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Potential gains in life expectancy by improving road safety in China☆

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ABSTRACT

Objectives: Road traffic injuries (RTI) cause a significant number of injuries and deaths in China every year; the World Health Organization estimated 261,367 deaths due to RTI in 2013. As a result of the ongoing growth of China's economy, road construction and motorisation, RTI are expected to impose a heavy health burden in the future. However, the public and policy makers have not widely perceived RTI as a public health issue commensurate with its consequences, in part, due to a lack of intuitive indicator measuring the health impact.

Study Design: Employs the cause-eliminating life table technique to provide a measure of the burden of RTI based on data from a nationally representative surveillance system in China.

Methods: Previous studies have used indicators such as event counts, rates and disability-adjusted life years to measure the health impact of RTI; but this study uses potential gains in life expectancy to measure this impact.

Results: Eliminating RTI could lead to a gain of 0.52 years in life expectancy in 2012, meaning that on average Chinese people could live a half year more than they would in the presence of RTI. Males have a substantially higher RTI death rate and consequently could have a gain in life expectancy more than twice as large as females (male 0.72 years vs female 0.28 years). The gain in rural areas (0.65 years) is twice that in urban areas (0.32 years).

Conclusions: The significant gain in life expectancy signals the urgency for public actions to improve road safety; the disparity in the burden across regions and sexes indicate a great opportunity for targeted interventions to protect health and save lives.

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Introduction

Road traffic injuries (RTI) have been recognized as an increasingly significant public health problem by governments, academia and non-governmental organisations around the world. Each year about 1.25 million people are killed as a result of RTI, and about 50 million are injured.[1] RTI are among the top 10 leading causes of disability-adjusted life years (DALYs) lost and are projected to be ranked the third by 2020.[2] RTI is the leading cause of death among people 10–24 years old globally,[3] and around 85% of deaths and 90% of DALYs caused by RTI in the world occur in low- and middle-income countries.[1]

For more than a decade, the World Health Organization (WHO) and many other organisations have been making great efforts to reframe RTI as a global health problem that can be controlled.[4] The aim is to elevate public awareness of the preventable nature of the RTI,[5] and emphasize that when crashes do occur, safety measures such as wearing a seatbelt and a helmet, can significantly reduce the severity of injuries.[6–8]

As one of the most commonly used demographic indicators, life expectancy is a statistical measure of the average time a person is expected to live at a given age under given age-specific mortality rates.[9] For example, a life expectancy of 70 years at birth means that a newborn is expected to live 70 years if she/he were to experience the given age-specific mortality rates through her/his lifetime. Accordingly, a 0.5-year gain in life expectancy by eliminating a disease means that on average people will live half a year more than they would in the presence of that disease. Lowering death rate due to diseases such as RTI at young ages will contribute more to life expectancy compared with the same percentage point reduction in death rate at older ages. So a gain in life expectancy has the potential to call attention to a disease condition.

With rapid increases in motorized travel, China is also facing road safety challenges.[10,11] According to WHO estimates, there were 261,367 deaths caused by RTI in China in 2013.[1] In March 2016, the Chinese government approved its 13th Five-Year Plan for National Economic and Social Development (2016–2020). The proposed goal on wellbeing is to increase the life expectancy by one year in the coming five years. Our analysis will inform policy makers the degree that improving road traffic safety could contribute to achieving this target.

Methods

The data in this study come from the Chinese Disease Surveillance Points (DSP) system. DSP was introduced by the Ministry of Health of China in 1980 for the purpose of monitoring the national level of cause-specific mortality rates.[12] In 2012, DSP system consisted of 161 nationally representative sample sites in 31 provinces (municipalities and autonomous regions) that covered 77 million people, approximately 6% of the national population. International Classification of Diseases 10 was used to record the underlying cause of death.[13] As a result, this study is able to calculate the cause-specific counts and rates of deaths that are used in construction of life tables.

Although based on a representative sample, DSP data suffer from under-reporting issues.[14,15] To estimate the missing rate and obtain the true mortality level, an independent investigation of missingness is conducted every three years. Based on the most recent under-reporting field survey that covered 2009–2011, Guo et al.[16] applied propensity score weighting and capture-mark-recapture to estimate the under-reporting rate by a series of indicators such as age, region and cause of death. These two methods arrived at comparable estimates, and they produced essentially identical adjusted mortality levels that were consistent with WHO estimates in terms of key health indicators, including infant mortality rate, under-five mortality rate and life expectancy at birth. The under-reporting rate by age groups based on the propensity score weighting method is used in this study. In particular, we applied the formula below to adjust the observed RTI deaths.

$$D_x^{ad} = \frac{D_x^{ob}}{(1 - r_x)}$$

where D_x^{ad} and D_x^{ob} are the adjusted and observed numbers of death for age group x; r_x is the under-reporting rate estimated by Guo et al. Although the present study is based on DSP 2012 data, the estimated under-reporting rate for 2011 is used since Guo et al. only estimated the under-reporting rates during 2009–2011 and their estimates indicate little secular variation over time in age-specific under-reporting rate.

We applied the cause-eliminated life table technique to measure the potential health gain if RTI could be reduced or eliminated.[17] The purpose of this technique is to develop a one-parameter measure of the health impact of the cause of death. The parameter, namely gain in life expectancy, represents the change in life expectancy that would be obtained under the hypothetical elimination of the cause under investigation. Let e_0 and e_0^{-i} denote the life expectancy at birth (age 0) from actual life table and cause i-eliminated life table, respectively. Then the gain in life expectancy due to cause i is defined as $\Delta_0^i = e_0^{-i} - e_0$. This technique has been widely utilized to assess the health impact of a cause of death or the potential gain if the cause could be eliminated.[18–20]

Age-specific counts of surveillance population, all-cause deaths, and RTI-related deaths from the DSP population were used to construct an actual and a cause-eliminated life table. RTI-related life expectancy gain is the difference of life expectancies in the two life tables.

In constructing life tables, we first computed the age-specific mortality rates by dividing the age-specific deaths of all causes by the age-specific person-years of exposure of the surveillance population, then we constructed life tables to obtain the actual level of life expectancy in the DSP population. Similarly we calculated the age-specific mortality rates by dividing the deaths for causes other than RTI by person-years of exposure, and got a RTI-eliminated life expectancy. The difference between two estimates is defined as the life expectancy lost to RTI or the gain in life expectancy under the hypothetical scenario of eliminating RTI.[9]

In addition to the scenario of complete elimination, we also estimated the potential gains in life expectancy under two hypothetical reduction scenarios: (i) male RTI level improved

Table 1 – Road traffic deaths and mortality rate per 100,000 people by sex and residence in China 2012.

Group	Population		Deaths		Death rate (per 100,000 people)
	Number	Proportion (%)	Number	Proportion (%)	
Total	77,215,997	100	14,678	100	19.01
Male	39,344,367	51	11,217	76	28.51
Female	37,871,630	49	3461	24	9.14
Rural	46,448,777	60	11,096	76	23.89
Urban	30,767,220	40	3582	24	11.64

Chinese Disease Surveillance Points (DSP) system 2012.

to current female level; and (ii) rural RTI improved to urban level. Those results show what health gain could be achieved if the mortality rate of one group could be reduced to a better level. In the investigation of potential gains under various hypothetical scenarios, we replaced the actual age-specific mortality rates for RTI with hypothetical levels and replicated the steps above. The difference in the gain in life expectancy after the replacement is defined as the potential gain in life expectancy if the actual road safety level could be improved to a better level.

Results

In the DSP surveillance areas, 14,678 people died of RTI in 2012 out of a population of 77 million (Table 1); of these, 11,217 (76%) deaths were among males and 3461 (24%) deaths were among females; and 11,096 (70%) occurred in rural areas while 3572 (24%) in urban areas. Significant differences in the mortality rates between sexes and regions were observed (Table 1). The mortality rate of RTI was more than three times higher for males than for females; similar disparity was found between rural and urban areas.

Most road traffic deaths were concentrated in the working age population, three quarters of deaths coming from age group 20–64 years (Fig. 1). Different from death count, the RTI death rate nearly linearly increases with age.

Traffic crashes caused a 0.52 year reduction of life expectancy in China in 2012, meaning that an average Chinese newborn would live half a year longer if RTI could be eliminated (Fig. 2). The gain would be higher for males (0.72) than for females (0.28) and higher in rural areas (0.65) than in urban areas (0.32). If male age-specific mortality rate from RTI could be lowered to the current female level, then life expectancy of males would increase by 0.40 years. Similarly, if the traffic safety in rural areas could be improved to the urban level, rural life expectancy would increase by 0.53 years.

Discussion

This study used a demographic indicator, the gain in life expectancy, to assess the health impact of RTI in China with disaggregation by region and sex. We estimated that RTI caused a half-year reduction in life expectancy in the country. This can be compared with the elimination of diabetes, which is estimated to lead to 0.15-year gain in life expectancy for the overall Chinese population, and 0.21 and 0.08 year for urban and rural residents, respectively.[21] The reduction of life expectancy caused by pulmonary tuberculosis is 0.11 at national level, and 0.14 and 0.08 year for males and females, respectively.[22] Hypertension causes 0.36 year reduction of life expectancy for the Chinese population, without variation by sex, in 2002.[23] Despite the high prevalence of these diseases in China, the health impact of RTI is larger than all of them, even though they have drawn more public attention and resources than RTI. The large impact of RTI on life expectancy in part results from the fact that most road traffic deaths occur at young ages while the other causes mentioned above mainly affect older people.

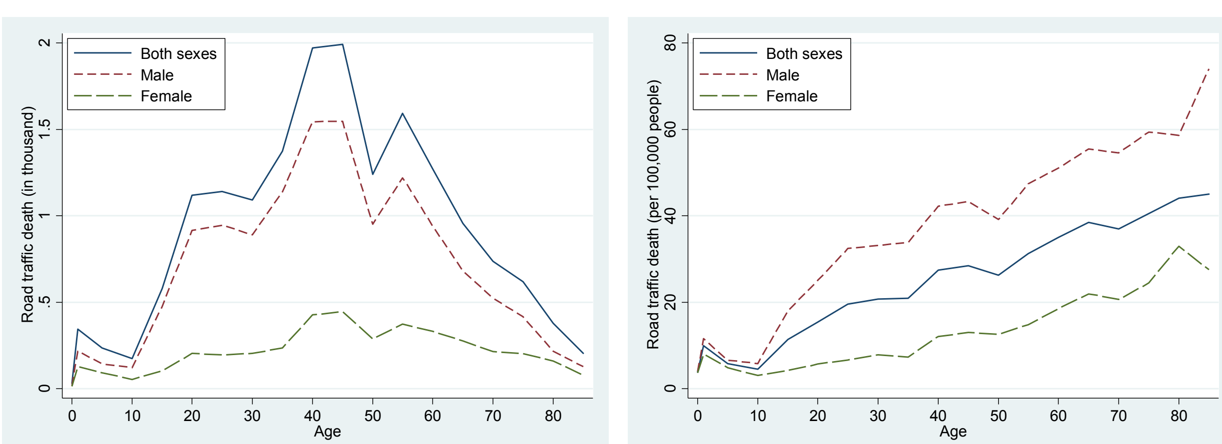

Fig. 1 – Age distribution of road traffic deaths by sex in China 2012. Chinese Disease Surveillance Points (DSP) system 2012.

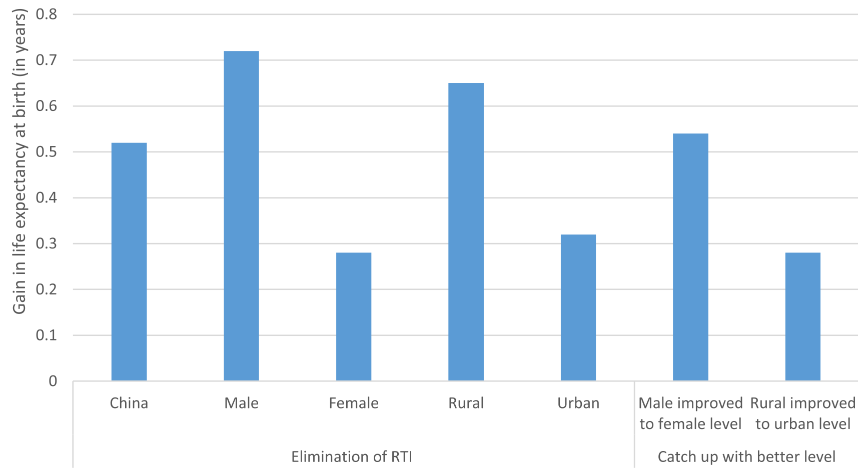

Fig. 2 – Potential gains in life expectancy by preventing road traffic injuries (RTI) by sex and residence in China in 2012.

We also illustrated the potential gains in life expectancy from improving road traffic safety. Males could live 0.54 more years and rural residents could live 0.28 years longer if their RTI level could be reduced to female or urban levels. RTI affects young people disproportionally and therefore this reduces life expectancy significantly.

The present study assumes that the risk of mortality from RTI is independent of the risk of mortality from all other causes of death. The assumption is usually made in applying cause-eliminated life tables in the absence of convincing evidence that clearly indicates the existence of dependence. The main barrier in implementing models that explicitly consider the independence of causes is limited availability of cause-specific mortality data.[24] The independence is considered as a reasonable approximation to the reality of cause elimination of acute causes of death.[25]

In our context, the independence assumption is necessary and appropriate given that RTI only caused 3.4% of the total deaths and traffic crashes are an acute cause of death. The risks of many causes of death, particularly infectious diseases, tend to be related due to the shared biological, environmental and probably also genetic risk factors. But traffic injuries are more affected by travel mode, transportation infrastructure and behavioural factors. As a result, the correlation between deaths caused by crashes and other causes is expected to be weak. Empirically, previous studies showed that for a cause that accounts for a small proportion of total deaths, the violation of the independence assumption would not significantly alter the results.[25] Consideration of competing risks only makes the model unnecessarily complicated.

Our results confirmed the large health impact of RTI on population that was found in previous studies using other disease burden indicators such as event counts, event rate and DALYs.[13] We also identified significant disparity between age groups, sexes and regions in China. The overall health and economic cost of RTI warrants increasing investment in road safety. More importantly, we hope to use this intuitive indicator to draw public and policymaker's attention to road traffic safety and make the case for timely and effective interventions.

The burden and gaps identified in this study could be used to guide targeted intervention design. Given the heavy burden among males and high speeding and drink driving rates among male road users (particularly motor vehicle drivers, motorcyclists and bicyclists) found in the literature, measure to reduce speed (e.g. installing speed bumps), social marketing campaigns and effective enforcement need to be promoted to reduce the prevalence of the two risk factors.[26,27] As to the substantial burden in rural areas, previous studies found a large proportion of people injured or killed are vulnerable road users (e.g. pedestrians, bicyclists and motorcyclists). In addition to reducing speeding and drink driving, interventions such as wearing helmets and building sidewalks and bicycle lanes have been proven to be effective in protecting those road users.[28]

Author statements

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Ethical approval

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Competing interests

None declared.

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