Existing Disparities in Injury-related Mortality Rates in China: A Public Health Challenge

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Abstract: Injury-related mortality is a major public health concern worldwide. Globally, about 16,000 people die from injury-related causes every day. In China, after malignant tumors, cardiovascular diseases and respiratory disorders–injury ranks as the fourth leading cause of death. These mortality rates associated with injury are disproportionately higher according to demographic factors such as age, gender, geographical location, and occupation-demonstrating a need for public health interventions among these groups. Increase in injury-related mortality rate leads to loss of productivity and serious economic burden, such as 3.5 million hospitalizations with total annual economic loss of approximately U.S. $12.5 billion-almost four times the Chinese public health budget. Our paper aims to explore the current trends in the area of injury- related deaths, disparities associated with demographic factors along with cultural factors unique to China, and identify possible approaches that may reduce associated public health implications.

Our literature review identified problems in the existing injury prevention programs in China such as: (a) China has two mortality registry systems and both have high rates of missing data, problematic content validity, and persistent issues with data management; (b) There is a lack of knowledge among the public health practitioners who do not consider injury prevention as a public health goal, an area that requires immense improvement; (c) Neither do medical schools have any structured courses to deal with injury prevention nor does CDC consider this issue as a routine job; (d) There is a dearth of training programs for injury prevention at the provincial and central level, thereby, creating a shortage of specialized workforce; (e) Underreporting of Road Traffic Injury (RTIs) data especially in rural areas points to a surveillance system of questionable quality.

These existing disparities need to be addressed promptly with a particular focus on the rural population. Evidence-based models such as Haddon's matrix and Public Health Approach may be used to develop injury control and prevention programs along with enforcement of strong governmental policies.

Keywords: China, Injury control, Injury prevention, Health disparity, Haddon's matrix.

INTRODUCTION

Injury-related mortality is a major public health concern worldwide [1]. Globally, about 16,000 people die from injury-related causes every day. In China, after malignant tumors, cardiovascular diseases and respiratory disorders-injury ranks as the fourth leading cause of death [2]. Further, the mortality rates associated with injury are disproportionately higher for diverse factors across age, gender, geographical location and occupation-demonstrating a need for public health interventions [3]. Such injury-related deaths, disparities associated with age, gender, and geographic regions create various public health implications.

Since the last half century, the disease control measures in The People's Republic of China could be divided into three phases [4]. The first phase focused on the control of acute infectious diseases, which either were caused by microbes, parasites or were endemic in nature. The second phase witnessed a continued emphasis on acute infectious diseases accompanied by increased rates of chronic diseases, and elevated numbers of the geriatric population. However, a period of rapid urbanization and economic growth marked the beginning of the third phase. This stage was associated with a steep rise in the injury-related mortality rates. Until the 1950s, these rates were ranked ninth but became fourth during the 1990s. The increase in injury-related mortality rate leads to loss of productivity and serious economic burden; thereby making this issue a major public health concern and demanding immediate consideration for governmental interventions [5].

The causes of injury-related deaths can be divided into intentional and unintentional injuries. Unintentional injuries would include road traffic injuries (RTIs), drowning, falls, poisoning, suffocation, electrocution, fire, cutting injury, natural disaster and crushing injuries; while intentional injury comprises of suicide and murder [6]. The risk factors for injury-related death rates include increased construction projects, changes in the mode of transport accompanied by exponential growth in traffic, extensive exposure and acceptance of

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western culture and lifestyle habits, and exponential growth of the manufacturing units, to name a few [4-7].

In China, injuries account for almost 10% of all deaths. In comparison to developed countries, these injury death rates are nearly double. It has been estimated that each year injuries account for about 750,000 deaths, 3.5 million hospitalizations, and 12.6 million annual loss in productive years of life, which is the highest loss compared to any other disease group [8, 9]. It is important to note that the total annual economic loss due to injuries is about U.S. $12.5 Billion—almost four times the Chinese public health budget [9]. Despite wide-ranging health and economic implications, injury- related fatalities remain an under-recognized and neglected problem among low and middle-income countries [10] and a public health challenge in China. Our paper aims to explore the current trends in the area of injury-related deaths, disparities associated with demographic factors along with cultural factors unique to China, and identify possible solutions for reducing associated public health implications.

Epidemiological Trends for the Injury-Related Deaths

Several research studies indicate that injury mortality is associated with per capita Gross Domestic Product (GDP) in an inverted U-shaped pattern [7]. This relation means that injury mortality rates rises with the increase in the per capita GDP of a country. Interestingly, accompanied by continued economic growth-the injury mortality rate begins to fall after the GDP crosses a threshold point. This may be associated with advancement in the nation's healthcare system, industrial safety features to reduce injuries, increased occupational and safety health regulations, and laws for seat belt usage. Considering that China's economic development has propelled the country's GDP by 77 times and surged the foreign exchange reserves by 10,000 times, injury mortality rates have also risen in a similar pattern [4]. In fact, epidemiological trends for both intentional and unintentional injuries have been linked to a country's growing economic status [4, 11].

According to World Health Organization (WHO), the three major sources of injuries in China are RTIs, suicide, drowning and falls [6, 7, 12]. Studies have shown a massive increase by 97 times in deaths due to RTIs during the period of 1950 to 1999 [13]. In 2010, about 65,000 deaths due to RTIs were reported [13]. This increased rate of RTIs is caused by dangerous driving behaviors such as fatigued drivers, as well as high traffic law violations such as drunk driving and speeding [14]. Similarly, deaths by suicide are a public health concern with an overall national rate of 9.8 per 100,000 people [15], and these rates are even higher in rural areas [6]. Surprisingly, due to a 57% decrease in suicidal rates, the injury-related mortality rates have dropped by 17% [6]. However, these decreasing rates of suicide may be due to missing data and incorrect classification. Further, 35% of suicidal deaths and 60% of attempted suicides are not caused due to mental illness as seen in Western countries. Specific suicidal risk factors unique to China are "*chronic and acute psychosocial stressors (particularly family conflicts, impulsive personality traits, and poor conflict-resolution skills).*" 6(pg55)

The high rate of injury-related deaths in China is different among various demographic groups. Using the Ministry of Health vital registration (MOH-VR) system during 2002-06, Wang *et al*. [2008] estimated a yearly 846,510 total deaths from all injury deaths, which constitute about 10% of all deaths. A national injury death rate of 65 deaths per 100,000 people was calculated, and this mortality rate accounts for almost 30% of all potentially productive years of life lost (PPYLL) [6]. However, these rates differ significantly based on age, gender, housing, education, socioeconomic status, and occupation [3, 6, 13, 16, 17]. Rebholz *et al*. [2011] showed in their study that demographic variables- like old age, male gender, rural residence area and no education background are related to higher mortality rates from an external cause of injury. In particular, miners in China who are mostly males with limited education and low socioeconomic status, face disproportionately high mortality rates [18]. Even though coal miners comprise only 4% of the entire workforce, they account for nearly 45% of total occupational mortality and morbidity rates. Such high numbers indicate a need for studying these patterns according to different demographic variables.

Age

The injury-related death rate among the Chinese children aged less than 15 years is 39 per 100,000 people, and it accounts for almost 26% of all deaths [6]. In younger children aged less than 15 years–drowning is the major cause of mortality among all unintentional injuries [19, 20]. Zhao *et al*. [2012] noted that injuries such as RTIs, suicide and falls accounted for 40% of the deaths in the population aged 1-34 years. The age group of 15-44 years has an injury mortality rate of 58 deaths per 100,000 people, which accounts for 41% of all deaths [6]. Among this specific age group, RTIs are the leading cause of death. In the 45-64 years age group an estimated 68 deaths per 100,000 people (10% of all deaths) [6].

Injury rates are disproportionately higher in rural areas [6]. Various factors cause such high rate of drowning among children such as: (a) lack of parental supervision of children, (b) absence of barriers around water sources like river, dams and septic tanks, (c) no prior knowledge of swimming, and longer travel distance to medical facility [19]. Among middle-aged individuals–RTIs and suicide are the major causes of injury while suicide accounts for 34% of all deaths due to injury in older adults [6]. For ages 65 and older, the mortality rate increases to 158 deaths per 100,000 people but accounts for 3% of total deaths. Rising stress levels due to increased socio-economic conditions and rapid urbanization have been considered as suicidal risk factors among older adults [15].

Gender

There has been a considerable difference seen between gender as men are 1.9 times more likely to die from injury than women [6]. Again, such differences are much more pronounced at urban-rural level [17]. Studies have found suicide as the major cause of injury-related deaths among Chinese woman aged 15 years and above, which is a deviant from the general trend in most other countries [21]. Such high numbers are attributable in women due to rising conflicts and changing social and environmental conditions. Pressures to adhere within traditional boundaries and regulations of Confucianism and marriage, contrary to growing female social and economic foothold in modern world, may be attributed as sources of depression and suicide in Chinese women [6, 22].

The RTIs are the leading cause of death among men and according to estimates by Ma *et al*. [2012]–about 77% of the casualties from RTIs primarily occurred in men. A possible explanation may be that the Chinese drivers are more likely be males rather than females [23]. As mentioned before, male occupation can have serious implication over their life course. For example, injuries are leading causes of death in miners aged less than 50 years and fourth leading cause among those aged above 50 years [18, 24].

Geographical Factors-Urban Vs. Rural

Studies have consistently shown the existence of disparity for injury-related deaths due to geographical factors, with the rates being twice for rural areas compared to urban areas [17, 25, 27]. Significant changes in the rates of injury-related deaths have occurred in the past two decades [6]. Rural males have shown the highest increase in injury rates by 6% while it reduced by 45% among the urban females.

Hu *et al*. [2010] reported a difference of 47% for injury-related death rates in rural males compared to urban males. Among women, these death rates are about 33% higher in rural women compared to urban women. These differences become more pronounced when the rates were adjusted according to age groups. Injury death rates among a rural male child aged less than one year are three times than those of an urban male child. A similar pattern is seen for females especially for the suicide and drowning rates.

These findings indicate a great need for interventions specifically aiming at unintentional suffocation, drowning, and suicide. According to Wang *et al* [2008], impulsive yet unintended ingestion of lethal pesticides in rural areas is a common suicidal means. Compared to rural males, females exhibits a low-intent suicidal pattern that inadvertently leads to higher injury rates. Lastly, higher rates of mortality has been found among the urban migrant workers and it is vastly linked to the unsafe workplace environment [28]. This population makes up for almost 90% of the workforce at unregulated construction places and a significant number of 83,196 injuries are reported within this group.

DISCUSSION

A country's political, social and economic changes hold the capacity to lessen the mortality rates [7]. China has witnessed a massive increase in the injury-related deaths; however, more research needs to be done on prevention measures and policies. It is interesting to note that due to successful injury prevention strategies, countries like Sweden, the Netherlands, and the UK have decreased deaths due to RTIs by 60%, and Australia has reduced deaths from drowning by 80% [6]. Successful examples include Vision Zero program in Sweden where "*road safety is improved gradually until, over time, the vision is achieved*" [29 (p8)]. Another strategy used in Netherlands utilizes selective traffic implementation for increased seat-belt uptake as they "*involve well-publicized, highly visible and intensive enforcement over particular periods, several times per year*" 29 (p32). Thus, some of the successful strategies developed by high-income countries can be identified and locally adapted for Chinese communities and systems.

Various studies have identified problems gaps in the existing injury prevention programs. First, China has two mortality registry systems-Ministry of Health vital registration (MOH-VR) and Disease Surveillance Points (DSP) system [6]. However, both systems have high rates of missing data, problematic content validity, and persistent issues with data management. Further, RTIs surveillance data is collected by two additional systems–police reported data and National Surveillance System (NISS) [13]. Second, the public health practitioners who do not consider injury prevention as a public health goal, an area that requires immense improvement [29]. In fact, according to the latest Chinese CDC injury prevention reports, only about 1,000 public health practitioners in China are trained in injury prevention [29]. Third, neither do medical schools have any structured courses to deal with injury prevention nor does Chinese CDC considers this issue as a part of its routine job [29]. Fourth, there is a dearth of training programs for injury prevention at the provincial and central level, thereby, creating a shortage of specialized workforce. Fifth, underreporting of RTIs data especially in rural areas points to a surveillance system of questionable quality [30]. Solutions to listed shortcomings can only be appropriately addressed with strong government support and initiatives and application of public health injury models [6, 28].

Public Health Implications

Based on the identified gaps in knowledge, several important steps may help in reducing injury-related deaths and bridge the existing gaps within the system. Some of the steps postulated are: (a) Increasing collaboration among different government agencies to work towards a common goal of development of preventive measures especially in rural communities [6]; (b) Improving the surveillance system for effective reporting of injury-related deaths [6]; (c) Revising the traffic regulations for increasing usage of helmets, strict rules for seat belt usage and enhancing safety measures for roads in rural areas [7, 31]. Emphasis on strict adherence to laws may further aid in injury control; (d) Enforcing stricter laws of supervision of children under 12 years of age especially in dangerous conditions like swimming without supervision and safe handling of packages containing hazardous contents [7]; (e) Monitoring occupational health safety at the workplaces and educating the workers about safety regulations especially construction workers [7, 28]; (f) Addressing the shortage of specialized workforce of doctors, nurses and public health professionals-focusing on injury prevention [29]; (g) Mobilization of government resources, institutional partnerships with rural communities and inclusion of injury prevention as a key issue in "National Mid-& Long–term Science and Technology Development Planning Outline" (2006-2020) [6, 7].

Various prevention programs for injury control have incorporated the theoretical foundations of Haddon's Matrix [32]. This matrix comprises of rows and columns based on primary, secondary, and tertiary prevention. The rows are representative of different events of an injury–pre-event, event, and post-event while columns signify factors, which may impact these events-environment, host, and agent. Further, primary prevention refers to disease prevention interventions and strategies; secondary preventions focuses on early disease detection; and tertiary prevention denotes managing disease effects [33].

An example of Haddon's matrix usage is provided in Table **1**. According to this matrix, environment refers to the physical environment (place of injury) or a social environment (sociocultural norms). Host or human column may refer to the person(s) at injury risk. An agent may indicate vehicle (object causing injury) or vector (person or an organism that may cause injury). Detailed applied examples in selected studies for both intentional and unintentional injuries are provided in Table **2**. Haddon further introduced ten counter-measures (see Table **3**) for injury control and prevention [34]. Studies have documented diverse prevention measures from flood management, cancer control from smoking to gun control [35, 36]. However, efforts are still needed for developing Chinese injury prevention programs based on Haddon's matrix. A study conducted by Kwong (2004) pointed to a lack of knowledge about Haddon's matrix among Hong Kong traffic engineers, which might impact designing of injury control prevention programs [37]. Haddon's matrix may also be helpful in serving as template for designing future government policies and strategies.

Table 1: Usage of Haddon's matrix [32]

Phases	Host/Human	Vehicle/Vector	Environment (Physical or Social)
Pre-event			
Event			
Post event			
Results			

Table 2: Application of Haddon's Matrix to Injury Control

Type of injury	Phase	Host	Agent/Vehicle	Physical Environment	Social Environment
Pedestrian injury from vehicles [38]	Pre-event	-Drunk driver -Drunk pedestrian -Aged pedestrian -Pedestrian with conditions such as osteoporosis	-High speed vehicle -Worn out tires -Work out vehicle brakes	-Slippery pathways -Improper street lights -Damaged roads -Night	-Lack of traffic law enforcement -Unsafe crosswalks
	Event	-Pedestrian with earphones -Pedestrian with hearing disability	-Vehicular motion	-Hospitals nearby	-Laws encouraging passerbys to help
	Post-event	-Care received by victim -Psychological aftermath on victim	-Injury severity -Psychological impact severity	-Availability of rehabilitation services	-Family and community support -Health insurance support
Elderly injury [39]	Pre-event	-Delayed reflexes -Decreased judgment of distances -Vision problems	-Condition of automobile -Presence of hazardous material such as firearms	-Placement and prominence of traffic signals -Placement and visibility of hazardous materials -Highway designs	-Voluntary license surrender -Healthcare screening for at-risk drivers
	Event	-Seat belts use -Conditions such as osteoporosis	-Air-bag deployment -Amount of tablets in bottle	-Guard rails -Highway barriers -Seat belt laws	
	Post-event	-Beta blocker medication -Comorbid conditions	Fuel tank durability Medication half-life	-Insurance coverage for follow-up appointments	-Rehabilitation services in vicinity
Children falling on playgrounds [35]	Pre-event	-Instructing children to follow safety guidelines	-Constructing equipment which can be handled by children safely and without slipping	-Constructing sliding boards	-Enforcing social norms in playground for maintaining proper conduct on playground
	Event	-Demonstrating different ways of falling that reduce injury	-Reducing sharp protrusions and edges of equipment on which children might fall	-Designing playground with resilient surface	-Enforcing community-watch for safe playground
	Post-event	-Teaching different help protocols and resources after falling (e.g. emergency call phones)	-Designing equipment and areas from where children can be rescued easily by emergency health workers	-Building sitting areas for caretakers so as to provide good visibility of children and the time they might fall	-Sustaining emergency personnel situations by maintaining funding
Agricultural women farmers [40]	Pre-event	-Legs fall short to reach the tractor pedal	-Difficulty in pedaling	-Rainy climate, aiding as secondary help to farmer husband	

	Event	-Improper shoes	-Slipping of foot from pedal or brake	-No protection gear to prevent tractor rollover	-Tipping of tractor due to uneven surface
	Post-event	-Pre-existing conditions such as diabetic foot	-Farmers wife pinned under tractor after injury	-Emergency aid not in vicinity	
Construction injury [41]	Pre-event	-Orientation of workers regarding tools and safety procedures -Systematic scheduling of workers shift to provide ample time to complete work -Random drug testing of workers -Conducting hazard analyses	-Regularly cleaning debris from worksite -Protecting workers from hazardous materials and chemicals -Correct labeling of containers -Regular inspections for any violations -Availability of required tools	-Project planning -Regular site inspection -Regular cleaning of debris from worksite -Temporary worksite modifications such as handrails -Anti-slip flooring for worksite	-Orientation of workers regarding tools and safety procedures -Regular safety trainings Regular cleaning of debris from worksite -Correct labeling of containers -Enforcing safety guidelines in workplace -Random drug testing at workplace -Electrical boxes and equipment correctly labelled
	Post-event	-Procedures established for emergency first aid -Guidelines establishes for immediate medical care if needed -Modified work shifts available for injured workers	-Due investigation conducted into the accident in accordance with safety guidelines	-Due investigation conducted for preventing future injuries by enforcing worksite modifications	-Providing medical attention to injured workers -Providing alternate work shifts for injured workers -Conduct investigations for identifying and remedying primary cause of injury

Table 3: Haddon's 10 Countermeasures [34, pg. 171]

Countermeasure 1	Prevent the creation of the hazard
Countermeasure 2	Reduce the number of the hazard brought into being
Countermeasure 3	Prevent the release of the hazard
Countermeasure 4	Modify the rate of release of the hazard from its source
Countermeasure 5	Separate the hazard from that which is to be protected by time and space
Countermeasure 6	Separate the hazard from that which is to be protected by a physical barrier
Countermeasure 7	Modify relevant basic qualities of the hazard
Countermeasure 8	Make what is to be protected more resistant to damage from the hazard
Countermeasure 9	Begin the counter damage done by the hazard
Countermeasure 10	Stabilize, repair, and, rehabilitate the object of damage

CONCLUSION

Mortality rates in China from injuries have risen during the past fifty years with a differential distribution according to age, sex, occupation, and geographical location. These existing disparities needs to be addressed promptly with a particular focus on the rural population. Evidence-based models such as Haddon's matrix and CDC's Public Health Approach model may be used to develop injury control and prevention programs [42]. Research has indicated that most of the WHO and The World Bank recommended initiatives for injury prevention are not only effective, but also locally adaptable, realistic and economical [7]. The Safe Community-a community intervention recommended by the WHO, has a cost-benefit ratio of 1:10 and has been currently adapted in 35 Chinese communities [4]. The concept of safety promotion follows a top down approach-meaning that crucial steps of adoption, promotion, and financing fall under the jurisdiction of the government. Thus, strong governmental policies are important for successful functioning of this model and the steps taken to adopt "The Safe Community" are in the right direction. However, there is insufficient literature reporting its long-term effectiveness in China. With the development of efficient interventions and regulations, China can build a well-organized public health framework to prevent injury-related deaths, which will not only create safer communities but also set an example for other developing countries.

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