreover, according to the first national economic census, China is divided into three regions: eastern, central and western regions (Figure 4). More than half of the secondary and tertiary industry units are concentrated in the eastern regions, and the number of units displays a decreasing trend from east to west. There are economic gaps between the eastern and central and western regions in China. The economy in the eastern region of China is considerably stronger than those in other regions [38,39].

Data Analysis

Epidata 3.1 was used for data input, as statistical software SPSS 20.0 (SPSS, Inc., Chicago, IL, USA) was used for data analysis. Rates and proportions were the main indexes of the study. Age- and gender-specific mortality rates per 100,000 person-years were calculated using the methods suggested by Rothman and Greenland [40]. For comparison purposes, the age- and gender-specific mortality rates by category of injury were also calculated as well. Chi-square test was used for examining the eastern, central and western regions differences in injury mortality. When the assumptions for the chi-square test were violated, it was replaced by Fisher’s exact test. Time trends were calculated using linear regression analysis. $p<0.05$ was selected as the statistically significant level.

Formula and calculation [35]: Person Years of Life Lost ($\text{PYLL} = \sum_{i=1}^{N-1} d_i(N-i)$, Average Years of Life Lost ($\text{AYLL} = \sum_{i=1}^{N-1} d_i N_i$)
\[
(\text{AYLL}) = \frac{\text{PYLL}}{\sum d_i}, \quad I = \text{age at death}; \quad d_i = \text{number of deaths at age i}; \\
N = \text{upper cut-off age, 71 for males and 75 for females were adopted, respectively.}
\]

Author Contributions
Conceived and designed the experiments: LZ CJ JL. Performed the experiments: LZ ZL. Analyzed the data: LZ. Contributed reagents/materials/analysis tools: XL LZ JZ. Wrote the paper: LZ.

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Figure 4. Map of China with geographical divisions. A map shows the locations of eastern, central and western regions divided by geographical position. Red: eastern region; blue: central region; white: western region. doi:10.1371/journal.pone.0085319.g004
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