# The Contribution of Diseases to Disability Burden among the Elderly Population in China: Empirical Evidence for Health Policy Priorities

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**Background**: With the rising prevalence of disability in China, the disabled elderly, who require and utilize more health services than their counterparts, put heavy pressure on the health system. However, our knowledge of the disease pattern of disability burden among the Chinese elderly is still limited.

**Methods**: Based on the 2006 China Disability Survey, we used the attribution method to obtain disability prevalence by disease and then employed the Sullivan method to produce life expectancy lived with disability (LWD) by diseases. The analyses were carried out at both for disease groups and for individual diseases.

**Results**: At the disease group level, ear, eye, circulatory and musculoskeletal diseases and injury and poisoning were the 5 leading causes of disability burden in terms of their contributions to disability prevalence and LWD. At the individual disease level, presbycusis, cataract, cerebrovascular disease, osteoarthritis and unclassified injury were the 5 leading individual diseases, which totally accounted for 66.21% (male: 65.16%; female: 67.16%) of disabilities among older population. Besides, gender disparities also existed in disease pattern of disability burden. For example, the prevalence of disability due to injury and poisoning among male aged 60 was almost twice that among female.

**Conclusion**: Along with epidemiologic transition, chronic diseases have become the predominant contributor to disability burden among elderly population in China. And, presbycusis, cataract, cerebrovascular disease, osteoarthritis and unclassified injuries should be the priorities in fighting against disability.

## INTRODUCTION

Along with rapid increase in the ageing population, disability prevalence has risen considerably in China during recent decades.[1] Older persons with disability often require and utilize more health care services than their counterparts and thus put a heavy pressure on the provision of health services and their financing.[2, 3] However, our knowledge of the disease pattern in the disability burden among Chinese elderly remains limited, which impedes ability to develop effective policy to prevent disability.

Only a handful of studies have tried to decompose the disability burden into diseases among elderly populations.[4-10] And, almost all the studies concern developed countries, e.g. Australia,[8] Netherlands,[6] UK,[4, 5, 9] and USA[10]. Musculoskeletal and circulatory diseases are two of the most important causes of disability burden.[5, 6, 8] Sensory organ disorders and injuries are also reported to be influential factors.[5, 8] In addition, some individual diseases like arthritis,[5, 6] diabetes,[4, 5, 7] depression,[9, 10] and stroke[5, 6, 8] also exhibit significant impact on disability. Studies also show that elimination or postponement of nonfatal but disabling diseases, like arthritis and visual impairment, can lead to compression of morbidity.[5, 8]

China, as a developing country, is at a different epidemiologic transition stage than developed countries,[11, 12] which means the conclusions drawn from these countries may not reflect the situation in China. Although the Global Burden of Disease Study (GBD) produced country-specific estimates including China, the term disability as used in GBD refers to the gap between current health status and ideal health status, but not to the actual presence of physical or mental disabilities.[13] Therefore, there is still a need to further understand the disease pattern in

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disability burden in the context of China.

How to deal with comorbidity, especially among older people, is one of the core problems in assessing the impact of diseases on disability burden.[14, 15] The earliest method used was to attribute all of a person's disability to the main health problem and to assume that disability will be eliminated after deletion of the main health problem.[8, 16] This actually overestimates the impact of main health condition and underestimates the impact of other diseases.[17] In an attempt to deal with this, Nusselder and colleagues employed a multiple logistic regression model to control for comorbidity.[18] All potential health problems and age categories are initially included in a regression model and then diseases are deleted from the model. The difference between the fitted total and cause-deleted disability prevalence is regarded as the impact of eliminated diseases.[18] The drawback of this method is that the impact of diseases depends on the order of elimination, i.e. the diseases still present in model after elimination. With the increased availability of longitudinal data, multistate life tables are frequently used in these analyses.[4, 5, 9, 10] Through comparing healthy expectancies of people with or without health problems at baseline, researchers assess the impact of health problems on disability burden. However, the number of covariates included in multistate life tables is limited in current studies, which makes it difficult to incorporate all the comorbidity. Recently, an attribution tool was proposed, which is based on a multivariate additive regression model.[19, 20] With this approach it is possible to partition the disability burden into additive contributions of diseases taking into account of the presence of comorbidity.[19] Using the attribution tool and the Sullivan method, this study aimed to analyze the contribution of diseases to the burden of disability among the elderly population in China. The disability burden is presented both in terms of disability prevalence and life expectancy with disability (LWD), which will help better define the priority of health policies.

## METHODS

### Data

The 2006 China Disability Survey was implemented in all province-level administrative units of mainland China. This survey was approved by the Chinese State Council and all respondents provided consent to it. Within each provincial stratum, a strategy combining four-stage sampling method and probability proportional to size cluster sampling method was employed to derive nationally representative sample. Excluding institutionalized population, the survey finally interviewed 2 526 145 respondents from 734 counties (3 169 communities) and representing 1.9‰ of the total non-institutionalized population in China.[1] This study focused on adults aged 60 years and above (n= 354 859), including 171 903 males and 182 956 females.

### Measurements

Disability

Trained interviewers used a structured questionnaire to ask respondents whether they or their family members had difficulties in visual, hearing, speech, physical, intellectual and mental functions. Then, people with functioning difficulties were referred to doctors for further disability screening and confirmation. In analyses, disability was dichotomous with a 1 indicating presence of disability.

Disease coding

During the disability screening, doctors chose up to 2 causes for confirmed disability. The total number of cause options for disability is 103. If a doctor specified a cause not listed in the questionnaire, they would choose the option of "others"; if a doctor could not determine a cause(s) of the disability, they would choose the option of "unknown reasons". About 90% of disabilities were given specified diseases as causes, which provided a solid basis for attribution analyses, better than data with self-reported health conditions.

We analyzed the contribution of diseases to disability burden at both the disease group level and the individual disease level. Firstly, the original 103 causes were coded into 15 disease groups according to the 10th version of International Classification of Diseases (ICD-10),[21] and 6 disease groups were dropped because of low prevalence (range: 0.04%-1.19%). The 9 disease groups included in final analyses were infectious and parasitic (infectious) diseases, mental and behavioral (mental) disorders, eye and adnexa (eye) diseases, ear and mastoid process (ear) diseases, circulatory system (circulatory) diseases, musculoskeletal diseases, pregnancy, childbirth and the puerperium (PCP) disorders, injury, poisoning and external causes (injury and poisoning), and others. And, injury and poisoning was the combination of "injury, poisoning and certain other consequences of external causes" and "external causes of morbidity and mortality", which are the nineteenth and twentieth chapters in ICD-10 respectively; the disease group "others" referred to the "unknown reasons" option, "others" option and causes that could not be included in any single disease group.

At the individual disease level, when disability causes in the questionnaire had corresponding individual disease categories in ICD-10, the causes were coded according to ICD-10; otherwise, the original causes in the questionnaire were used. To maintain consistency with disease group analyses, the 6 disease groups excluded from group disease analyses were also dropped in individual disease analyses. The individual diseases in analyses were presbycusis, cataract, cerebrovascular disease, osteoarthritis, unclassified injury, tympanitis, retinopathy, keratopathy; all the remaining causes were coded into "others".

**Analyses**

We employed the attribution tool proposed by Nusselder and colleagues,[20, 22] which takes into account the background risk that persons without reporting any diseases may be disabled, and the existence of comorbidity that persons can have more than one disease.[6] Subsequently, we applied the Sullivan method to obtain life expectancy with disability by diseases.

Prevalence of disability by diseases

Four assumptions were made to estimate the disability prevalence by diseases from cross-sectional data: (1) the distribution of disability by diseases is explained entirely by diseases identified during the survey plus the background risk; (2) this distribution is proportional to the risk distribution of becoming disabled in the time-period preceding the survey; (3) all persons of a given age are exposed to the same background disability risk; (4) the disability causes and background risk act as independently competing factors.[19, 20] The multivariate additive regression model, the core of the attribution tool, is specified as follows:

$$\hat{y}=1-e^{-\eta} \quad (1)$$

$$\eta=\alpha_a+\sum_d \beta_d X_d \quad (2)$$

Where $\hat{y}$ is the estimated probability of being disabled, $e$ is the base of the natural logarithm and $\eta$ is the linear predictor. The observed disability ( $y$ ) follows a binominal distribution. And, $\eta$ is defined as the sum of the background rate by age ( $\alpha_a$ ) and disease-specific rates of disability ( $\beta_d$ , the disabling impact) for the diseases ( $d$ ) whose presence are indicated by dummy variable $X_d$ . In addition, Reduced Rank Regression (RR) was also conducted to test whether $\beta_d$ varied by age.[22-24] To be more parsimonious, we started with reducing the rank of

interaction to one. Thus, the age-specific disabling impact of each disease ( $\beta_{da}$ ) was estimated as the product of an age pattern $\gamma_a$ which varied by age but was equal for each disease group, and a disease effect $\delta_d$ which varied by disease groups but not by age. Based on the Bayesian information criterion (BIC-$BIC_{RR}$= -11),[25] adding one rank interaction did not improve model performance and Eq.(1) and Eq.(2) were employed in further analysis. Besides, as the tests for gender differences in rates of background and disease were not significant, we used the same model for males and females. And, model was fitted using the Newton-Raphson algorithm.

Then, to estimate the disability prevalence by diseases, we combined the disease-specific rates of disability ( $\beta_d$ ) and prevalence of diseases ( $X_d$ ). At an individual level, the part attributed to a specific disease or background was the proportion of the disease rate in the total rates (i.e. the sum of background and disease rates). Thus, the attribution of disease $d$ is $\beta_d X_d / \eta * \hat{y}$ and of background is $\alpha_a / \eta * \hat{y}$. Through adding the disease-specific or background probabilities of all persons, we obtained the total number of disabled persons by diseases or background. Dividing the total number of disabled persons by diseases by the total number of elderly gives the prevalence of disability by diseases among the older population.

Life expectancy with disability by cause

LWD by diseases were computed using the Sullivan method, which can provide acceptable estimates of health expectancy if there has been no sudden or large changes occur to population health.[26, 27] The mortality data was primarily from National Bureau of Statistics of China[28] and the infant mortality rate was from UN data.[29] The life table was adjusted according to the west model life table by Coale and colleagues[30], which has proven to be suitable for adjusting life table of China [31]

Sample weights were used to derive national representative data.[32] The data was prepared with Statistical Package for the Social Sciences (SPSS) 16.0 and analyzed with the statistical package R version 2.7.1.

**RESULTS**

About 30% of the elderly lived in urban areas. With increasing age, fewer people were married or had ever attended school, especially among the female elderly; on the other hand, more and more people wereare disabled at older ages, with 50% of oldest-old (i.e. people aged 80 and above) being disabled. (Table 1)

Table 1 Descriptive statistics by age group and sex among Chinese elderly (%)

| | Males | | | | | Females | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 60-64 | 65-69 | 70-74 | 75-79 | 80+ | 60-64 | 65-69 | 70-74 | 75-79 | 80+ |
| Urban | 27.68 | 30.00 | 31.31 | 31.14 | 30.43 | 31.51 | 33.55 | 32.03 | 29.42 | 28.01 |
| Married | 87.38 | 83.74 | 77.30 | 68.41 | 50.94 | 80.41 | 67.92 | 53.32 | 36.44 | 16.57 |
| No school | 14.58 | 22.75 | 32.45 | 38.87 | 45.65 | 44.15 | 58.89 | 73.78 | 81.91 | 87.81 |
| Elementary education | 46.38 | 47.02 | 44.13 | 41.90 | 38.72 | 35.93 | 27.79 | 19.38 | 13.84 | 9.38 |
| Second and tertiary education | 39.03 | 30.23 | 23.42 | 19.23 | 15.62 | 19.92 | 13.32 | 6.84 | 4.25 | 2.81 |
| Disabled | 12.96 | 18.74 | 27.04 | 37.07 | 49.26 | 11.91 | 17.58 | 26.61 | 37.03 | 51.61 |

At the disease group level, the 5 leading causes of disabilities were ear, eye, circulatory and musculoskeletal diseases and, injury and poisoning (Table 2). Sensory organ disorders took a much higher toll than others, which

accounted for 55.05% of disabilities among all elderly and for 66.90% among oldest-old. Gender disparities also existed in the influence of disease groups on the disability burden. For example, the prevalence of disability due to injury and poisoning among males aged 60 was almost twice that among females. The disease pattern of LWD was consistent with that of disability prevalence (Figure 1). Of the 4.78 years (female: 5.60 years) of LWD in males at age 60, 1.86 (1.73) were contributed by ear diseases, 0.81 (1.52) by eye diseases, 0.51 (0.43) by circulatory diseases, 0.45 (0.40) by injury and poisoning, and 0.29 (0.49) by musculoskeletal diseases.

Table 2 The prevalence of disability by disease groups among Chinese elderly, by age group and sex (%)

| Diseases groups | Males | | | | | Females | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 60-64 | 65-69 | 70-74 | 75-79 | 80+ | 60-64 | 65-69 | 70-74 | 75-79 | 80+ |
| Background | 0.35 | 0.29 | 0.24 | 0.28 | 0.22 | 0.36 | 0.29 | 0.24 | 0.28 | 0.21 |
| Infectious | 0.27 | 0.30 | 0.24 | 0.30 | 0.30 | 0.23 | 0.22 | 0.26 | 0.28 | 0.24 |
| Mental | 0.62 | 0.58 | 0.66 | 0.68 | 0.68 | 1.03 | 0.89 | 0.89 | 1.02 | 1.13 |
| Eye | 1.78 | 2.82 | 4.49 | 6.57 | 9.54 | 2.56 | 4.27 | 7.40 | 10.99 | 14.48 |
| Ear | 2.87 | 5.74 | 10.54 | 16.27 | 23.49 | 1.86 | 4.04 | 7.69 | 12.12 | 19.99 |
| Circulatory | 1.75 | 2.51 | 3.26 | 3.63 | 3.50 | 1.17 | 1.79 | 2.44 | 2.75 | 2.73 |
| Musculoskeletal | 0.81 | 1.17 | 1.55 | 2.12 | 3.03 | 1.34 | 2.02 | 2.46 | 3.05 | 3.65 |
| PCP | 0.22 | 0.40 | 0.49 | 0.62 | 0.73 | 0.21 | 0.37 | 0.53 | 0.61 | 0.66 |
| Injury and poisoning | 1.94 | 2.24 | 2.50 | 2.77 | 3.35 | 1.07 | 1.36 | 1.83 | 2.45 | 3.58 |
| Other | 2.35 | 2.70 | 3.07 | 3.84 | 4.43 | 2.09 | 2.33 | 2.36 | 3.48 | 4.94 |
| Total percent disabled* | 12.96 | 18.74 | 27.04 | 37.07 | 49.26 | 11.91 | 17.58 | 26.61 | 37.03 | 51.61 |

* Because of rounding, the sum of percentages of disabled contributed by background and disease groups may not be equal to the total percent of disabled. PCP= pregnancy, childbirth and the puerperium.

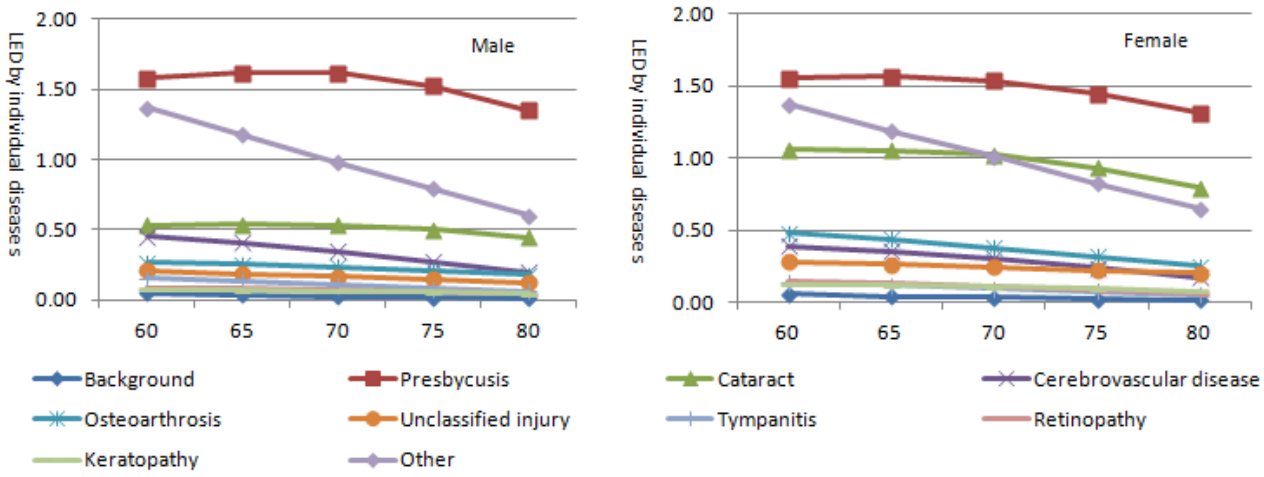


Figure 1 Life expectancy with disability by disease groups among Chinese elderly (years)

PCP=pregnancy, childbirth and the puerperium.

At individual disease level, presbycusis was the most significant disabling disease and its influence increased regularly with age (Table 3). For example, 1.82% of males aged 60-64 were disabled due to presbycusis and the percentage increased to 21.74% among the oldest-old. The 5 leading individual diseases (i.e. presbycusis, cataract, cerebrovascular diseases, osteoarthritis and unclassified injury) accounted for 63.51% (male: 61.27%; female: 65.15%) of disabilities among older population. The distribution of LWD by individual diseases was similar to that

of disability prevalence (Figure 2). For example, of the 4.78 years (female: 5.60 years) lived with disability in males aged 60, 1.58 (1.55) were caused by presbycusis, 0.53 (1.06) by cataract, 0.45 (0.39) by cerebrovascular diseases, 0.27 (0.48) by osteoarthritis and 0.21 (0.28) by unclassified injury.

Table 3 The prevalence of disability by individual diseases among Chinese elderly, by age group and sex (%)

| | Males | | | | | Females | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 60-64 | 65-69 | 70-74 | 75-79 | 80+ | 60-64 | 65-69 | 70-74 | 75-79 | 80+ |
| Background | 0.35 | 0.29 | 0.23 | 0.27 | 0.21 | 0.35 | 0.29 | 0.24 | 0.27 | 0.20 |
| Presbycusis | 1.82 | 4.27 | 8.87 | 14.22 | 21.74 | 1.26 | 3.29 | 6.71 | 11.00 | 18.98 |
| Cataract | 0.76 | 1.53 | 2.96 | 4.67 | 7.15 | 1.16 | 2.51 | 4.97 | 7.94 | 11.48 |
| Cerebrovascular disease | 1.52 | 2.21 | 2.93 | 3.21 | 3.17 | 1.05 | 1.61 | 2.23 | 2.53 | 2.48 |
| Osteoarthritis | 0.71 | 1.07 | 1.47 | 2.01 | 2.93 | 1.27 | 1.93 | 2.41 | 3.00 | 3.58 |
| Unclassified injury | 0.75 | 0.93 | 1.06 | 1.49 | 1.98 | 0.61 | 0.81 | 1.19 | 1.73 | 2.88 |
| Tympanitis | 0.65 | 0.89 | 0.90 | 0.97 | 0.96 | 0.48 | 0.58 | 0.72 | 0.85 | 0.71 |
| Retinopathy | 0.28 | 0.40 | 0.51 | 0.60 | 0.75 | 0.47 | 0.57 | 0.90 | 0.97 | 0.81 |
| Keratopathy | 0.24 | 0.36 | 0.38 | 0.56 | 0.73 | 0.30 | 0.43 | 0.57 | 0.85 | 1.08 |
| Others | 5.86 | 6.79 | 7.74 | 9.06 | 9.64 | 4.95 | 5.56 | 6.69 | 7.89 | 9.41 |
| Total percent of disabled* | 12.96 | 18.74 | 27.04 | 37.07 | 49.26 | 11.91 | 17.58 | 26.61 | 37.03 | 51.61 |

* Because of rounding, the sum of percentages of disabled contributed by background and disease groups may not be equal to the total percent of disabled.

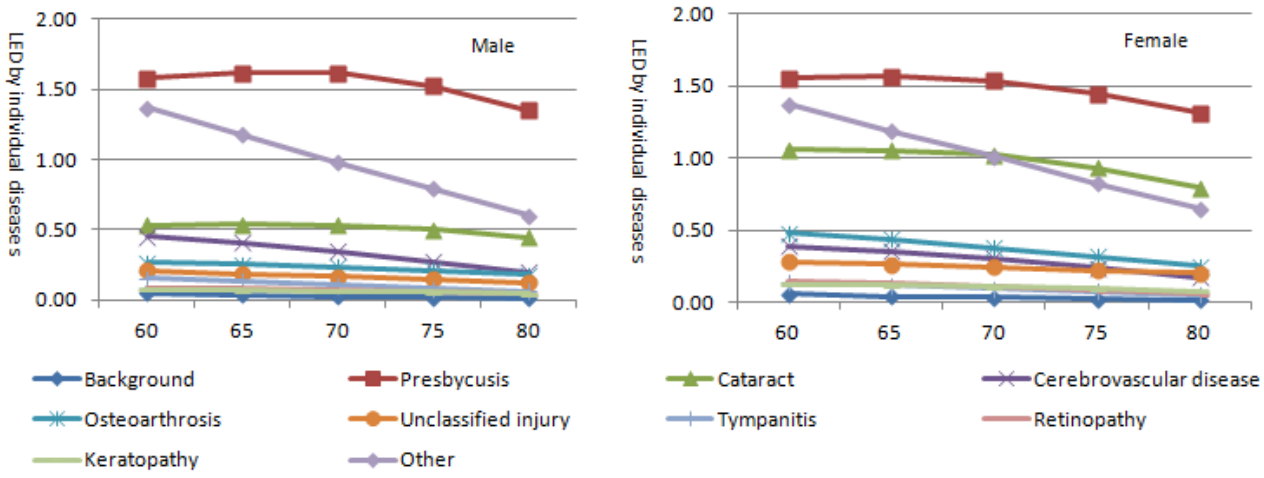


Figure 2 Life expectancy with disability by individual diseases among Chinese elderly (years)

## DISCUSSION

To our knowledge, this is the first study which attributes the disability burden of Chinese elderly into diseases in terms of both disability prevalence and LWD. The results suggest that chronic disease groups including ear, eye, circulatory, musculoskeletal diseases and injury and poisoning are the predominant contributors to the disability burden in China. Consistently, individual diseases such as presbycusis and cataract have a significant influence on disability, which provides a support for making health policies among older population in China.

Sensory diseases accounted for more than a half of the disability burden among Chinese elderly. Although few studies have ever included sensory diseases, this paper corresponds with most of the existing literature.[8, 33] Our results show that five out of the eight most important individual diseases, i.e. presbycusis, cataract, tympanitis,

retinopathy and keratopathy, belonged to sensory organ disorders. The GBD study regarded hearing loss, refractive errors and cataracts as the leading causes for moderate or severe disability, which is more similar with the definition of disability in this study, among elderly in low- or middle- income countries.[13] On the other hand, Jagger and colleagues reached the opposite conclusion, i.e. that visual and hearing impairments exhibited only minor influence on disability-free life expectancy in later life.[5] The difference arises from at least 3 aspects. First, the rankings of diseases in mortality and disability are different.[16] Some diseases are fatal but cause less disability, e.g. cancer; some are nonfatal but disabling, e.g. presbycusis.[8, 18] The attribution method we employed decomposes the disability prevalence into diseases, but does not take account of mortality. Secondly, different definitions of disability were used. The measurement of disability by Jagger and colleagues was based on ADL/IADL functions[5] and this paper primarily on impairments.[1, 15] Thirdly, UK and China were at different epidemiologic stages[11, 12] and they were probably also confronted with different disease pattern of disability.

The importance of circulatory and musculoskeletal diseases has been repeatedly reported in previous studies.[5, 6, 8] And, cerebrovascular diseases and osteoarthritis were among the four most important individual diseases for disability burden. Gender difference also existed in the contribution of diseases to the disability burden. Musculoskeletal disease was more important among women than men; conversely, circulatory diseases had a higher impact among men than women.[6, 8] There is evidence pointing toward men having more common fatal diseases, such as heart disease and cancer, and toward women having a higher prevalence of nonfatal chronic diseases and lower muscle strength and bone density.[34-36]

Both the injury and poisoning disease groups and unclassified injury among individual diseases showed significant influence on disability burden.[8] In addition to the observed higher mortality from injury or poisoning among males than female,[37, 38] this study indicated a similar trend in disability. For example, the prevalence of disability caused by injury and poisoning among males was almost double that among females at age 60-64. The gender disparities may result from the higher possibility of males being injured. An epidemiology survey conducted in Shandong province (China) reported the injury incidence rate among male was 1.5 times as high as that among females.[39]

Generally, the disease pattern in disability burden mirrors the health model in China. In the past, because of the public health intervention, better hygiene and sanitation and safe water, improved access to medical care and elevated social and living standards, the predominant causes of mortality have shifted from infectious diseases and maternal and perinatal conditions to chronic diseases and injury.[12] Myers and colleagues argued that there is a disability transition accompanying the epidemiologic transition.[40] In later stages of epidemiologic transition, the underlying causes of disablement change from those attributable to communicable diseases to those resulting from non-communicable diseases,[40] as indicated in present study. Moreover, the life course perspective is also useful for understanding the patterns we observed. The subjects we studied were born before the foundation of the People's Republic of China. Most of them grew up in a disadvantaged environment which included wars and famines and went through adulthood or middle-aged stage in the period of reform, opening-up and modernization. One sign of the life course influences is that tympanitis, a disease mainly occurring among children,[41] is still a significant contributor todisability among the elderly. Besides, health risk factors which dramatically increase with economic development show their potential impact on disability. For example, the significant contribution of cerebrovascular diseases to the disability burden may be a result of dietary changes and the higher prevalence of physical inactivity, smoking, hypertension and obesity.[12, 42]

This paper has several limitations. First, the prevalence of diseases was lower than usual because only disabling conditions were recorded. Although the sample size of elderly population was large (n= 354 859), we still could not include all the diseases in the analyses. Diseases with lower prevalence were dropped. Secondly, the survey did not incorporate some potential causes of disability, such as respiratory diseases[8] and diabetes[4, 5, 7], which may result

in overestimation of the diseases in the current model. Third, the measurement of disability was primarily based on impairment,[1, 15] which limits the comparability with other studies.[4-7, 9] But, the disability definition in this study is meaningful in China. The Chinese disability certificate, which is one of the qualifying criteria for a disability allowance and other preferential policies for the disabled, adopts the same disability definition as we did.[43]

This study underscores the contribution of chronic diseases and injuries, especially sensory diseases, to the disability burden. Identifying the most disabling individual diseases, i.e. presbycusis, cataract, cerebrovascular diseases, osteoarthritis and unclassified injury, provides an evidence basis for the disease prevention policy. As these diseases account for around 2/3 of disabilities, postponement or elimination of their occurrence are expected to bring substantial reduction in disability burden among Chinese elderly, which also could lead to an absolute compression of morbidity.[8, 18] Further study should include more common chronic diseases such as respiratory diseases and diabetes to produce more accurate and comprehensive estimates on disease pattern in the burden of disability.

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