The socioeconomic inequality in traffic-related disability among Chinese adults: the application of concentration index

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Traffic crashes have become the fifth leading cause of burden of diseases and injuries in China. More importantly, it may further aggravate the degree of health inequality among Chinese population, which is still under-investigated. Based on a nationally representative data, we calculated the concentration index (CI) to measure the socioeconomic inequality in traffic-related disability (TRD), and decomposed CI into potential sources of the inequality. Results show that more than 1.5 million Chinese adults were disabled by traffic crashes and the adults with financial disadvantage bear disproportionately heavier burden of TRD. Besides, strategies of reducing income inequality and protecting the safety of poor road users, are of great importance. The rurality of residence appears to counteract the socioeconomic inequality in TRD, however, it does not necessarily come to an optimistic conclusion. In addition to the worrying income gap between rural and urban areas, other possible mechanisms, e.g. the low level of post-crash medical resources in rural area, need further studies. China is one of the developing countries undergoing fast motorization and our findings could provide other countries in similar context with some insights about how to maintain socioeconomic equality in road safety.

Keywords Traffic-related disability; Inequality; Concentration index; Decomposition; Chinese adults

1. Introduction

Traffic crashes have become a major public health problem worldwide, especially for developing countries (Ameratunga *et al.* 2006, World Health Organization 2009). During last decades, traffic-related injuries and fatalities have increased dramatically in China (Wang *et al.* 2003), which makes traffic crashes the fifth leading cause of burden of disease and injury in terms of DALY (disability-adjusted life year) (World Health Organization 2008). Effective countermeasures to reduce the negative influence of road crashes would require understanding of various contributing factors, including the socioeconomic disparities, which is however missing in the Chinese literatures.

The socioeconomic inequalities in traffic injuries and fatalities have been demonstrated by previous studies (Hyder and Peden 2003, Nantulya and Reich 2003, Sethi *et al.* 2006, Laflamme *et al.* 2009, Chen *et al.* 2010). Risks for road traffic injuries and fatalities are higher among disadvantaged groups with less education (Murray 1998, Ferrando *et al.* 2005, Park *et al.* 2010), unskilled occupation (Hasselberg and Laflamme 2003, 2004, 2008), lower income (Hasselberg and Laflamme 2004, Chakravarthy *et al.* 2010), or lower socioeconomic status (SES) in general (Chen *et al.* 2010, Hanna *et al.* 2010). However, these studies were mainly conducted in developed countries, and the relationship between SES and traffic injuries in developing countries, including China, is still under-investigated (Ameratunga *et al.* 2006).

Besides, concentration index (CI) is one of the best summary measures of socioeconomic inequalities in health by meeting the following three key requirements: (1) reflecting the socioeconomic dimension to inequalities in health; (2) reflecting the experiences of the entire population; and (3) being sensitive to changes of population distribution across socioeconomic groups

(Wagstaff *et al.* 1991). Also, the application of CI has additional advantages over traditional regression models. For example, regression models usually indicate the existence of SES inequality through the comparison between SES categories in the model and the reference category, which means we still do not know the overall inequality degree of the whole study population. However, CI can easily solve this problem by producing a single CI value (Zhang and Wang 2004). Moreover, the newly developed decomposition technique further makes CI a valuable tool to analyze the potential sources in various health outcomes (Wagstaff *et al.* 2003, van Doorslaer *et al.* 2004). Although the CI method has demonstrated its advantages in many health issues, e.g. child-mortality (Wagstaff 2000), health service utilization (McKinnon *et al.* 2011) and obesity (Zhang and Wang 2004, 2007), few studies have employed it to measure the socioeconomic inequality in traffic injuries.

Therefore, this study used a nationally representative survey to calculate and decompose concentration index of traffic-related disability among Chinese adults. By doing this, we aim to depict a whole picture of the socioeconomic inequality in traffic-related disability and find out the potential ways to reduce the inequality.

2. Methods

2.1. Data source

The 2006 China Disability Survey was conducted in all province-level administrative regions of mainland China. The survey was approved by the State Council and all respondents provided consent to participate to the Chinese government (Zheng *et al.* 2011). Within each provincial stratum, a four-stage sampling strategy using four-level natural administrative units (i.e., county, town, village and community) and a probability proportional to size cluster sampling method were employed to derive nationally representative sample. The survey excluded the institutionalized population and comprised a total of 734 counties (3,169 communities) with a sample size of 2,526,145, representing 1.9‰ of the total non-institutionalized population in China (Zheng *et al.* 2011). For the current study, we focused on adults aged 18 years and above (n=1,909,205).

2.2. Measurement

2.2.1. Traffic-related disability (TRD)

During the survey, trained field interviewers used a structured questionnaire to ask questions about visual, hearing and speech, physical, intellectual, and mental functioning difficulties. Those who responded “yes” to any question were referred to doctors of various specialties for further disability screening and confirmation, as well as the severity and causes of disabilities according to medical examinations and diagnostic manuals. TRD was defined as physical or intellectual disability caused by traffic crashes, which was binary as yes or no.

2.2.2. SES indicator for calculation of CI

The calculation of CI requires a single indicator to capture respondents’ socioeconomic status characteristic (O'Donnell *et al.* 2008). In this study, we used the variable of per capita household income (PHINC, in Chinese Yuan (CNY)) . PHINC was obtained by dividing the household income by the size of a household. The household income referred to the total income of a household for the year of 2005, containing wages, net operating income, property income, and transfer income for the household. For households who had agricultural income, all the income in kind was converted into monetary terms.

2.2.3. Determinants for decomposition of CI

In order to decompose CI, we included a series of determinants: (1) demographic variables, including sex (categorized as male or female), age (years), rurality of residence (categorized as urban or rural) and marital status (categorized as married or unmarried); (2) SES variables, including education background (categorized as no higher than primary school, junior high school, senior high school, or higher than senior high school) and PHINC; (3) We also considered regional variability and assigned respondents to one of the following 8 regions of China: Northeast (NE), North Coast (NC), East Coast (EC), South Coast (SC), Middle Reaches of Yellow River (MRYeR), Middle Reaches of Yangtze River (MRYaR), South West (SW), and Northwest (NW) (Li and Hou 2003).

2.3. Concentration index

2.3.1. Calculation of CI

The value of CI is calculated based on the concentration curve (Figure 1), which plots the cumulative percentage of TRD (y-axis) against the cumulative percentage of the population, ranked by PHINC (x-axis) beginning with the poorest (left) and ending with the richest (right) (Wagstaff *et al.* 1991, Wagstaff *et al.* 2011). Then, the CI is defined as twice the area between the concentration curve and diagonal (also referred as the line of equality). When the concentration curve coincides with the diagonal, the CI is equal to zero usually indicating no socioeconomic inequality in TRD; when the curve lies above (below) the diagonal, the CI is negative (positive) indicating the TRD is more concentrated among people with lower (higher) PHINC. The larger the absolute CI value is, the greater inequality in TRD exists. Besides, as TRD is a binary variable with an interval of [μ-1, 1-μ], we followed the recommendation by Wagstaff (2005) and divided CI by (1-μ) to obtain the normalized CI (i.e., W value).

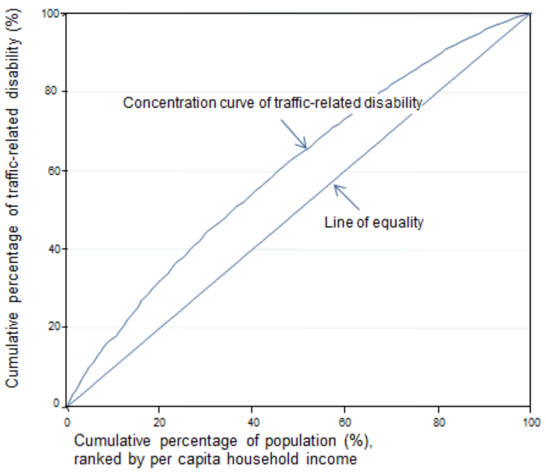

Figure 1 Concentration curve of traffic-related disability among Chinese adults

2.3.2. Decomposition of CI

When the health variable (y) is continuous, Eq. (1), a linear regression model linking y to a set of k determinants, x_k, is applied

$$y_i = \alpha + \sum_k \beta_k x_{ki} + \varepsilon_i \quad (1)$$

where the β_k are coefficients and ε_i is an error term. Irrespective of their socioeconomic status (PHINC), we assume that all the cases in the sample share the same coefficient vector, β_k. Thus, the interpersonal variations in y are assumed to come from systematic variations across socioeconomic groups in the determinants, x_k. We then have Eq. (2) (Wagstaff *et al.* 2003)

$$CI = \sum_k (\beta_k \bar{x}_k / \mu) CI_k + GCI_\varepsilon / \mu \quad (2)$$

where μ is the mean of y, $\bar{x}_k$ is the mean of x_k. Besides, CI_k is the concentration index of x_k, which measures the socioeconomic (PHINC) inequality of x_k and is comparable to each other. The Eq. (2) component of $\beta_k \bar{x}_k / \mu$ is defined as elasticity and measures the relationship between x_k and TRD, which standardizes β_k by including $\bar{x}_k / \mu$. The contribution of x_k to CI, one of the great concerns to this study, is the product of elasticity and CI_k. The GCI_ε is a generalized CI for ε_i (Eq. (3)).

$$GCI_\varepsilon = \frac{2}{n} \sum_i \varepsilon_i R_i \quad (3)$$

The main steps to decompose CI have been displayed with Eqs. (1)-(3). Moreover, as the health outcome (TRD) in this study is binary, we use the linear approximation process to extend the above CI decomposition method (van Doorslaer *et al.* 2004). We then have Eqs. (4)- (6)

$$y_i = \alpha^m + \sum_k \beta_k^m x_{ki} + u_i \quad (4)$$

$$CI = \sum_k (\beta_k^m \bar{x}_k / \mu) CI_k + GCI_u / \mu \quad (5)$$

$$GCI_u = \frac{2}{n} \sum_i u_i R_i \quad (6)$$

where the β_k^m measures the partial effects of each determinant treated as fixed parameters and evaluated at sample means, and the error term u_i includes approximations errors.

2.4. Statistical analyses

We managed the dataset for analysis using SPSS version 16.0 and analyzed the data using ADePT version 5.0, which was developed by the World Bank and specifically designed for analyzing inequality in health outcome and related research topics (Wagstaff *et al.* 2011). We used standard weighting procedures to construct the sample weights allowing for the complex sampling design (Korn 1999). Besides, as the TRD was defined as binary (i.e., yes or no), we used the Probit regression model to decompose the CI controlling for the sampling strata and clusters.

3. Results

3.1. Data description

Table 1 shows the characteristics of the study sample by demographic, socioeconomic and region variables. The mean age was around 44 years old (SD=16.15). Of all the study subjects, 50% were males; 32% resided in urban areas; 80% were married; and 46% had obtained education no higher than primary school. On average, each household member earned 4,390 (SD=4,883.48) CNY in 2005. Besides, SW, MRYaR, NC and MRYeR were the main dwelling regions, which accommodated 18%, 17%, 15% and 14% of the study sample, respectively.

Table 1 Sample characteristics (%)

Variables	Percent	Variables	Percent
Age (M±SD, years)	44.41±16.15	Region	
Male	49.74	NE	9.02
Urban	32.43	NC	15.30
Married	80.03	EC	11.84
Education		SC	10.02
No higher than primary school	45.61	MRYeR	14.43
Junior high school	35.08	MRYaR	17.13
Senior high school	13.62	SW	17.85
Higher than senior high school	5.70	NW	4.40
PHINC (M±SD, CNY)	4,389.77±4,883.48		

3.2. Concentration index of TRD

Traffic crashes disabled more than 1.5 million Chinese adults, accounting for 1.55 per thousand. Figure 2 indicates an obvious negative relationship between PHINC level and TRD prevalence (‰): the higher the PHINC quintile, the lower the TRD prevalence. This trend was further confirmed by the concentration curve of TRD, which lied above the line of equality (Figure 1), and the values of CI and W, both of which were rounded to -0.192. All these results demonstrated the TRD was unequally distributed among Chinese adults and more prevalent among those with lower PHINC.

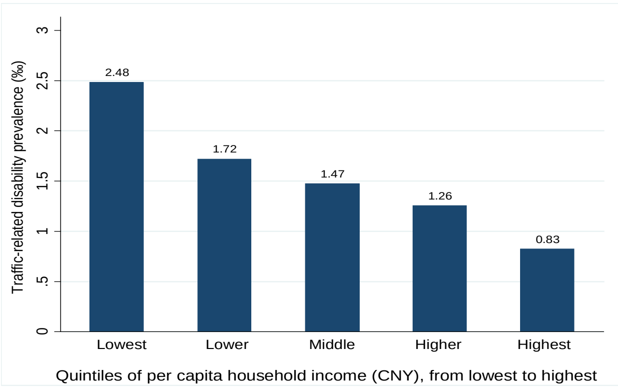

Figure 2 Traffic-related disability prevalence (‰) across quintiles of per capita household income (CNY)

3.3. Decomposition of concentration index of TRD

3.3.1. Concentration index of determinants

To decompose concentration index of TRD, we calculated CI_k, the concentration index of determinants (Table 2). Like the concentration index of TRD, the higher absolute value of CI_k indicates greater inequality of demographic, socioeconomic or region variables over PHINC. The CI_k of having education equal to (0.32) or higher than (0.70) senior high school indicated that people with higher education tended to be richer. Besides, the CI_k of PHINC is also worth noting, which has similar meaning with Gini coefficient. The high value of 0.47, the second highest CI_k, implied significant inequalities in PHINC among Chinese adults for the year of 2005. Where people lived was also linked to their PHINC level. For example, people residing in urban area (0.37), East/South/North Coast (0.41/0.15/0.07) or Northeast (0.05) regions appeared to earn more than their counterparts did. Moreover, the younger, male and married respondents were more concentrated among rich group, although these trends were not so obvious compared to the relationships between other determinants and PHINC.

Table 2 Concentration index of determinants

Variables	CI_k	Variables	CI_k
Age (years)	-0.01	Region	
Male	0.01	NE	0.05
Urban	0.37	NC	0.07
Married	0.02	EC	0.41
Education		SC	0.15
No higher than primary school	-0.19	MRYeR	-0.16
Junior high school	0.04	MRYaR	-0.01
Senior high school	0.32	SW	-0.18
Higher than senior high school	0.70	NW	-0.16
PHINC (CNY)	0.47		

3.3.2. Regression analyses and elasticity values

We ran a Probit regression model to obtain β_k^m, the partial effects of each variable treated as fixed parameters and evaluated at sample means. Table 3 shows Chinese adults, who were older, male, unmarried, lived in urban area, were less educated, had lower PHINC, or resided in North West region, faced higher probability of being disabled by traffic accidents.

Table 3 also includes the results of elasticity values, which resulted from multiplying β_k^m with $\bar{x}_k / \mu$ (the values of $\bar{x}_k$ could be found in Table 1 and μ was equal to 1.5‰). The variables of age (0.70), male (0.41) and PHINC (-0.38) had the highest absolute elasticity values.

Table 3 Probit regression results and elasticity values

Variables	β_k^m*1000 [d]	Elasticity	Variables	β_k^m*1000 [d]	Elasticity
Age (Years [a])	0.02	0.70	Region (NE [b])		
Male (Female [b])	1.27	0.41	NC	-0.27	-0.03
Urban (Rural [b])	0.55	0.11	EC	-0.24	-0.02
Married (Unmarried [b])	-0.26	-0.13	SC	-0.35	-0.02
Education (NHTPS [b, c])			MRYeR	-0.18	-0.02
Junior high school	0.12	0.03	MRYaR	-0.38	-0.04
Senior high school	-0.09	-0.01	SW	-0.53	-0.06
Higher than senior high school	-0.44	-0.02	NW	0.15	0.00
PHINC (CNY [a])	0.00	-0.38			

Note: [a] Age was measured in years; PHINC was measured in CNY. [b] Categories in brackets were reference categories. [c] NHTPS was the abbreviation of 'no higher than primary school'. [d] All the β_k^m were significant at P<0.001.

3.3.3. Contributions of determinants to CI

According to Eq. (5), we calculated the contribution of each determinant to the concentration index of TRD and further obtained the percentages of these contributions through dividing the contributions by concentration index of TRD. The contribution percentages are plotted on Figure 3. We explained 83.28% of the socioeconomic inequalities of TRD, through including demographic, socioeconomic or region variables in the decomposing model. PHINC had a dominant contribution (94.84%), followed by education (6.71%), age (4.50%) and being married (1.24%). Education was the total effects of having education of junior high school (-0.52%), senior high school (1.36%), and higher than senior high school (5.87%). On the other hand, the left three variables of region, sex and residence area appeared to help reduce concentration index of TRD. Especially, the rurality of residence counteracted more than 1/5 of the socioeconomic inequalities in TRD. In addition, region was the total effects of all the region categories, i.e., EC (3.89%), SC (1.84%), NC (0.94%), NW (0.37%), MRYeR (-1.45%), MRYaR (-0.21%), and SW (-5.59%).

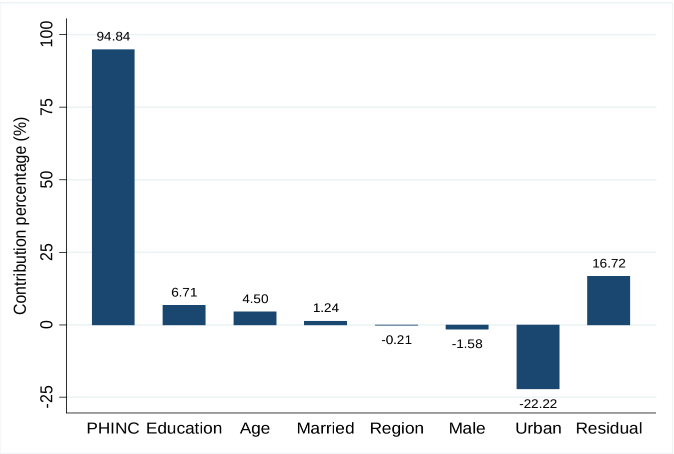

Figure 3 Contribution percentages of determinants to concentration index of traffic-related disability (%)

4. Discussion

This study generally has three merits. Firstly, based on a nationally representative data, we discuss in detail the socioeconomic inequality of traffic-related disability among Chinese adults, which is lacking in existing literatures (Ameratunga *et al.* 2006). Secondly, to our best knowledge, few studies have utilized concentration index, one of the best summary measures of socioeconomic inequalities in health, to study the relationship between socioeconomic status and TRD. Thirdly, using decomposition technique of concentration index, this study sheds lights on the potential sources for the socioeconomic inequality of TRD, which is essential for reducing the health burden of traffic crashes in China and other developing countries (World Health Organization 2009).

The negative value of concentration index of TRD (-0.192) implies that the adult population with disadvantaged financial status in China are more likely to suffer from disability caused by traffic crashes, which is consistent with previous studies conducted in other countries (Hyder and Peden 2003, Hasselberg and Laflamme 2004, Sethi *et al.* 2006, Laflamme *et al.* 2009, Chakravarthy *et al.* 2010). Besides, CI also measures the whole income-related inequality degree of TRD. For a straightforward intuitive interpretation, 14.4% of the TRD, i.e. about 220,000 disabled adults resulted from traffic accidents, would need to be redistributed from the poorer half to the richer half of population to achieve CI value of zero (14.4 equals 0.192 multiplied by 75, see details in (Koolman and van Doorslaer 2004)).

About the potential sources of socioeconomic inequality in TRD, the effects of PHINC and residence area are worth noting. Although a series of variables are controlled during decomposing process, PHINC can still account for 94.84% of the total inequality in TRD. According to the CI decomposition method (Eqs. (4)-(6)), the predominant contribution of PHINC comes from two components: (1) High level of income inequality exists among the Chinese adults. The concentration index of PHINC (0.47) ranked the second highest among all the factors. Such high income inequality has also been shown by (Gustafsson *et al.* 2008). (2) Lower income is closely related to higher risk of TRD. One possible explanation is that those who having lower income are more likely to be pedestrians, bus passengers, bicyclists or motorcyclists, and these types of road users are over-represented among crash victims (Wang *et al.* 2003, Ameratunga *et al.* 2006). In addition, financially disadvantaged population is more likely to face limited access to qualified post-crash trauma care, which may also increase the TRD prevalence among poor population (Mock *et al.* 1997, Grimes *et al.* 2011).

Contrary to PHINC, rurality of residence seems to considerably counteract the socioeconomic inequality in TRD (-22.22%), which can also be understood following the CI decomposition method. On one hand, the high concentration index of rurality of residence (0.37) confirms the huge income gap between urban and rural residents in China reported by other studies (Sicular *et al.* 2007). On the other hand, consistent with previous findings in other developing countries (Ghaffar *et al.* 2004, Moshiro *et al.* 2005), our study shows urban residents have higher risk of being disabled by traffic crashes compared to their rural counterparts. It is possible that (1) rural crashes may be more severe than urban crashes; or (2) under the same severe degree, urban crash victims may have a higher likelihood of survival with disability rather than loss of lives compared with rural residents, which is a result of more post-crash medical services provided in urban area (Zwerling *et al.* 2005, Li *et al.* 2008). However, the national survey did not comprise such information and the mechanism needs further exploration.

The current study has a few limitations. First of all, the cross-sectional nature of the survey data would have little implication of causality. Secondly, because we derived the partial effects at a particular value, i.e., the sample means, the CI decomposition results were not unique. Wagstaff et al. (2011) suggested that when the binary variable is nearly 50–50 split, it may be estimated by ordinary least squares. However, the prevalence of TRD among Chinese adults was only 1.55 per thousand, which did not satisfy the aforementioned balance (Wagstaff 2011). Therefore the linear approximation seemed to be an appropriate choice. In addition, the current study focused on disability as the crash outcome, which may differ with other injurious outcomes, assuming differentiated exposure effects. Although the study results should be interpreted with cautions, they may provide useful indication for further investigation and policy initiatives to prevent TRD in China or elsewhere in a similar setting.

In conclusion, we methodologically demonstrate the applicability of concentration index in the research field of road safety. The value of this study also lies in its practical meanings. Adults with financial disadvantage bear disproportionately heavier burden of traffic-related disability, which requires considerate commitment and resources from authorities and stakeholders to eliminate the socioeconomic inequality in the adverse health outcome of traffic crashes. The CI decomposition results provide clues of potential countermeasures to these inequalities. Strategies of reducing income inequality and protecting the safety of poor road users, are of great importance. Although we did not discuss the specific countermeasures in this paper, to keep the vulnerable road users like pedestrians safe and to guarantee the accessibility of poor population to qualified medical service after traffic accidents may be efficient means (World Health Organization 2009). Besides, the rurality of residence appears to counteract the socioeconomic inequality in TRD, however, it does not necessarily come to an optimistic conclusion. In addition to the worrying income gap between rural and urban areas, other possible mechanisms, e.g. the low level of post-crash medical resources in rural area, need further studies. Finally, the findings in China, the largest developing country undergoing fast motorization, could provide other countries in similar context with some insights about how to maintain socioeconomic equality in road safety.

Acknowledgement

This study was funded by National “973” project on Population and Health (No. 2007CB5119001), National Yang Zi Scholar Program, 211 and 985 project of Peking University (No. 20020903), Cai Zhai Scholarship of Peking University (CZ201115) and China Disabled Person’s Federation. And, China Disabled Person’s Federation also helps to collect the data used in this research.

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