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Original Article

Disease Burden Evaluation of Injury and Poisoning in China from 2009 to 2019

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Abstract

Background: We aimed to analyze the differences and changing trends of mortality of Injury and Poisoning (IP) between urban and rural areas and gender in China to find out the influencing factors and to propose improvement measures.

Methods: IP mortality, population, economy, medical and health information data came from the official website of the National Bureau of Statistics, and basic data on education level came from the Chinese Ministry of Education. Then the differences of the mortality of IP were compared between different areas and gender in China from 2009 to 2019, and the relationships between the mortality changes of IP and education level, GDP per capita, the numbers of practicing physicians, health institutions and urbanization rate were also explored by establishing a ridge regression model.

Results: The mortality of IP in rural areas was significantly higher than that of urban areas, and in male was higher than that of female (both $P<0.001$). Primary school graduates, GDP per capita, the number of practicing physicians, health institutions and urbanization rate had strong correlations ($r_{min}=-0.622$) with the mortality of IP. Ridge regression model showed that there was a quantitative relationship between primary school graduates, GDP per capita, the number of practising physicians, health institutions, urbanization rate and the mortality of IP in China.

Conclusion: As the difference of working nature, economic development imbalance, psychological and gender, the mortality of IP was significantly different, so the state should take more effective measures to develop the urban and rural areas balanced, and reduce the IP risk in some particular occupations.

Keywords: Mortality; Injury and poisoning; Gender difference; Urban and rural areas

Introduction

Injuries were one of the leading causes of death and disabilities and became a major public health concern worldwide, about 5.8 million people died each year because of injuries, accounting for 10% of all deaths (1-3). Injury-related mortality accounts for more than 90% of the total mortality in Low- and Middle-Income Countries (LIMCs) (4). China is one of the LIMCs. Rapid economic development, urbanisation, motorisation, ageing, and environmental and lifestyle changes over the past three decades, have led to injury being reported as the fifth leading cause of death, only after malignant neoplasms, cerebrovascular dis-

ease, respiratory diseases, and heart attacks in China (5,6).

Poisonings also constituted a major public health problem worldwide, and they were one of the major causes of patient admissions to emergency departments and intensive care units, especially in developing countries (7). There were 315 000 fatalities due to poisoning in the earth. However, this number accounted for 2% of the total reported cases of poisoning globally (8), meaning that the majority of cases are ignored and the number of known cases is only the tip of the iceberg. According to 2015 global burden of disease data statistics, 90.4% of accidental poisoning deaths occurred in LIMCs (9). Unfortunately, by 2016 the situation had not improved, with 67,454 more unintentional poisoning deaths in 2016 than in 2015, according to WHO (https://www.who.int/data/gho/publications/world-health-statistics). Poisoning was also an important health problem, especially in the developing countries (10,11).

IP (Injury and Poisoning) have caused a heavy burden of disease in China and even around the world and the waste of most medical resources, so it had attracted widespread worldwide attention. A large number of past studies on IP showed that its intervention effect is better than other diseases (4,7), and studying its prevention has practical public health significance. The composition of IP systems varies slightly in different countries, so this paper aims to analyze the changing trend of IP mortality in China, explore its related factors, and propose feasible measures to reduce the burden of IP diseases. In this paper, the combination of mortality of IP was discussed and analyzed as an index, because the National Bureau of Statistics of China combines the two data.

This study reports details of changes in IP mortality rates in China from 2009 to 2019. We aimed to test the hypothesis that IP mortality rates vary between regions and between genders. We also aimed to reveal the trends and possible influencing factors for mortality of IP among different regions and gender, and give some target preventative suggestion for policy makers in China, even for some other similar developing countries besides China.

Methods

Data source

This longitudinal study was based on the national data of China for the time period from 2009 to 2019. Data were extracted from the National Bureau of Statistics (http://www.stats.gov.cn/english/) and the Ministry of Education of the People's Republic of China (http://en.moe.gov.cn/). Data extraction and analyses were used a two-track process, one researcher (Xiuli Hu) was responsible for extraction and statistical analyses, another researcher (Miao Qi) to verify the accuracy of data and reviewed the results of analyses. The information includes the mortality of external causes of IP. The mortality of IP included urban, rural and male and female. Demographic characteristics data, education level, GDP (gross domestic product, GDP)-per-capita, health institutions data, health personnel data. Our analyses did not include the data of Taiwan, Hong Kong, and Macau as the data of these areas are not available.

Study variables

The independent variables in the ridge regression model explaining the mortality of IP included the following variables: education level, GDP-per-capita, the number of practicing (assistant) physicians, health institutions and urbanization rate. The details of related definitions could be found from the website of National Bureau of Statistics of China.

The number of regular primary school graduates from 2009-2019 was based on the sum of the number of male and female regular primary school graduates.

Statistical analysis

Annually frequency of mortality from IP (including urban, rural and male and female) were used as the basic variable to conduct statistics and analysis. Microsoft Excel 2019 and SPSS statisti-

cal software (ver. 25.0, IBM Corp., Armonk, NY, USA) were used for data entry, management and analyses. Evaluation of differences in the mortality of IP between areas and between genders by using t-tests. Pearson correlation analysis had been used to explore the correlation between IP mortality data and variables like population, economy, education, healthcare and more. As a serious collinearity among independent variables existed, then a more feasible ridge regression model was established to explore possible influencing factors of the mortality of IP (including its area and gender subgroups). Continuous and normal data were represented by mean ± standard deviation. All tests were two-tailed, and $P<0.05$ was considered statistically significant.

Results

The number of health technicians, practicing (assistant) physicians and registered nurses per 100,000 persons increased steadily in 2009 to 2019 (Fig. 1).

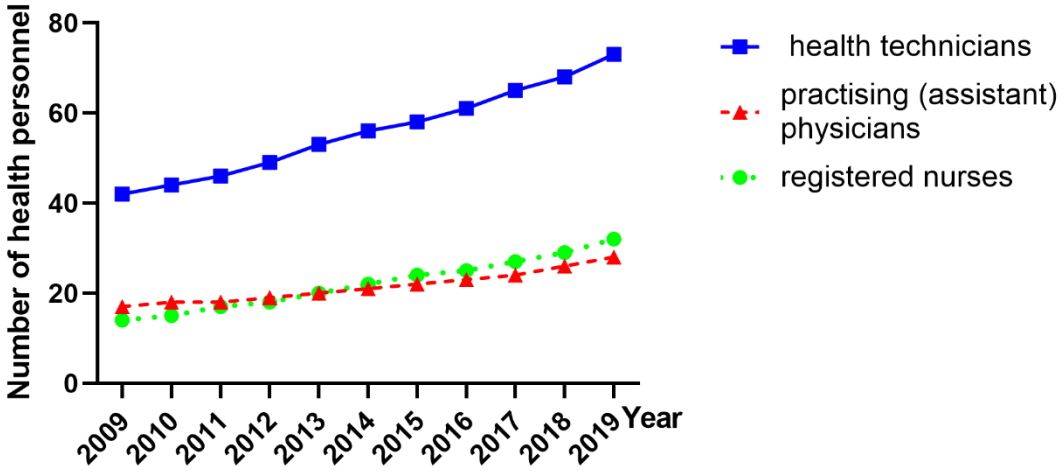

Fig. 1: Trends in the number of health personnel per 10,000 population, 2009-2019

Between 2009 and 2019, the fluctuation of the mortality of IP in urban and rural areas was obvious. For the last 11 years, the number of deaths due to IP in rural areas generally declined, while the number of deaths in urban areas was the opposite, by 2018 and 2019, IP kill more people in urban areas and rural areas (Fig. 2).

There was a difference in the mortality of IP of urban and rural between 2009 and 2019. And the mortality of IP of rural areas had been higher than that of urban areas (54.39±2.40 in rural, 36.66±1.51 in urban). Especially in 2012, the mortality of IP's gap between urban and rural reached its peak, and after that year, the difference between urban and rural the mortality of IP gradually narrowed.

Between 2009 and 2019, there were fluctuations in the mortality rate of sexual mortality of IP between male and female in urban areas. Overall, the mortality of IP of male fluctuated more sharply, and during the past 11 years, the mortality of IP of male was much higher than that of female (46.96±2.74 in urban male, 25.72±1.05 in urban female). We observed a significant increase (8.23 per 100,000) in the mortality of IP of male in urban areas during the period 2009-2013, while there was no significant fluctuation in the mortality of IP of female during this period. After 2013, there was a significant decrease in the mortality of IP of male urban (6.82 per 100,000), during which there was still no significant fluctuation in the IP of female (Fig. 3).

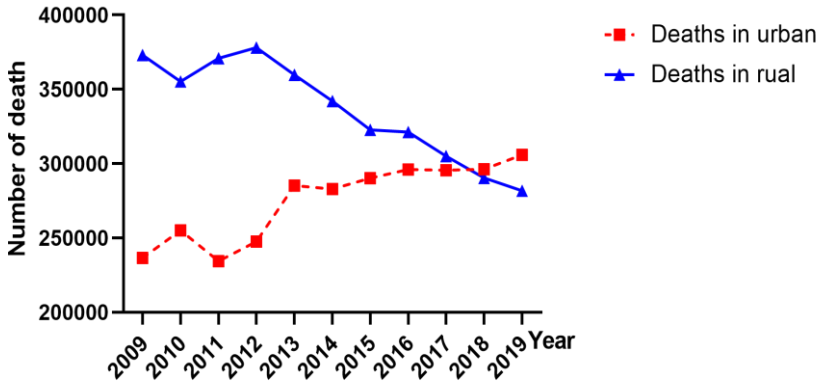

Fig. 2: Trends in injury and poisoning deaths, 2009-2019

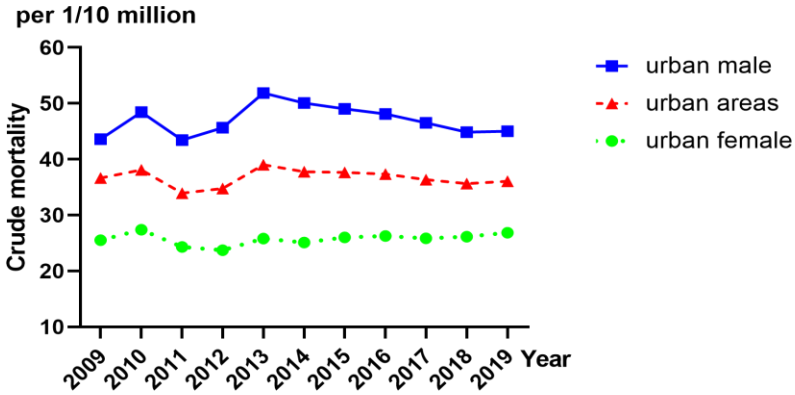

Fig. 3: Trends in deaths from urban injury and poisoning, 2009-2019

Five variables were correlated with the mortality of IP of China. The lowest correlation coefficient between independent variables and the mortality of IP of China was 0.622 (*P*-value was 0.041), which indicates that there was a fairly strong correlation between 5 possible influencing variables and the mortality of IP of China (Table 1).

Table 1: Correlation coefficients related to mortality from external causes of injury and poisoning in China

Independent variables	*Correlation coefficient*	*P*
$\mathbf{X_1}$	-0.862	0.001
$\mathbf{X_2}$	-0.787	0.004
$\mathbf{X_3}$	-0.827	0.002
$\mathbf{X_4}$	-0.622	0.041
$\mathbf{X_5}$	-0.751	0.008

Notes: X_1: Regular Primary School Graduates (10^4persons), X_2: GDP per capita (Yuan), X_3: the number of Practising (assistant) physicians, X_4: the number of Health institutions, X_5: Urbanization rate

During the period 2009-2019, the fluctuation trend of the mortality of IP in rural areas was consistent with that in urban areas. Similarly, the mortality of IP of rural male fluctuates more ob-

viously, and the mortality of IP of male was still much higher than that of female (72.81±3.92 in rural male, 35.25±1.32 in rural female). And the difference between male and female the mortality of IP in rural areas was more than 1.5 times that of urban areas. The mortality of IP in rural areas was stable until 2012, after that, there was a downward trend in the mortality of IP of rural areas for both male and female, male's mortality of IP declined significantly more than female's (Fig. 4).

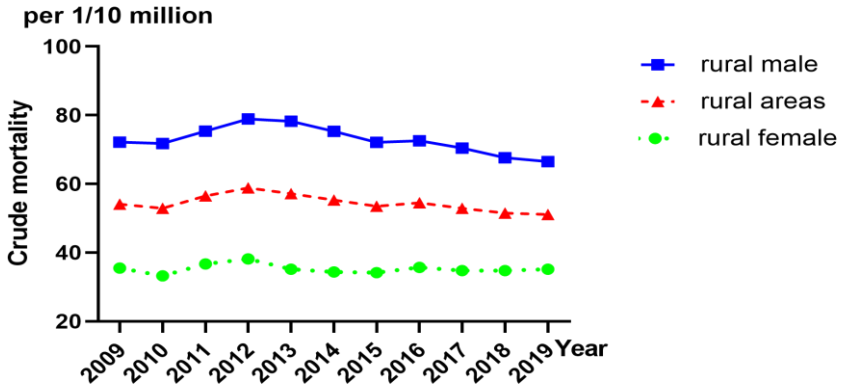

Fig. 4: Trends in deaths from injury and poisoning in rural areas, 2009-2019

The mortality of IP of urban compare with rural, urban male compare with urban female, rural male compare with rural female were analyzed by us. Results showed statistically significant differences between urban and rural, also in both gender (*P* were all less than 0.001). Firstly, the mortality of IP of rural areas was higher than that of urban areas (*d*=-17.73, 95%CI (-19.51~-15.95)). Secondly, the mortality of IP of urban male was higher than that of urban female (*d*=21.23, 95%CI (19.32~23.15)). Lastly, the same situation existed in rural and urban areas, where there was even greater gap in the mortality of IP between male and female in rural areas, which was higher in male than in female (*d*=37.57, 95%CI (34.86~40.28)) (Table 2).

Table 2: Comparison of crude mortality from injury and poisoning in three groups

Group (crude mortality of IP)	*t value*	*P*	*Mean Difference (1/100,000)*	*95%CI(1/100,000)*
Urban vs rural	-20.778	< 0.001	-17.730	-19.510 ~ -15.950
Urban males vs urban females	24.006	< 0.001	21.234	19.321 ~ 23.146
Rural males vs rural females	30.105	< 0.001	37.568	34.855 ~ 40.281

The quantitative relationships between independent variables and dependent variables were expressed by ridge regression formulas. From our results, all the seven ridge regression equations had high coefficient of determination (the minimum coefficient of determination was 0.711), and the penalty value was relatively small (the maximum K-value was 0.16, the smaller the K-value was, the less information was lost in the original data, which suggested a better fitting effect in the ridge regression). The ridge regression model and the data fitted well (Table 3).

Table 3: The ridge regression coefficient value of each factor with mortality of injury and poisoning

Indicators	*K*	R^2	*Ridge coefficient*				
			X_1	X_2	X_3	X_4	X_5
Y_1	0.12	0.804	-0.818	-0.278	0.078	-0.193	0.320
Y_2	0.14	0.940	-0.759	-0.217	0.111	-0.060	0.157
Y_3	0.12	0.711	-0.196	-0.683	0.353	-0.101	0.641
Y_4	0.08	0.903	-0.442	0.106	-0.467	0.020	-0.181
Y_5	0.14	0.990	-0.307	0.075	-0.291	-0.298	-0.118
Y_6	0.12	0.715	0.389	0.684	-0.429	0.125	-0.490
Y_7	0.16	0.984	-0.269	-0.177	-0.188	-0.105	-0.286

Notes: X_1: Regular Primary School Graduates (10^4persons), X_2: GDP per capita (Yuan), X_3: the number of Practising (assistant) physicians, X_4: the number of Health institutions, X_5: Urbanization rate. Y was the mortality of IP(IP is injury and poisoning, 1/10 million),Y1: the mortality of IP in urban, Y2:the mortality of IP in urban male, Y3: the mortality of IP in urban female,Y4: the mortality of IP in rural areas, Y5: the mortality of IP in rural male,Y6: the mortality of IP in rural female, Y7: the mortality of IP in China

Discussion

In the past 11 years, the death toll from IP in urban areas has increased significant. We found that the trend of the change was closely related to the trend of urbanization rate. The urbanization rate was positively correlated with the death of IP in urban areas, but negatively correlated with the death of IP in rural areas.

IP have caused a great hospitalization burden in China. Our study combined rural-urban and gender IP mortality in China, whereas previous literature mainly has focused on individual regional hospital data. Our results found there were significant differences in the mortality of IP between urban and rural areas and between the genders over the past 11 years, suggesting that more attention should be paid to reduce the disease burden of IP in China in the future. Our results showed that the mortality of IP fluctuated significant between urban and rural areas, from 2009 to 2019. The mortality of IP of rural and urban areas reached their maximum level (the mortality of IP was 58.86 in rural and 39.01 in urban per 100,000 in 2012 and 2013, respectively). After that, the mortality of IP began to decline, meanwhile coincidentally the number of regular primary school graduates increased between 2013 and 2019. Perhaps there was a link between the increase in the number of regular primary school graduates and the decline in the mortality of IP, because of the increased awareness of self-protection as people accepted more knowledge about prevention of IP. The prevalence of injury-related knowledge in schools was likely to affect the mortality of IP among children and adolescents, indicating that universal education plays a positive role in reducing injury mortality (12,13). There were previous researches had also provided some support for our hypothesis. The underlying mechanisms of these fluctuations are unclear, but recalling the great changes that have taken place in China in recent years, mainly in the main aspects of its economic, social and political status, and these aspects of progress will improve people's living standard directly or indirectly (14).

Our study found a difference in the burden of disease between urban and rural areas caused by IP. The mortality rate of IP in rural areas was higher than that in urban areas which also approved by the t test. Perhaps the primary reason for the significantly higher injury mortality rate in rural China than in urban China is the huge gap in emergency resources between rural and urban areas (3). In general, rural areas are far from hospitals and the terrain is more rugged, making it difficult to transport and treat the injured persons in a timely manner. Secondly, because rural households lack safe and clean heating, especially in rural areas in southern China, where traditional

coal stoves are still used for indoor heating, CO poisoning is more common in rural than in urban areas (15). Another reason for the higher mortality rate of IP in rural areas may be the education level is relatively lower, which results in a weaker mentality and sense of self-protection among rural people (16). In addition, there is a disparity in access to medical care between urban and rural areas. Urban populations account for only 30% of the total population but own 80% of total health resources. Thus, the difference in medical welfare may cause more labour loss and deaths in rural areas than urban areas (17,18).

In addition, the incidence of pesticide poisoning in agricultural cities has been high. China is a large agricultural country, and pesticide poisoning is one of the main reasons for the burden of disease in China. In a study on poisoning in developing countries, pesticide is the most common cause of self-poisoning (19). The availability of pesticides in rural areas is much higher than urban areas, so it is very common for pesticides to be self-toxic and taken by mistake.

The degree of disease burden caused by IP is different for different sexes. The results of our study showed that the mortality of IP of male was higher than that of female in both urban and rural areas that is the same as the South Korean and Iran studies. These two studies found that for most injury types, males were more likely than females to be affected, and the gender difference in the total death by injury revealed that the total death cases in male were about twice more than those in female, and our findings was consistent with these (20,21). In Taiwan, males had higher poisoning mortality than females (22). Alcohol poisoning is a very common form of poisoning in life, which may also be the reason for the gender difference in the death rate due to poisoning. Indeed, male have more chance for work intercourses and parties, moreover, solitary drinking is also commonly seen for stress reduction and coping among males (15,23,24). IP place a greater and more severe burden of disease on male than female, who believed that this was caused by the nature of work and life stress of male (25,26).

IP elements are mainly composed of people and the environment. Each subsystem contains multiple factors. Our research selected a wide range of index factors that affect IP. We found that there was a significant correlation between GDP-per-capita, education level, the number of medical institutions, the number of practicing (assistant) physicians, urbanization rate and the mortality of IP, which data also fitted well in the ridge regression model. Economic growth, urbanization and education for all policies may lead to a decline in injury mortality (6,27,28). Economic development has brought many benefits to our country, whether in rural or urban areas, such as a substantial improvement in people's living standards and medical care, and a sharp reduction in unemployment, the expansion of the scope of the public health service, raising basic awareness of injury prevention, which benefited more people (5). Previous studies have found a strong association between the number of medical facilities and health technicians and IP mortality (3), above all our results are consistent with them.

There are some limitations in our study. Firstly, because this data cannot divide the mortality of IP, this paper discussed the two indexes together. In future studies, discuss and analyze them separately. Secondly, under-reporting biases cannot be excluded in China. As our data came from the State Statistical Bureau records, under-reporting might be a major study limitation. Lastly, the data does not distinguish between suicides and self-harm associated with IP, therefore, identification of these causes is an important step in reducing the disease burden of IP of China. Due to these limitations, our study mainly provided results about some changing trends and possible influential factors of IP in China.

There are different mortalities of IP between urban and rural in China, and the rural areas are higher than the urban areas, and there are differences in the mortality of IP among different genders, and males are generally higher than females. Therefore, in different regions and genders, further interventions may focus on detailed influencing factors. Moreover, future studies should consider how to conduct some targeted interven-

tions and assess their effects to reduce the disease burden of IP in China.

Conclusion

Analysis of the mortality of IP from 2009 to 2019 found that rural casualty mortality was higher than in urban areas due to economic level and medical education resources. And differences in the nature of work and the pressures of life between male and female, so the mortality of IP varies by gender. Thus, education and medical treat in rural areas should be strengthened and effective agro-chemical safety management methods should be learned from other low IP-mortality countries. Moreover, sex-specific reductions in the intensity of some high-risk occupations should be effective in reducing the mortality of IP.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors have no conflicts of interest to declare.

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