Research Highlight

The Nationwide Impact of Injury-related Deaths on Average Life Expectancy in China*

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To expand the evidence base to inform future public policy aimed at accident prevention, we investigated the impact of different categories of injury on average life expectancy in China. We used data from the National Death Cause Registration Information System and National Maternity and Children Health Surveillance databases, as well as 2010 population data from the National Bureau of Statistics. We then calculated the average life expectancy of the Chinese population, in addition to life expectancy after eliminating injury-related mortality. The average life expectancy of the Chinese population in 2010 was 74.93 years. After eliminating deaths due to injuries, the fourth leading cause of mortality in China, average life expectancy increased by 1.36 years. When this was broken down by population sub-groups, these gains were 1.76 and 0.79 years in men and women, 0.94 and 1.56 years in urban and rural residents, and 1.11, 1.30, and 1.67 years for residents in the Eastern, Central and Western regions respectively. After eliminating all categories of injury, the average life expectancy of the Chinese population was found to increase by 1.36 years. This figure was higher for males and residents of rural areas and Western China.

Mortality and morbidity due to injury is not only an important public health issue but also has significant social and economic costs. The World Health Organization (WHO) estimates that around one in ten (or 9.8%) of deaths worldwide in 2004 were injury-related. Furthermore, injuries were responsible for 12% of the total global disease burden, as calculated by loss of disability-adjusted life years[1].

In China, 62 million people require medical treatment for injuries every year, accounting for around 4% of the total hospital caseload nationwide. Furthermore, deaths caused by injuries have been shown to account for around 10% of total mortality. In 2005, injuries were the cause of 732 000 deaths in China, making injury the fourth most common cause of death across the whole population and the most common cause of death among children, adolescents and those of working age[2-3]. It has been estimated that the direct economic burden due to injuries in China was 77.45 billion Yuan in 2005, with further indirect economic costs of 275.06 billion Yuan in the same year[4]. Furthermore, because injuries mainly occur in young adults, injury-related deaths not only result in considerable loss to individuals and families but are also a substantial burden for the wider society and the country as a whole, thereby impeding social and economic development.

Life expectancy has been widely used as an overall indicator for evaluating the health of populations over time. It was not until the beginning of the 20th century, however, that cause-elimination life tables were adopted for evaluating the effects of specific diseases on population health and overall life expectancy[5]. Calculations using cause-elimination life tables are based on the hypothesis that if a specific cause of mortality is eliminated then the resulting reduction in life expectancy is also removed. The greater the mortality risk posed by a specific disease, the greater the resulting population-averaged loss of life years-and the greater the increase in life expectancy after it is eliminated. The resulting indicator is invaluable for a number of reasons. First, it can be used to generate a straightforward measure of the impact of a specific cause of death on overall life expectancy. Second, given that the effects are measured independently of a population's age structure, this measure of life expectancy can not only illustrate the overall effect of a specific cause of death on the population-level, but can also be used to evaluate its impact in different age groups and make direct comparisons between populations or sub-groups.

A one-year increase in average life expectancy is one of the major targets to be achieved during China's Twelfth Five-year plan for national economic

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and social development[6]. As one of the leading causes of death in China, injury-related mortality has a substantial impact on national life expectancy figures. Estimating the effects of different categories of injury on overall life expectancy is therefore important in informing future policies and developing targeted prevention and intervention strategies to reduce both the incidence of injuries and the resulting injury-related mortalities.

Few studies have been undertaken to estimate the impacts of injury on life expectancy in China, however, and few of these have been carried out at a national level[4,7-16]. We therefore undertook the present study to investigate the burden of injury-related mortality on the Chinese population as a whole.

Data Sources

Mortality data were extracted from the National Death Cause Registration Information System, a database designed to give a nationally-representative sample by collecting data from 161 Disease Surveillance Points (DSPs), each of which was a county-level district[17]. Information on all deaths, including cause of death, was collected annually from each of these 161 surveillance sites. The total population across all sites was 81 million, accounting for around 6% of the total national population. While ICD-10 was used to code for cause of death, the present analysis was based on data from 2010. For children under five years of age, we used 2010 mortality data provided by National Maternity and Children Health Surveillance. National Maternity, a population-based surveillance system implemented in 334 counties, is designed to give a nationally-representative sample of the Chinese population[18]. Data on the size of the population in each district in 2010 was provided by the National Bureau of Statistics.

Given that underreporting is likely to occur in any surveillance system, resulting in an underestimation of true mortality rates, it was essential to adjust the crude mortality figures. Furthermore mortality figures for children under five years of age are more likely to be subject to underreporting than those of other population groups. We therefore divided the study population into two age groups, those aged 0-5 years and those aged six years and above, and separately adjusted mortality rates for each group.

For the population aged six years and above, we used rates of underreporting from the Underreporting Survey of DSPs Death Surveillance for the years 2006-2008 to adjust our crude mortality rates by applying the following formula:

$$\text{Adjusted mortality rate} = \text{Crude mortality rate} / (1-\text{rate of underreporting}) \quad (1)$$

For the population aged six years and over, adjustment was performed separately for different groups, categorized according to gender, urban or rural district, and region of residence, using the rate of underreporting for each individual sub-population.

Calculation of Life Expectancy

Life expectancy was calculated using adjusted mortality rates. To calculate life expectancy after eliminating injury-related mortality, we subtracted injury deaths from total deaths and used this new figure to calculate average life expectancy using the normal procedure[19].

Life expectancy figures were also estimated for different sub-populations and according to different categories of injury to investigate their influence on life expectancy in different sub-groups according to age (0-5 years and 6 years and above), district (urban and rural districts) and region of residence (Eastern, Central and Western China). District type and region were classified according to the standard conventions used by the National Bureau of Statistics of the People's Republic of China[20].

Average Life Expectancy of the Chinese Population

In 2010, the average life expectancy of Chinese residents was 74.93 years. Life expectancy among females was found to be 77.60 years, higher than that in males (72.50 years). At the same time, life expectancy of urban residents was estimated at 76.87 years, higher than the figure of 73.70 years for rural residents. Finally, the average life expectancies of residents in Eastern, Central and Western China were 76.44, 74.41, and 73.30 years respectively.

Increases in Life Expectancy after Eliminating Injury-related Mortality

After eliminating injury-related deaths, the average life expectancy of Chinese population was 76.26 years. The increase in life expectancy was estimated at 1.36 years, suggesting that injuries represent the third most common cause of death after cardiovascular disease and cancer (Figure 1).

When broken down by gender, the average life expectancies for males and females were 74.26 and 78.39 years respectively-representing increases of

1.76 years for males and 0.79 years for females. These figures were 77.81 years for urban residents and 75.26 years for rural residents, with increases of 0.94 and 1.56 years respectively. When broken down by region of residence, the estimated average life expectancies of residents in Eastern, Central and Western China after eliminating injury-related mortality were 77.55, 75.71, and 74.97 years, representing increases of 1.11, 1.30, and 1.67 years respectively.

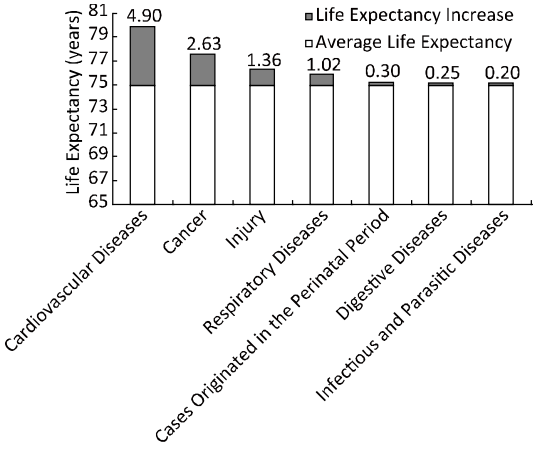

Figure 1. Life expectancy of Chinese residents after eliminating major causes of death, 2010.

Finally, our comparison of different age groups showed that the gains in life expectancy after eliminating injury-relayed mortality fell gradually as age increased. Our results indicated that injuries had no impact on life expectancy among those aged 80 years or above (Table 1, Figure 2).

Analysis of the Relative Impacts of Different Categories of Injury

Among the categories of injury analyzed, we found that the gains in average life expectancy were highest after eliminating road traffic injury (RTI), followed by suicide, drowning and falls. This held true for all age groups. After eliminating RTI, the overall increase in average life expectancy among Chinese residents was 0.53 years. When broken down by population sub-groups, these figures were 0.75 for males, 0.27 for females, 0.38 for residents of urban districts, 0.62 for residents of rural districts, and 0.49, 0.51, and 0.61 years for residents in Eastern, Central and, Western China respectively (Tables 2 and 3).

Table 1. Increases in Life Expectancy for Different Age Groups After Eliminating Injury-related Mortality, 2010

Age (years)	Average Life Expectancy (years)	Injury eliminated Life Expectancy Increase (years)	Life Expectancy Increase (Years Old)							
			Injury	Road Traffic Injury (RTI)	Suicide	Fall	Drowning	Poisoning	Violence	Fire
0	74.93	76.25	1.32	0.53	-	0.13	0.16	0.08	0.03	0.01
1-5	74.61	75.90	1.29	0.53	-	0.13	0.16	0.08	0.03	0.01
5-10	70.84	72.04	1.20	0.51	-	0.13	0.11	0.07	0.03	0.01
10-15	65.94	67.08	1.14	0.50	0.17	0.12	0.08	0.07	0.03	0.01
15-20	61.04	62.12	1.09	0.48	0.17	0.12	0.06	0.07	0.03	0.01
20-25	56.17	57.18	1.01	0.44	0.16	0.12	0.05	0.06	0.02	0.01
25-30	51.35	52.25	0.89	0.38	0.15	0.11	0.04	0.06	0.02	0.01
30-35	46.54	47.33	0.79	0.33	0.13	0.11	0.04	0.05	0.01	0.01
35-40	41.78	42.46	0.68	0.27	0.12	0.10	0.03	0.04	0.01	0.01
40-45	37.06	37.64	0.58	0.22	0.11	0.09	0.03	0.04	0.01	0.01
45-50	32.46	32.93	0.47	0.17	0.09	0.08	0.02	0.03	0.01	0.01
50-55	27.96	28.33	0.37	0.13	0.08	0.07	0.02	0.02	0.00	0.01
55-60	23.54	23.84	0.30	0.10	0.07	0.06	0.02	0.02	0.00	0.01
60-65	19.30	19.53	0.23	0.06	0.06	0.05	0.01	0.01	0.00	0.00
65-70	15.39	15.56	0.16	0.04	0.04	0.05	0.01	0.01	0.00	0.00
70-75	11.76	11.87	0.11	0.01	0.03	0.04	0.01	0.00	0.00	0.00
75-80	8.54	8.60	0.06	0.00	0.02	0.03	0.00	0.00	0.00	0.00
80-85	5.69	5.69	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
85-	3.26	3.14	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00

Furthermore, the increases in life expectancy after eliminating deaths resulting from other categories of injury, including suicide, drowning, falling, poisoning, violence and fire, were found to be higher in males than in females, and among residents of rural districts compared with those living in urban areas. In addition, eliminating these causes of death had the greatest estimated effect for residents of Western China when compared with Central and Eastern China. Eliminating suicides, however, resulted in the greatest increase in life expectancy for residents of Central China when compared with other regions.

For the population over 60 years of age, however,

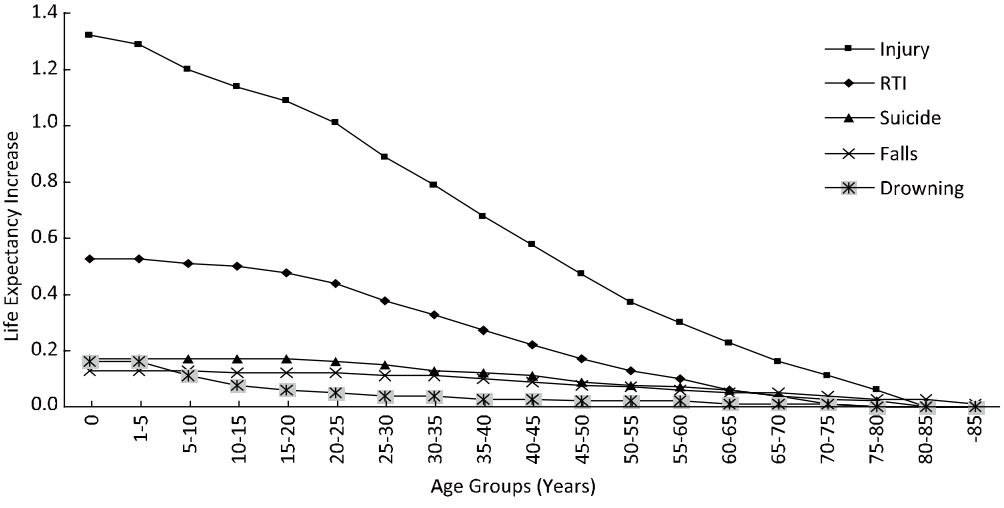

Figure 2. Increases in life expectancy by age group after eliminating different categories of injury, 2010. RTI is an abbreviation for road traffic injury.

Table 2. Increases in Life Expectancy by Gender After Eliminating Injury-related Mortality, 2010

Rank	All		Male		Female	
	Injury Type	Life Expectancy Increase	Injury Type	Life Expectancy Increase	Injury Type	Life Expectancy Increase
1	RTI	0.53	RTI	0.75	RTI	0.27
2	Suicide	0.17	Drowning	0.21	Suicide	0.17
3	Drowning	0.16	Suicide	0.17	Drowning	0.10
4	Falling	0.13	Falling	0.17	Falling	0.08
5	Poisoning	0.08	Poisoning	0.10	Poisoning	0.05
6	Violence	0.03	Violence	0.04	Violence	0.02
7	Fire	0.01	Fire	0.02	Fire	0.01

Table 3. Increases in Life Expectancy by District Type and Region of Residence after Eliminating Injury-related Mortality, 2010

Rank	Urban Areas		Rural Areas		Eastern Region		Central Region		Western Region	
	Injury Type	Life Expectancy Increase	Injury Type	Life Expectancy Increase	Injury Type	Life Expectancy Increase	Injury Type	Life Expectancy Increase	Injury Type	Life Expectancy Increase
1	RTI	0.38	RTI	0.62	RTI	0.49	RTI	0.51	RTI	0.61
2	Suicide	0.12	Drowning	0.22	Suicide	0.14	Suicide	0.20	Drowning	0.25
3	Falling	0.12	Suicide	0.20	Drowning	0.12	Drowning	0.17	Suicide	0.18
4	Drowning	0.10	Falling	0.14	Falling	0.11	Falling	0.12	Falling	0.17
5	Poisoning	0.10	Poisoning	0.09	Poisoning	0.05	Poisoning	0.07	Poisoning	0.12
6	Violence	0.02	Violence	0.03	Violence	0.02	Violence	0.03	Violence	0.05
7	Fire	0.01	Fire	0.02	Fire	0.01	Fire	0.02	Fire	0.01

eliminating mortality due to RTI, suicides and falls had little effect on estimated life expectancy. Furthermore, as age increased, the impacts of RTI (after 75 years) and suicide (after 80 years) on life expectancy tended towards zero-although mortality due to falls increased. Finally, we observed that eliminating mortality due to drowning had a greater impact than eliminating deaths due to falls among children under five years of age (Table 1, Figure 2).

Discussion

Previous work on the effects of eliminating different causes of death on average life expectancy has mostly concentrated on developed countries. At the same time, few studies have investigated these effects in China, particularly at a national level. However, all of these previous studies, regardless of their country of origin, have found that average life expectancy increased after eliminating the effects of different injuries[7-16,21-28]. Our results also show that death due to injury had the most significant influence of on life expectancy after circulatory system diseases and cancers-indicating that injury prevention is a major public health issue in China.

Our results show that the increase in average life expectancy for the Chinese population as a whole after eliminating injury-related mortality was 1.36 years, a figure higher than that for the majority of developed countries. Furthermore, results from other countries have also shown that potential gains in life expectancy are higher among men than women. Two studies by Rockett[21-22] have used data on injury deaths from 11 developed countries with populations of less than 15 million and a GDP per capita of more than $13 000 where average life expectancy exceeded 75 years. These studies concluded that, although female life expectancy was generally higher, the increase in life expectancy ranged from 0.88 to 2.15 years for males and 0.45 to 1.09 years for females after removing injury-related deaths. However, the potential impact of eliminating all injuries in developing countries is higher than that for developed counties. A study conducted by Manuel et al.[23] using mortality data from Ontario, Canada suggested that the life expectancy of male and female residents increased by 0.7 years and 0.5 years respectively after eliminating all categories of injury. As the same, work carried out by Conti et al.[24] showed that life expectancy increases for male and female Italians after eliminating all types of injury were 0.87 and 0.40 years respectively. However, injury-related mortality has been shown to be a more significant public health issue in developing countries. A study conducted among residents of Hai Duong Province in Vietnam estimated the impact of six categories of disease on life expectancy during the period 1997-1998. While overall life expectancy was 73.82 years among the participants studied, this figure increased by 1.41 years after the eliminating injury-related deaths[25].

Of all the categories of injury evaluated, our results showed the greatest increase in average life expectancy after eliminating mortality due to road traffic injuries, which represented the most common cause of injury-related mortality in all age groups. Furthermore, our results are consistent with those found in other counties. For example, the same two studies by Rockett[21-22] have also concluded that eliminating motor vehicle accidents had the greatest impact on life expectancy of all the causes of injury evaluated, followed by suicide. At the same time Tsai et al.[26] have also estimated potential gains in life expectancy after eliminating deaths due to motor vehicle injury in the United States using data provided by the National Center for Health Statistics covering the period 1969-1971. The results showed that average life expectancy at birth would increase by 0.7 years, a figure higher than that for most developing counties. Finally, a previous study by Mba[27] found that the average life expectancy of South Africans would increase as much as 17 years if road traffic injuries and suicides were eliminated.

While few studies of the effects of injuries and other causes of mortality on life expectancy have been conducted in China, their results need updating. An analysis based on retrospective survey data from the National Health Services (NHS) in China[4] showed that average life expectancy increased by 1.89 and 1.62 years in 1992 and 2005, respectively, after eliminating injury deaths. These results, which are higher than the potential gain of 1.36 life years found in our study, indicate a downward trend in rates of injury-related deaths over the past twenty years-suggesting that these results need to be validated and followed up over time. Furthermore, the NHS data also showed a higher burden of injury-related mortality in rural areas. In 2005, loss of life years due to transport accidents was found to be 0.33, lower than our figure of 0.53. A comparison of these results suggests that RTI deaths in China have increased during the past 5 years.

Consistent with previous studies[25-26,28], our results show that as age increased, the loss of life years due to different categories of injury gradually decreased, suggesting that injury was a more

common cause of death in young people. Of all the categories of injury evaluated, the impact of RTI was found to be highest in almost all age groups. For children and older adults, however, drowning and falls respectively had the greatest effect on life expectancy.

Research on the impact of injury on life expectancy could provide further evidence to inform the development of disease prevention strategies and for improving the allocation of health resources to maximize the effectiveness of health services at increasing life expectancy and promoting health. Improved injury prevention is likely to make a significant contribution to achieving the Chinese government's goal of increasing the average life expectancy by one year. To be maximally effective and to promote health equity, future interventions should focus on the male population, in addition to residents of rural districts-particularly those in Western China. Measures to reduce RTI, suicide and drowning should also be emphasized. Moreover, prevention strategies and measurements of their effectiveness should consider the specific characteristics of different population sub-groups. For example, interventions targeted towards children and older adults should place greater emphasis on preventing drowning and falls.

While cause-elimination life expectancy tables have primarily been used to evaluate the impact of different causes of death on population health, their results cannot be used to evaluate the impact of different diseases on the prevalence of disability or quality of life. Furthermore, it has been estimated that while injury causes 1% of all annual deaths in China, it is also responsible for 0.13%-1.1% of all disabilities[2]. Our results therefore cannot fully reflect the impact of injury on health. To address this limitation, measures such as Disabled Adjusted Life Years (DALY), Health Adjusted Life Expectancy (HALE) and other more comprehensive indicators are being increasingly used to evaluate the impact of different diseases on population health.

Our results did not account for the effects of competing risks, however, which may have resulted in overestimations of the impact of injury-related deaths on overall life expectancy[29-30]. To remedy this issue, a new indicator to account for competing risks of mortality should be developed.

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