REGULAR ARTICLE

Measuring the burden of disease using disability-adjusted life years in Shilin County of Yunnan Province, China

Shang-Cheng Zhou · Le Cai · Jing Wang · Shao-guo Cui · Yun Chai · Bing Liu · Chong-Hua Wan

Abstract

Background Few studies calculating burden of disease (BOD) have been carried out in China. Disability-adjusted life years (DALY) is one of the useful methods used to estimate BOD. This study aims to use DALY for evaluating BOD and to provide useful information for health planning for residents in Shilin Yi Nationality Autonomous County (Shilin County) of Yunnan Province, China.

Methods Methods developed for the Global Burden of Disease (GBD) Study by the World Bank and World Health Organization (WHO) were adapted and applied to Shilin County population health data. DALY rate per 1,000 was calculated from medical death certificates in 2003 in Shilin County. The geographic coordinates of towns or townships were determined using the geocode function of R2.3.1 geographical information system (GIS) software.

Results Respiratory diseases were by far the leading cause of years of life lost (YLL) in both males and females. The four other leading causes of YLL in descending order were: unintentional injuries, cardiovascular diseases, intentional injuries, and malignant neoplasms. However, the five leading causes of years lived with disability (YLD) were, in descending order: neuropsychiatric conditions, intentional injuries, respiratory diseases, unintentional injuries, and cardiovascular diseases. The leading cause of total disease burden (DALY) was neuropsychiatric conditions. Townships of Muzhuqing, Xijiekou, and Weize were the areas with most serious disease burden in Shilin County.

Conclusions Prevention and treatment of neuropsychiatric conditions and respiratory diseases for both females and males should be enhanced in Shilin County, so as to decrease injury. More preventive interventions for noninfectious chronic diseases should be emphasized in remote townships.

Keywords Burden of disease · Disability adjusted life years · All-causes-of-death survey data · Geographical information system

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Background

In the current situation with increasing threat of chronic diseases and emerging and re-emerging infectious diseases, how to allocate limited health resources is always a common serious problem for the World Health Organization

(WHO) and each nation [1, 2]. The study of burden of disease (BOD) provides important evidence for setting priorities and emphases in health research, and favors optimization of allocation of health resources and improving human quality of life. Valid health statistics are required for policy-making and taking essential measures. With the development of society, the sequence of disease and causes of death are changing. People have realized that health outcomes are not only fatal but also include nonfatal situations and disability in different degrees. Traditional indexes such as mortality rate, prevalence or incidence are limited and unilateral and cannot value severe diseases' effect on health. So, more sensitive measures are needed to study overall health and BOD [3]. Study of BOD was based on use of a single death indicator for evaluating BOD until the adoption of certain compound indicators considering disability and death. During this process, many indicators have emerged sequentially, including morbidity rate, mortality rate, years of potential life lost (YPLL), disability-adjusted life years (DALY), and so on [4, 5].

Shilin Yi Nationality Autonomous County (Shilin County) is a rural region in the southeast of Kunming City, Yunnan Province [6, 7]. It is 78 km from the main urban area of Kunming and covers a land area of 1,719 km^2. Its permanent population amounts to 230,548 (116,204 males, 114,344 females) in 2003, wherein Yi population account for 34% [8, 9]. Average life expectancy in Shilin County was 70.12 years for males and 73.89 years for females [10].

The Shilin County burden of disease and injury studies were the first comprehensive studies of this type in Yunnan Province. The study used methods developed for the Global Burden of Disease Study (GBD) [11] to quantify loss of health from a comprehensive set of 135 causes of disease and injury. It used a common metric of DALY, which combines information on both the impact of premature death and the impact of disability and other nonfatal health outcomes. One DALY can be thought of as one lost year of "healthy" life, and the burden of disease can be considered as a measurement of the gap between current health status and an ideal situation of living into old age free of disease and disability. DALY has previously been used to provide a comprehensive assessment of global burden of disease and injury for the World Bank [12], to inform global priority setting for health research [13], and to report on trends in population health across the world [14].

Methods

Study population

Shilin County was selected as the study region. There were 1,065 deaths (563 males and 502 females) in the region.

Data source

Causes of death were based on medical death certificate information, maintained by Shi lin Center for Disease Control and Prevention (CDC). All death reports were grouped by underlying cause of death as defined in the GBD study [15] and coded using the International Classification of Diseases, 9th revision (ICD-9) coding system.

To avoid misreporting of age at death or misclassification of cause of death, all medical death certificates were verified for underlying cause of death by a team of two independent physicians. Any discrepancies were reviewed to obtain consensus. All death conditions were distributed to other more well-defined causes according to the age and gender distribution of specific conditions, following the conceptual approach in the GBD study [16]. These were subdivided into several more specific causes [16]. Because ill-defined causes were exist, 50 deaths of ill-defined causes were beyond this analysis.

Calculation of YLL

Premature mortality was estimated in terms of YLL using the widely used formula [17–19]. To calculate YLL, the GBD DALY template was used in this study [20]. This is a Microsoft Excel spreadsheet that contains the formula to calculate YLL.

Calculation of years lived with disability and DALY

The GBD formula was applied for calculation of DALY. DALY was calculated by summing YLL and YLD:

$$DALY = YLL + YLD.$$

DALY was calculated using both a 3% discount rate and no discounting, although in this paper we only report discounted estimates. Death estimates alone were the data source for YLL computation. Prevalence estimates, together with disability weighting data, were used to calculate YLD. Because we are short of incidence, prevalence, even sequelae of disease and injury, we use the indirect method. We can estimate YLD and DALY indirectly according to death register data, demographic data, and the YLD/YLL ratio for China taken from the WHO World Health Report 2002.

Geographical information system (GIS) methodology

Geographic information system (GIS) mapping technologies have potential to advance public health promotion by mapping regional differences in attributes to suggest priorities for public health interventions. The geographic

Table 1 Distribution of deaths using mortality and DALY by age and sex in Shilin County (2003)

Age group	Male		Female		Total	
	DALY/1,000	Mortality (‰)	DALY/1,000	Mortality (‰)	DALY/1,000	Mortality (‰)
0~	1,309.0	39.53	1,009.0	30.37	1,164.1	35.11
1~	164.8	4.69	117.8	3.34	142.0	4.03
5~	32.9	0.88	17.2	0.46	25.2	0.68
10~	22.3	0.60	31.6	0.84	26.8	0.72
15~	24.2	0.67	39.8	1.10	31.4	0.87
20~	54.8	1.62	51.8	1.52	53.4	1.57
25~	43.8	1.41	33.2	1.06	38.8	1.24
30~	71.0	2.53	25.6	0.90	49.1	1.75
35~	56.9	2.29	44.8	1.77	51.2	2.04
40~	82.8	3.82	44.9	2.03	64.5	2.96
45~	64.8	3.50	53.1	2.79	59.0	3.15
50~	100.2	6.44	67.7	4.17	84.4	5.34
55~	144.3	11.32	50.2	3.75	99.2	7.69
60~	209.1	20.69	95.7	8.77	154.2	14.93
65~	221.4	28.69	160.2	18.77	191.1	23.78
70~	263.2	46.28	220.9	34.52	241.9	40.35
75~	296.5	73.87	246.0	53.89	269.0	63.00
80~	396.8	147.40	306.1	99.64	344.0	119.58
85~	293.5	201.52	264.8	172.79	275.2	183.20

coordinates of towns or townships were determined using the geocode function of R2.3.1 geographical information system (GIS) software. Addresses that did not automatically match during batch processing with R2.3.1 were geocoded manually using detailed paper street maps [21].

Ethical approval

This study was approved by the Ethics Committee of Kunming Medical College, before carrying out the research.

Results

Table 1 presents the distribution of deaths using mortality and DALY by age and sex in Shilin County (2003). Measuring on different indexes of the mortality or DALY, the leading age groups of disease burden were different. The mortality of age groups increased gradually with age increasing by no weight, whereas DALY emphasized the weight of young people and weakened the weight of elder.

Respiratory diseases were by far the leading cause of years of life lost in both males and females, followed by unintentional injuries, cardiovascular diseases, intentional injuries, and malignant neoplasms (Table 2).

Neuropsychiatric conditions were the leading cause of YLD. These were followed by intentional injuries and

Table 2 YLL by sex and broad disease groups in Shilin County (2003)

Male	YLL	Female	YLL
Respiratory diseases	1,605	Respiratory diseases	1,567
Unintentional injuries	1,545	Cardiovascular diseases	1,193
Cardiovascular diseases	995	Intentional injuries	840
Intentional injuries	905	Unintentional injuries	679
Malignant neoplasms	863	Malignant neoplasms	571
Maternal conditions	697	Maternal conditions	397
Digestive diseases	304	Respiratory infections	320
Infectious and parasitic diseases	276	Infectious and parasitic diseases	181
Respiratory infections	275	Congenital anomalies	120
Neuropsychiatric conditions	217	Digestive diseases	90
Congenital anomalies	171	Genito-urinary diseases	85
Genito-urinary diseases	129	Neuropsychiatric conditions	70
Diabetes mellitus	79	Diabetes mellitus	20
Uncertain cause	122	Uncertain cause	141
Total	8,183	Total	6,274

respiratory diseases. In terms of specific conditions, neuropsychiatric conditions were the leading cause of nonfatal disease burden in Shilin County, causing 48.5 YLD/1,000 in 2003 (Table 3).

Table 3 YLL/1,000, YLD/1,000, and DALY/1,000 population by broad disease groups in Shilin County (2003)

All causes	YLL	YLD	DALY
Infectious and parasitic diseases	2.1	1.4	3.5
Respiratory infections	2.7	0.5	3.2
Respiratory diseases	14.2	6.6	20.8
Maternal conditions	4.9	1.3	6.2
Malignant neoplasms	6.4	1.7	8.1
Diabetes mellitus	0.4	0.5	0.9
Neuropsychiatric conditions	1.3	48.5	49.8
Cardiovascular diseases	9.8	2.2	12.0
Digestive diseases	1.8	1.1	2.9
Genito-urinary diseases	1.0	0.7	1.7
Congenital anomalies	1.3	0.7	2.0
Unintentional injuries	9.9	4.8	14.7
Intentional injuries	7.8	13.2	21.0
Total	63.6	59.1	122.7

Fig. 1 Distribution of disease burden by DALY in Shilin County (2003) by towns and townships. The serial numbers (1, 2, 3, etc.) have the same meaning as in Table 3

Table 4 Ordering of towns and townships in Shilin County by disease burden (DALY/1,000) (2003)

Serial number	District	Population	DALY/1,000
1	Muzhuqing township	12,835	70.9
2	Xijiekou township	15,105	70.8
3	Weize township	13,541	68.3
4	Lumeiyi township	31,364	65.4
5	Shilin town	12,284	64.7
6	Dake township	16,947	59.7
7	Beidacun township	25,104	53.3
8	Guishan township	18,025	51.7
9	Banqiao township	35,253	48.0
10	Lufu town	50,180	31.0

Table 5 YLL/1,000, YLD/1,000, and DALY/1,000 population by major disease groups of the heaviest disease burden township in Shilin County (2003)

Causes	YLL/1,000[a]	YLD/1,000[a]	DALY/1,000[a]
Maternal conditions	13	1.3	14.3
Unintentional injuries	11.6	0.7	12.3
Intentional injuries	8.1	1.3	9.4
Cardiovascular diseases	8.9	0.4	9.3
Respiratory diseases	7.5	0.7	8.2

[a] These indicators are calculated by summing Muzhuqing township and Xijiekou township

As shown in Table 4, inclusion of nonfatal health outcomes led to a substantially different picture to that provided by traditional mortality statistics: respiratory diseases became the third leading cause (20.8 DALY/1,000), after neuropsychiatric conditions (49.8 DALY/1,000) and intentional injuries (21.0 DALY/1,000).

Shilin County includes 2 urban townships (Lufu town, Shilin town) and 8 rural townships (Muzhuqing township, Xijiekou township, Weize township, Lumeiyi township, Lumeiyi township, Dake township, Beidacun township, Guishan township, Banqiao township). Methodological quality tended to produce variation in different directions for different causes of deaths. Table 4 and Fig. 1 show the regional variation of disease burden by DALY in Shilin County. Townships of Muzhuqing, Xijiekou, and Weize were areas of serious disease burden.

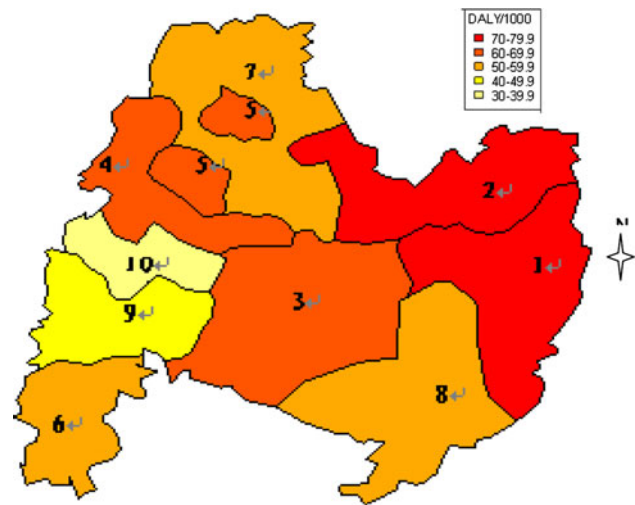Table 5 presents YLL/1,000, YLD/1,000, and DALY/1,000 population by major disease groups of the heaviest township in Shilin County (2003). The indicators above were calculated by summing Muzhuqing township and Xijiekou township because their disease burden was the heaviest. The five leading causes of DALY/1,000 in descending order were: maternal conditions, unintentional injuries, intentional injuries, cardiovascular diseases, and respiratory diseases.

Discussion

As expected, our investigation of all disease burden showed variation both by cause and within geographical regions.

Burden-of-disease analysis provides a unique perspective on health that integrates fatal and nonfatal outcomes yet allows these two classes of outcomes to be examined separately. Among the top 10 causes of burden of disease and injury in Shilin County were two nonfatal or low-fatality diseases: neuropsychiatric conditions and congenital anomalies. The burden of neuropsychiatric conditions

and congenital anomalies had been seriously underestimated by traditional approaches to disease burden assessment that disregard disability and take into account only deaths. Especially, neuropsychiatric conditions had the highest DALY rate (49.8 DALY/1,000), similar to in another study (Shanghai, 30.52 DALY/1,000) [22].

The calculation of YLL was straightforward, and the precision of the estimates was almost entirely dependent on the quality of the data for underlying cause of death. The YLD required much more grounding data and extensive epidemiological modeling. Thus, the precision of the YLD estimates was not calculated in the usual statistical sense. In our study, we used the indirect method to calculate YLD. We estimated YLD according to death register data, demographic data, and the YLD/YLL ratio for China from the WHO World Health Report 2002. As a next step in these studies, we plan to detect the uncertainty in these burden-of-disease estimates using simulation modeling and sensitivity analysis to calculate YLD directly and accurately.

In Shilin County, burden of disease in 2003 was about 14,457 DALY. Depending on the mortality and DALY used for calculation, rank results could be slightly different. DALY led to overestimation for young people compared with the mortality norm, decreasing the burden of disease of the elder gap. That is to say, the social and economical values were considered by DALY. Actually the GBD study weighted a year of healthy life lived at youngest ages and oldest ages lower than years lived at other ages.

Few previous studies have reported cause-specific mortality or DALY in China [23], and Shilin County is distinctive. Respiratory diseases, unintentional injuries, cardiovascular diseases, intentional injuries, and malignant neoplasms were important causes of YLL and DALY in the study region. Despite the fact that economic growth has resulted in more high-speed vehicles in China, the reduction in disease burden due to respiratory diseases indicates a positive trend in this context. As in other locations [22], high injury rates in Shilin (Shilin: unintentional injuries 14.7 DALY/1,000, intentional injuries 21.0 DALY/1,000; Shanghai: unintentional injuries 9.38 DALY/1,000) may be due to multiple factors such as religious beliefs, social isolation, family problems, stressful life events, chronic painful diseases, mental disorders, and substance abuse [24]. In this study, digestive diseases led to more premature deaths in males than females, whereas deaths due to neuropsychiatric conditions were more common in females. As such, these diseases need better control according to sex.

GIS is a geomatic tool used for geographical analysis and is crucial to understand injury distribution better. This computer mapping technology has introduced a new era in computational epidemiology. Through GIS, epidemiologists can translate or geocode street addresses into unique latitude and longitude locations [25]. In our study, the cause of heavy disease burden in the townships of Muzhuqing and Xijiekou may be mainly mountainous with high variability in level of socioeconomic development of different areas. Strategies of economic development should be reviewed to avoid adverse effects on health, especially due to maternal conditions.

A few limitations should be recognized in interpreting this study's results. The strength of this study comes from its use of complete data from death registration systems. The problem of underreporting of deaths found in many studies was thus minimized. Underreporting of deaths has been shown to be more common in infant deaths in a previous study, especially in rural regions [26]. Such work will be the focus of future research. More detailed work could be done to estimate disease burden at specific disease level, which would take account of differences in mortality outcomes.

This study is a first step in exploring the usefulness of BOD methods for Yunnan Province. Although the application of the cause-of-death evaluation framework at the county level in Shilin County produced important findings, some of these should be viewed with caution; for example, there was uncertainty regarding the validity of registration diagnoses for specified causes of death without the issue of ill-defined causes.

Conclusions

Overall, our findings for Shilin County's disease burden suggest that DALY could provide a more complex measure of the impact than traditional death rates. Prevention and treatment of neuropsychiatric conditions and respiratory diseases for both females and males should be enhanced in Shilin County, so as to decrease injuries. Prevention and intervention for noninfectious chronic diseases should be emphasized in remote townships. Additional studies are needed to determine whether these findings are true for other areas, including rural areas and more minor nationality autonomous areas.

Appendix

In this article, the YLD/YLL ratio was taken as that of China from the WHO World Health Report 2002 (Table 6).

Table 6 YLD/YLL ratio by broad disease groups in Shilin County (2003)

Cause	Shilin County		CHN (WHO report)	
	YLL	YLD	YLL	YLD
(1)	(2)	(3) = (2)×(5)/(4)	(4)	(5)
Infectious and parasitic diseases	2.1	1.4	7.5	5.0
Respiratory infections	2.7	0.5	4.3	0.76
Respiratory diseases	14.2	6.6	8.4	3.9
Maternal conditions	4.9	1.3	7.6	2.0
Malignant neoplasms	6.4	1.7	14.3	3.7
Diabetes mellitus	0.4	0.5	0.8	1.0
Neuropsychiatric conditions	1.3	48.5	0.7	26.1
Cardiovascular diseases	9.8	2.2	15.3	3.4
Digestive diseases	1.8	1.1	4	2.5
Genito-urinary diseases	1.0	0.7	1.3	0.9
Congenital anomalies	1.3	0.7	2.4	1.3
Unintentional injuries	9.9	4.8	12.5	6.1
Intentional injuries	7.8	13.2	4.9	8.3

Table 7 Impact of age-weighting and discounting on YLL in Shilin County (2003) $[r, K, \beta]$

Age group	Male			Female		
	0.03, 1, 0.04	0, 1, 0.04	0.03, 0, 0	0.03, 1, 0.04	0, 1, 0.04	0.03, 0, 0
0∼	1,309.0	3,396.1	1,198.0	1,009.0	2,648.4	926.9
1∼	164.8	400.9	141.0	117.8	289.8	101.2
5∼	32.9	72.9	26.2	17.2	38.5	13.7
10∼	22.3	45.6	17.3	31.6	65.9	24.8
15∼	24.2	46.7	19.0	39.8	77.9	31.5
20∼	54.8	101.3	44.5	51.8	97.1	42.5
25∼	43.8	77.4	37.3	33.2	59.6	28.6
30∼	71.0	120.0	64.4	25.6	44.1	23.6
35∼	56.9	92.3	55.3	44.8	74.1	44.2
40∼	82.8	128.4	86.7	44.9	71.3	48.0
45∼	64.8	96.1	73.5	53.1	80.8	61.6
50∼	100.2	142.0	123.4	67.7	98.7	85.2
55∼	144.3	195.2	193.3	50.2	70.0	69.1
60∼	209.1	269.6	305.6	95.7	127.4	143.7
65∼	221.4	272.2	353.8	160.2	203.4	263.2
70∼	263.2	309.7	460.9	220.9	267.4	397.8
75∼	296.5	335.7	573.2	246.0	284.8	487.1
80∼	396.8	434.7	855.1	306.1	340.7	671.8
85∼	293.5	310.6	738.6	264.8	281.7	689.5
Total	103.3	190.4	116.4	75.7	142.4	88.6

Table 7 presents the impact of the use of discounting and age-weighting on the distribution of deaths by age and sex of YLL. We can see that use of discounting and age-weighting slightly modified the ranking of diseases for both males and females. That is to say, the result of this study was generally stable.

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