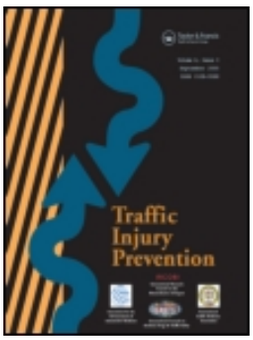

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Estimated trends and patterns of road traffic fatalities in China, 2002–2012

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ABSTRACT

Objective: This study examined the time trends and age distribution patterns of estimated road traffic fatalities (RTFs) in China over the period 2002–2012.

Methods: Data on age-, sex-, and region-specific RTF rates were provided by the Chinese Ministry of Health. The crude rates were standardized and the Mann-Kendall test was used to test the significance of time trends. Annual number of RTFs was calculated. To minimize the effect of yearly variations, magnitude of changes in and age distribution patterns of the RTFs were examined using mean values of 2 years.

Results: RTFs increased significantly in China during the study period. Several features were identified for the RTFs in China. First, RTF rates skyrocketed in rural areas including towns and counties. Second, a significant increase in RTFs was also observed in cities even though the change in RTF rates was not statistically significant there. Third, individuals aged 20–24, 40–49, and 55–64, especially in rural areas, were particularly at risk for RTFs in recent years. Finally, RTFs became more common among middle-aged and older adults than young Chinese, with roughly 57% of all RTFs occurring among individuals aged 45 and above during 2011–2012.

Conclusions: RTFs increased dramatically in China during the past decade, especially in rural areas. Age distribution patterns of RTFs have changed there. Community-based public health education and intervention programs are warranted.

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road traffic fatality; mortality; time trends; China

Introduction

With rapid motorization worldwide, road traffic accidents (RTAs) have become the leading cause of injury-related deaths and a major public health problem in many countries (Peden 2004). Around 1.3 million people die from RTAs each year worldwide, and most of them occur in developing countries where road injury is in the top 5 causes of death (Naghavi et al. 2015). Road traffic fatalities (RTFs) have been significantly associated with economic growth, but the direction of the correlations is quite different across countries. A positive correlation is usually observed in developing countries, whereas a negative correlation has been observed in some developed countries (Kopits and Cropper 2005).

Over the past decade, China has experienced one of the most astounding and enduring periods of economic growth in the history of humankind. China's nominal gross domestic product has surpassed that of France, the United Kingdom, Germany, and Japan, such that since 2009 it has become the second largest economy in the world after the United States (Barboza 2010). The economic booms may have resulted in substantial changes in RTFs. It is therefore important to explore the time trends and patterns of RTFs in a rapidly changing society, given the important policy implications for injury prevention in other countries in the region that are undergoing similar changes.

Two studies examined the time trends of RTFs in China during 1985–2005 (Hu et al. 2008) and 2005–2010 (Huang et al. 2013). The data analyzed, however, came from difference resources and the crude rates of RTFs were not standardized in the 2 studies, which made it difficult to compare or synthesize their results. The whole picture regarding the time trends of RTFs in China over the past decade remains unclear. Three studies examined the age distribution patterns of RTFs at the national level in 1999 (Wang et al. 2003), over the period 2004–2008 (Zhang et al. 2011), and in 2009 (Zhang et al. 2013). However, the findings were inconsistent.

The primary purpose of this study was, therefore, to present the time trends of RTFs in China over the period 2002–2012. The secondary aim of the study was to examine the age distribution patterns of RTFs in China in recent years.

Methods

Data source

The data on RTFs over the period 2002–2012 were obtained from the *Chinese Health Statistics Yearbooks 2003–2013*, which are provided by the statistical division of the Chinese Ministry of Health. The death rates from this source are estimated based on Chinese Ministry of Health Vital Registration (MOH-VR) system, which covers 41 urban areas, including large, medium, and small cities, and 85 rural areas including towns and counties, with roughly 8% of the national population (Yang et al. 2005).

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The selected urban and rural areas vary each year on the basis of stratified randomization. The data are based on physicians' death certificates, which are submitted to the Household Registration Management Department and then forwarded to the municipal, provincial, and national departments of health. Families are generally required to present the death certificate in order to be granted permission for cremation or burial (Yang et al. 2005). The data include death rates by sex for 18 5-year age groups for both urban and rural residents (72 cohorts). The total rates by sex and region are also provided additionally (6 cohorts). Since 2002, the data have been coded according to the 10th version of the *International Classification of Diseases* (WHO 2011). Several studies have been conducted using MOH-VR data on RTFs in earlier years (Hu et al. 2010; Huang et al. 2013; W. Y. Wang et al. 2008). Thus, using the data from the MOH-VR system in the present study would makes our results comparable to the findings from previous studies.

Data analysis

In this study, the RTF rate was specified per 100,000 persons for each of the age-, sex-, and region-specific groups. The crude rates were standardized by the direct method of adjusting to the age distribution of the World Health Organization (WHO) world standard population (Ahmad et al. 2003). The standardized rates were used to assess the time trends within the study period. Mann-Kendall trend test was used to test for the significance of the changes in RAF rates in the time series (Helsel and Hirsch 2002). The advantage of the Mann-Kendall test is that it is more suitable for nonnormally distributed data and can be applied to a small number of observations. The null hypothesis H_0 is that there is no trend. Statistically significant trends were reported at $\alpha = .05$, 2-tailed test.

To examine the magnitude of changes in RTFs within the study period, we compared the estimated mean rate and number of RTFs for each cohort over the last 2 years (2011–2012) to that over the first 2 years (2002–2003). To demonstrate the changes in age distribution patterns of RTFs within the study period, we presented the estimated mean rate and number of RTFs for each cohort over 3 representative periods: 2002–2003, 2006–2008, and 2011–2012. Such methods minimized the effect of yearly variations. The number of RTFs for each cohort in each year was estimated by multiplying the crude rate by the population of the specified cohort. Given the difference in the definitions of the urban and rural populations used in the MOH-VR system (counties and towns are classified as rural for the calculations of the deaths) and by the Statistics Bureau (which regards both cities and towns as urban areas for the calculations of the population), we projected the urban data from the MOH to the city population reported by the Statistics Bureau and the rural data to the combined town and county population. Previous works suggested that this gave a fairly good despite imperfect match (Phillips et al. 2002; Wang et al. 2014). The estimated mean number of RTFs for each cohort was taken as the simple mean over the period, and the mean rate was the combined number of the RTFs divided by the combined size of the cohort over the period. The mean national number of RTFs was estimated by combining the numbers from all cohorts.

Results

Figure 1 displays the region- and sex-specific RTF rates for the period 2002–2012. The rates increased significantly during the study period, especially in rural areas including towns and counties, but fluctuated greatly before 2009. The crude rates increased by 149% in rural areas (from 6.46 during 2002–2003 to 16.12 during 2011–2012) and 53% in cities (from 5.80 during 2002–2003 to 8.87 during 2011–2012). The standardized rates increased by 131% in rural areas (from 6.60 during 2002–2003 to 15.23 during 2011–2012) and 31% in cities (from 5.59 during 2002–2003 to 7.34 during 2011–2012). The upward trend of the standardized rates (Appendix 1, see online supplement) was statistically significant in rural areas (Kendall's $\tau = 0.67$, $P = .003$) but not statistically significant in cities (Kendall's $\tau = 0.46$, $P = .06$). Specifically, the upward trend was highly significant for rural males (Kendall's $\tau = 0.64$, $P = .006$) and rural females (Kendall's $\tau = 0.70$, $p = .004$) and slightly significant for urban males (Kendall's $\tau = 0.49$, $P = .041$) but not significant for urban females (Kendall's $\tau = 0.34$, $P = .165$). The male-to-female ratio increased slightly in rural areas (from 2.58 during 2002–2003 to 2.66 during 2011–2012) but reduced slightly in cities (from 2.67 during 2002–2003 and 2.51 during 2011–2012). The rural-to-urban ratio increased for both males (from 1.10 during 2002–2003 to 1.84 during 2011–2012) and females (from 1.14 during 2002–2003 to 1.73 during 2011–2012).

Projecting the RTF rates to the corresponding population groups without adjusting for uncounted deaths resulted in an estimated total of 1,499,000 deaths due to RTAs during 2002–2012. Annual number of RTFs changed from 79,600 during 2002–2003 to 186,500 during 2011–2012, with an increase rate

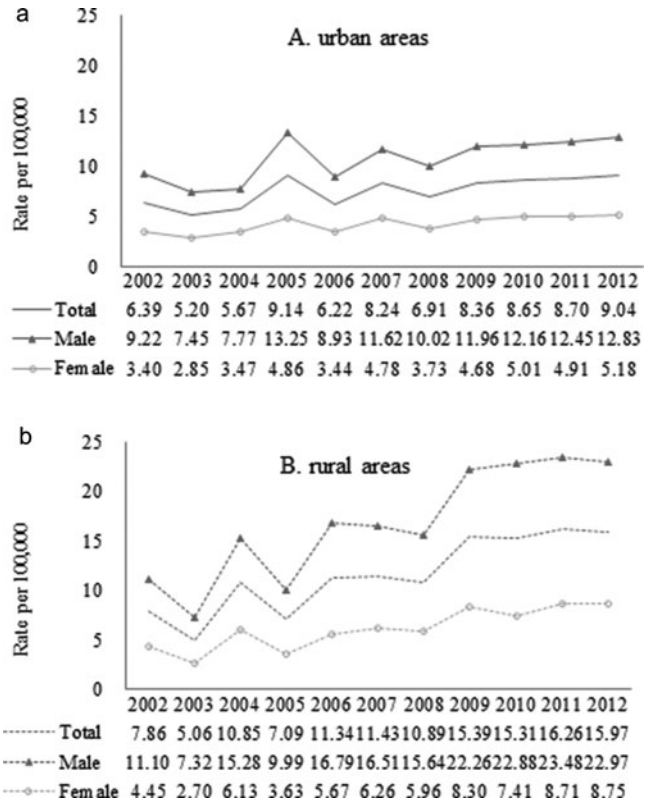

Figure 1. Time trends of region- and sex-specific road traffic fatality rates, China, 2002–2012.

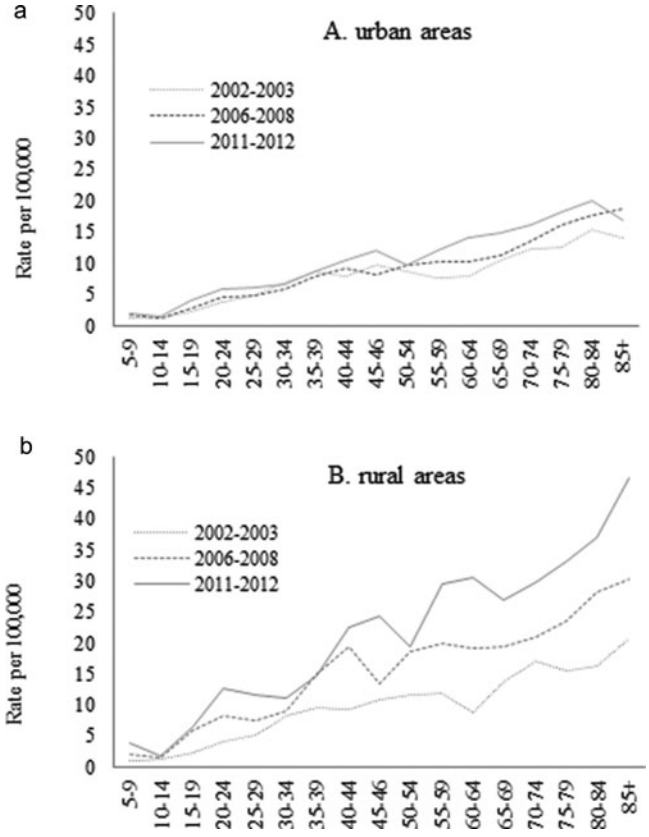

Figure 2. Age-specific road traffic fatality rates by region in China over different periods.

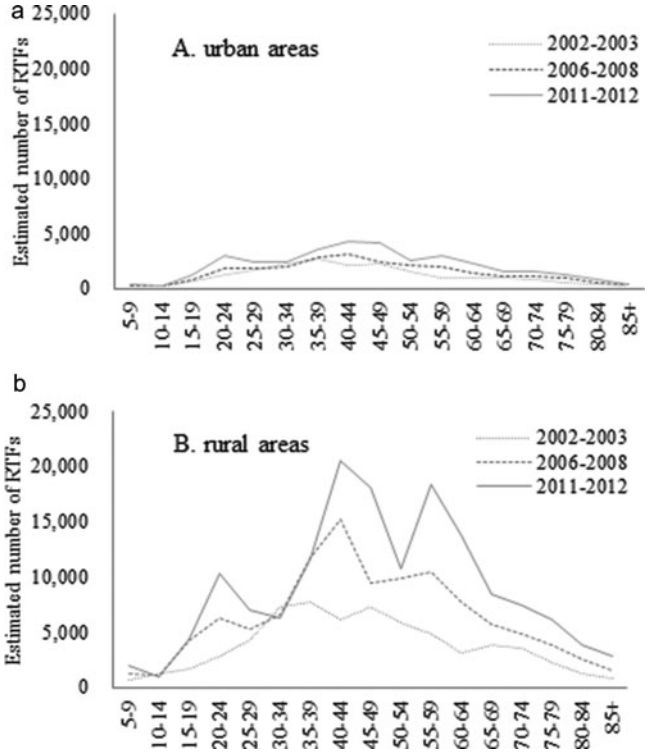

Figure 3. Estimated mean numbers of age-specific road traffic fatalities by region in China over different periods.

of 134%. Specifically, the annual number of RTFs increased by 144% in rural areas (from 61,000 during 2002–2003 to 149,200 during 2011–2012) and 101% in cities (from 18,500 during 2002–2003 to 37,200 during 2011–2012).

Figure 2 depicts the age-specific RTF rates by region over the 3 representative periods. The rate increased significantly among most age groups, especially the middle-aged and older groups in rural areas. Figure 3 depicts the estimated numbers of age-specific RTFs by region over different periods. The age distribution patterns of RTFs changed significantly in rural areas and mildly in cities. Specifically, the estimated number of RTFs increased mainly among individuals aged 20–24 and those aged 40 and above, with 3 peaks (individuals aged 20–24, 40–49, and 55–64, respectively) being observed in recent years. Within the study period, the estimated number of RTFs among the 3 age groups increased by 141, 89, and 173%, respectively, in cities and 266, 189, and 305%, respectively, in rural areas including towns and counties. The largest proportion of RTFs changed from the group aged 35–39 during 2002–2003 to the group aged 40–44 during 2011–2012. The change was particularly obvious in rural areas. During 2002–2003, a total of 51% of RTFs occurred among individuals aged younger than 45. This figure was reduced to 43% for the period 2011–2012. The proportion of RTFs occurred among individuals living in rural areas increased slightly from 77% during 2002–2003 to 81% during 2011–2012.

Discussion

This study showed significant increases in RTFs in China over the period 2002–2012, especially in towns and counties. The upward trends identified in this study are consistent with the trends found in some developing countries such as Brazil (Chandran et al. 2012), Oman (Al-Maniri et al. 2013), and the United Arab Emirates (Ibrahim 2014) but contrary to the trends found in Hong Kong, Canada, the United States, and most of the Organization for Economic Cooperation and Development countries (Kopits and Cropper 2005; Nghiem et al. 2013), where RTF rates have decreased gradually since the 1970s, as well as in Iran, where RTF rates have been declining since 2007 (Moradi and Rahmani 2014). It was also noted that RTF rates in China were relatively stable at a high level in recent years, with a slight decrease in rural areas in 2012. However, it is still unclear whether or not the RTF rate in rural China has reached the turning point (Brüde and Elvik 2015). It will be important to continue monitoring the situation.

An earlier report by the World Bank predicted that a 92% increase in RTFs would occur in China between 2000 and 2020 (Kopits and Cropper 2005). Our study demonstrated a much higher rate (134%) of increase in RTFs in China over the period 2002–2012. The underlying mechanism is mainly related to the rapid motorization of lifestyle. With the economic booms, China has become a leading producer and consumer of automobiles. Its automotive industry has been the largest in the world since 2008 (Gachúz 2012). The number of private vehicles in China has increased from 7.7 million in 2001 to 73.2 million in 2011, and the total number of registered vehicles has increased from 65.2 million in 2001 to 209.1 million in 2011 (Chinese Ministry of Health 2002–2012). However, RTFs are still an underrecognized or neglected public health problem in China, especially in rural areas (Huang et al. 2013; Wang et al. 2008). Given the increasing number of RTFs in recent years, this should be a public health priority. National targets to

reduce RTFs, especially in towns and counties, are warranted for China.

As demonstrated in this study, an astonishing increase in RTF rates was mainly observed in rural China. The major reason may be related to a dramatic increase in the number of motor vehicles. More than 10 years ago, the bicycle was a major means of transportation among rural residents. Nowadays, motorcycles are popularly used. Although the Chinese government has made great efforts to improve the quality of roads in rural areas during past decades (Wang et al. 2013), poorly regulated behaviors of road users and poor performance of auto drivers (such as speeding, careless driving, driving without a license, driving in the wrong lane, and driving under the influence of alcohol) are still major concerns (Wang et al. 2008; Zhang et al. 2013).

In Chinese cities, the estimated number of RTFs increased significantly over the study period, though the time trend of the standardized RTF rates was not statistically significant. The underlying mechanism may be related to the increased population size in cities. According to Chinese Census data, the population living in cities increased by 37.9% during the past decade, from 0.29 billion in 2000 to 0.40 billion in 2010, whereas the population living in rural areas, including towns and counties, decreased slightly from 0.95 billion in 2000 to 0.93 billion in 2010 (National Bureau of Statistics 2008, 2012). Although the mixed effect of an increased number of vehicles and improved prevention measures in cities might lead to lower speeds and more traffic jams (Hu et al. 2008), the increased number of vehicles might increase the risk of exposure to RTAs and the expanded size of the population might result in an increase in the number of RTFs. Thus, the time trend of the RTF rates in urban areas should be interpreted with caution.

This study further indicated that RTFs in China were particularly common among 3 age groups in recent years, especially in rural areas. Although the 3-peaks pattern is consistent with the 3 peaks in the population distribution based on the 2010 Census data (Figure 4), an examination of the RTF changes in relevant groups during the study period (Figure 3) may provide valuable insights. Our results might be slightly different from the findings in previous studies, which indicated that RTFs peaked in the age groups of 26–30 in 1999 (Wang et al. 2003) and 31–40 during 2004–2009 (Zhang et al. 2011, 2013). A possible reason might be related to the different sources of the data used. The present study indicated that RTFs peaked in the age group of 40–49 during 2011–2012. This group of people might have mostly benefited from economic achievements during the past decade due to their ages and capabilities. They might be the largest group of vehicle owners. The second group consisted of individuals aged 55–64, especially those living in rural areas. On the one hand, they might still be active in the labor market; on the other hand, their sensitivity, reactivity, and physical functioning might have decreased as a result of aging. They might not be drivers but might have an increased risk of exposure or become more vulnerable to RTAs. Another group consisted of individuals aged 20–24. Generally, most young adults are enthusiastic about driving activities. With increased access to motorized vehicles, they might have a high risk of exposure to RTAs because of inexperience, poor hazard perception, and high-risk driving behaviors such as speeding, aggressive driving, mobile phone use while driving, and unlicensed driving (Boufous et al. 2010; Hanna et al. 2014). Given that the majority of Chinese people in this population group might belong to the one-child generation as a result of the family control policy active since the 1980s, RFTs occurring in this group might be emotionally unaffordable for their families (Chan et al. 2012). The burden of RTFs, calculated in terms of loss of productivity, is also much higher for young adults. Thus, reducing RTFs is particularly important for this group of young people.

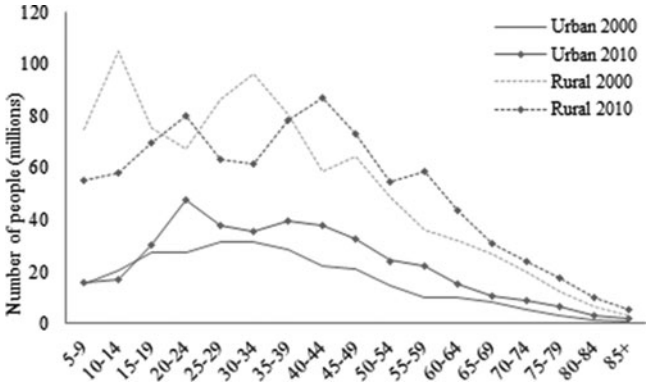

Figure 4. Age distribution patterns of the population in China, 2000 and 2010 (Census data).

Finally, our study indicated that RTFs became more common among middle-aged and older adults than among young Chinese, with 57% of all RTFs occurring among individuals aged 45 and above during 2011–2012. This result is unexpected and nontypical because it is contrary to an earlier report that detailed how RTFs among individuals aged 45 years or younger accounted for more than 60% of the total deaths due to RTAs (Zhang et al. 2011) and an international report that highlighted that almost 60% of RTFs occur among young adults aged 15–44 years in low- and middle-income countries (WHO 2013b). The increase in RTFs was particularly obvious among middle-aged and older adults living in rural areas including towns and counties (Figure 3), possibly due to a mixed effect of an increased number of vehicles and the increased middle-aged and older members of the population in the region. According to the Census data, the proportion of individuals aged 40 and above who were living in towns and counties increased from almost 25% in 2000 to more than 30% in 2010 (Figure 4), even though the proportion of the total population in the areas reduced from 76.5% in 2000 to 69.7% in 2010 (National Bureau of Statistics of China 2008, 2012). Thus, particular attention should be paid to middle-aged and older adults living in towns and counties when implementing preventive strategies for RTAs and RTFs.

According to the MOH-VR data, RTF ranked as 10th in the list of the most important causes of death for the rural population and 15th for urban residents (Wang et al. 2014). It is believed that auto drivers are responsible for fatal crashes in about 92% of the RTFs in China (Zhang et al. 2013). Some strategies to improve road traffic safety and reduce RTAs in rural China have been proposed elsewhere (Hu et al. 2008; Huang et al. 2013). The recommendations include improving road safety infrastructures in rural areas (such as traffic lights, sidewalks, cycle tracks, and speed cameras) and enhancing surveillance and punishment for traffic safety law violations (such

as setting speed limits, standardizing warning signs and signals, and improving driver licensing) to modify drivers' high-risk driving behaviors. In addition, it is important to launch or reinforce community-based educational programs, especially among high-risk groups of people as identified in the present study.

In conclusion, our study has indicated a substantial increase in the estimated number of RTFs and a shift of age distribution patterns of RTFs in China during the past decade, especially in rural areas including towns and counties. The results may have immediate implications for policy making and public health intervention. Community-based public health education and intervention programs, especially among high-risk groups of people, are warranted.

Limitations of the study

As documented in previous studies (Ma et al. 2012), mortality data in the MOH-VR system have suffered from quality issues such as underreporting and misclassification, although it is the largest system for regular surveillance and monitoring of causes of deaths in China. Given the sheer size of the population (1.3 billion), a complete mortality registration system in China is not feasible (WHO 2013a). The MOH-VR data are based on roughly 8% of the national population, mainly in areas with relatively good reporting mechanisms, so there may be a higher proportion of urban residents in the sample than the proportion that is present in the population as a whole. Thus, there is concern about the representativeness of the samples drawn from the MOH-VR system given that some cities and towns are inaccessible (Phillips et al. 2002). However, the comparison of the MOH-VR data with those from other national data sources has indicated that the impact on the RTF rates is not significant (Ma et al. 2012). Another concern may be that the MOH-VR system is based on the registered population. Deaths among rural residents who go to work in the cities are usually registered as rural deaths because their residence permits remain unchanged (Yang et al. 2005). Given the large number of domestic migrants, this phenomenon may affect the accuracy of the mortality data. However, our major concern was on the time trends and distribution pattern of RTFs, which might have significant implications for public health intervention strategies, rather than their absolute levels. Thus, the results are less influenced by concerns about underreporting and misclassification.

In addition to the MOH-VR system, data on RTFs obtained from the National Traffic Accident Reporting System (NTARS) are often used by researchers and policymakers, as evident in several previous studies (Hu et al. 2008; Wang et al. 2003; Zhang et al. 2011, 2013). The NTARS data are mainly based on the reports by transportation police, in which only those who die of traffic-related injuries within 7 days of the incident are recorded as RTFs (Ma et al. 2012). In a recent study, Hu et al. (2011) compared the data from the 2 systems and suggested that underreporting is a serious concern for the NTARS data, whereas the quality of the MOH-VR data is much better. Thus, we regard our results based on the MOH-VR data as reliable. It should be noted that our study was based on the data on motorized vehicle–related RTFs in particular. We did not take the data on traffic fatalities not resulted from motorized vehicle–related accidents and non-road transport fatalities into account because they might be related to accidents involving watercraft, aircraft, and other modes of transport. Moreover, we did not distinguish between the variations in RTFs among different road users (e.g., drivers, pedestrians, and bicyclists) due to the unavailability of relevant data. Previous studies indicated that the proportion of RTFs accounted for by motor drivers, motorcyclists, and passengers increased from 50% in 1999 (Wang et al. 2003) to 58% in 2009 (Zhang et al. 2013). An examination of recent data in future studies would be meaningful.

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