

ORIGINAL ARTICLE: BEHAVIORAL  
AND SOCIAL SCIENCES

# Comparative study of disability-free life expectancy across six low- and middle-income countries

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**Aim:** There is a knowledge gap about the disability-free life expectancy (DFLE) in low- and middle-income countries. The present study aimed to compute and compare DFLE in six such countries, and examine sex differences in DFLE in each country.

**Methods:** Based on data from the World Health Organization Study on Global Aging and Adult Health wave 1 survey, we used the Sullivan method to estimate DFLE among persons aged years 50 years and older. Disability was divided into moderate disability and severe disability during the calculation.

**Results:** Of the six countries, China had the highest DFLE and lowest expected average lifetime with disability. India had the lowest DFLE and highest life years with moderate and severe disability. In each country, women live longer than men, but with more disabilities in both absolute and proportional terms. The huge sex difference in Russia requires special attention. In addition, most of the life expectancy lived with disability was spent with severe disability, rather than moderate disability.

**Conclusions:** The study has shed some light on the disparities across the six countries with regard to DFLE at old ages. The low percentage of DFLE in life expectancy in some countries, such as India, calls for effective policies on healthy aging. The “sex disability-survival paradox” in DFLE is supported by our results. To differentiate the severity of disability should be routine in calculating DFLE. *Geriatr Gerontol Int* 2017; 17: 637–644.

**Keywords:** comparative study, disability-free life expectancy, low- and middle-income countries, older people, sex difference.

## Introduction

Globally, populations are rapidly growing older than ever before, which is a result of declining fertility rates, together with increasing life expectancy (LE) at the older ages.<sup>1</sup> Although populations in developed countries have been aging for over a century now, the process has recently begun in developing countries, at a faster pace though.<sup>2</sup> In fact, approximately two-thirds (64%) of older persons currently reside in developing countries, and this is projected to increase to almost three-quarters (71%) by 2025.<sup>3</sup> The extension of LE signifies impressive gains in health status at old ages across the globe. Although population aging is a success story, it also comes along with challenges, such as increased health and long-term social care costs for older adults, who are more vulnerable to chronic diseases and

disability.<sup>1</sup> Hence, an important question remains about the quality of those extra years of life lived.

Traditionally, LE has been used as a measure of population health. However, this indicator only reflects the mortality experience, and does not take into account the morbidity aspect. Disability-free LE (DFLE) is a meaningful population health measure that combines mortality and morbidity (disability) into a single index.<sup>4,5</sup> DFLE can be defined as the average number of years spent free of disability by an individual of a given age.

In some regions, such as Europe, DFLE has become a primary measure of population health and monitoring health outcomes instead of LE.<sup>5</sup> A large number of studies have used DFLE to monitor the progress of healthy aging in high-income countries.<sup>6–8</sup> However, there is no such awareness in using this measure in low- and middle-income countries (LMIC). Although a handful of studies have examined DFLE in some of these LMIC; for example, China, gaps in knowledge still exist.<sup>9</sup>

In the present study, we used the data from the World Health Organization's (WHO) Study on Aging and Adult Health (SAGE) survey. The data were designed to improve

Accepted for publication 4 January 2016.

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the empirical understanding of health status and the aging process in LMIC. The surveys use standardized methods of data collection that improve comparability of data across countries.<sup>10</sup> The SAGE data provides a unique opportunity to make country comparisons, which is often a weakness of studies that attempt to do so by using different survey data, disability definition and calculation methods that are not comparable.<sup>11,12</sup> In the present analysis, we differentiated between moderate and severe disability, which is overlooked by the majority of studies, but is important for later studies to be able to examine dynamic equilibrium hypothesis.<sup>13</sup> According to Manton, as LE increases over time, the years spent with morbidity will also increase, and those with severe morbidity and disability will remain relatively constant.<sup>13</sup>

The present study aimed to compare DFLE across six LMIC, namely, China, Ghana, India, Mexico, Russia and South Africa. The study also examined sex differences in DFLE in each country.

## Methods

### Data

In the analysis, we used both disability and mortality data. The disability data was from the WHO-SAGE wave 1. SAGE is a longitudinal survey organized by WHO and carried out in six countries: China, Ghana, India, Mexico, Russia and South Africa.<sup>14</sup> The selection of countries considers a series of factors, such as geographic range and population size. Generally, these countries are representative of low- to upper-middle income countries, and are at different stages of demographic and epidemiological transitions.<sup>15</sup> SAGE aims to collect comprehensive and nationally representative information on the health and well-being of adult populations and the aging process.<sup>14</sup> The core SAGE collects data on adults aged 50 years and older, and includes a smaller comparison sample of younger adults aged 18–49 years. SAGE wave 1 was carried out during 2007 and 2010. In all countries, multistage sampling techniques were used in order to obtain nationally representative samples, although there were contextual variations in the sampling process across the six countries.<sup>10,16</sup> Standardized training and survey materials were also used to increase comparability of data. Finally, 42 487 samples were obtained, including 14 813 from China, 5110 from Ghana, 11 230 from India, 2756 from Mexico, 4355 from Russia and 4223 from South Africa. The overall response rate for the six countries was 75%.<sup>10</sup> More information and detailed materials about the SAGE wave 1 can be found at: <http://www.who.int/healthinfo/sage/en/>.

In the present study, we focused on the elderly population, which was defined as persons aged years 50 years and older. This is in line with the definition used by WHO SAGE,<sup>15</sup> and the Minimum Data Set Project on Aging.<sup>17</sup> To match with the disability data, we used the abridged life

table estimates by sex for the period of 2005–2010 from World Population Prospects 2012.<sup>18</sup> As the number of respondents in some 5-year age groups was very small in countries such as Mexico, which produced unreliable results, we transformed the original life tables with 5-year age groups and open-ended age group ( $\geq 85$  years) into those with 10-year age groups and an open-ended age group ( $\geq 80$  years) in the final analysis for all six countries.

### Measurements

Consistent with other studies using SAGE wave 1, 17 items were included to measure activities of daily living (ADL).<sup>19,20</sup> Respondents were asked about their difficulty in 17 kinds of activities in the past month, such as standing up from sitting down and climbing one flight of stairs without resting (see details in Appendix S1). Each item has six options, 1 = none, 2 = mild, 3 = moderate, 4 = severe, 5 = extreme/cannot do and 9 = non applicable. The responses of 9 were treated as missing values. The number of items with responses of 4 or 5 was computed. Respondents were then categorized into three groups: non-disabled (0 ADL item choosing 4 or 5), moderate disabled (1 ADL item choosing 4 or 5) and severe disabled (at least 2 items choosing 4 or 5).

### Analyses

In the present study, we used one of the most widely used methods, the Sullivan method, to compute LE.<sup>4,5</sup> Specifically, DFLE at age  $x$  ( $DFLE_x$ ) was calculated using equation (1).  ${}_nd_x$  was the prevalence of disability in age group  $(x, x+n)$ ,  ${}_nL_x$  was person-years of life lived in age group  $(x, x+n)$  and  $l_x$  was the number of survivors at age  $x$ . LE lived with disability ( $LWD_x$ ) was equal to LE at age  $x$  minus  $DFLE_x$ . Then, LE lived with moderate disability ( $LWD_{1, x}$ ) or severe disability ( $LWD_{2, x}$ ) at age  $x$  were calculated in the same way, with  ${}_nd_x$  being the prevalence of moderate or severe disability in age group  $(x, x+n)$ , respectively. We also computed the confidence intervals for all the  $DFLE_x$ ,  $LWD_{1, x}$ ,  $LWD_{2, x}$  (see results in Appendix S2).

$$DFLE_x = \frac{\sum_x (1 - {}_nd_x) {}_nL_x}{l_x} \quad (1)$$

Individual weights were used to compute the disability prevalence; survey design and weights were used to calculate the standard error for the disability prevalence. All the surveys in six countries followed the same method to draw samples and construct individual weights. Take China for example. Weights were computed based on the selection probability at each stage of selection. Individual weights were post-stratified by province, sex and age groups (18–49 years, 50–59 years, 60–69 years,  $\geq 70$  years) according to the 2008 population estimates from the National Bureau of Statistic of China. National totals exclude Hong Kong and Macau. Weights were not

normalized. We used the strata (province), primary sampling unit (township/community) and secondary sampling unit (village/neighborhood community) to set survey design. The relevant information on the other five countries can be found on the SAGE website (<http://www.who.int/healthinfo/sage/en/>). In the analysis, we used Stata 12.0 (StataCorp, College Station, TX, USA) and Excel 2007 (Microsoft, Redmond, WA, USA).

## Results

### *Sample characteristics*

As age increased, the proportion of respondents in corresponding age groups decreased (Table 1). More elderly men were married or cohabited than women, especially in Ghana and South Africa. There was an obvious difference in education attainment among the six countries. In Russia, more than 90% of older persons had received education of more than primary school; however, in Mexico, the proportion was only approximately 20%. In addition, men usually had higher education levels than women, especially in Ghana and India. The proportion of older adults without disability was highest in China, followed by Russia, South Africa, Mexico, Ghana and India. The results also showed that women had significant disadvantages in the distribution of disability in some countries. The proportions of disabled women were 21.36% and 15.57% higher than those of men in India and Ghana, respectively.

### *Distribution of DFLE*

The distributions of  $LE_{50}$ ,  $DFLE_{50}$ ,  $LWD_{1,50}$  and  $LWD_{2,50}$  were quite different among these six countries (Table 2). Although Mexico had the highest  $LE_{50}$ , its proportion of  $DFLE_{50}$  to  $LE_{50}$  was much lower than other countries (ranked 5th). The proportions of  $DFLE_{50}$  to  $LE_{50}$  in Mexico were 63.71% and 50.58% for men and women, respectively. China had the second highest  $LE_{50}$ . The proportions of  $DFLE_{50}$  to  $LE_{50}$  in China were 87.77% and 82.55% for men and women, respectively, which were the highest among the six countries. India had the middle-level  $LE_{50}$  and the lowest proportion of  $DFLE_{50}$  to  $LE_{50}$ . The  $LE_{50}$  and the proportion of  $DFLE_{50}$  to  $LE_{50}$  in Ghana were both lower. A significant sex difference existed in Russia's  $LE_{50}$ ,  $DFLE_{50}$ ,  $LWD_{1,50}$  and  $LWD_{2,50}$ . The  $LE_{50}$  of Russian men ranked fifth, and women ranked third. The proportions of  $DFLE_{50}$  to  $LE_{50}$  were relatively high, ranked second for men and women. South Africa had the lowest  $LE_{50}$ , and the middle-level proportion of  $DFLE_{50}$  to  $LE_{50}$  (ranked 3<sup>rd</sup> for both men and women).

### *Sex differences*

Across the six countries, women had higher  $LE_{50}$ , a lower proportion of  $DFLE_{50}$  to  $LE_{50}$  and a higher proportion of

$LWD_{2,50}$  to  $LE_{50}$  (Table 3). These differences were more visible in some countries than in others. For example, in Russia, the  $LE_{50}$  for women was 8.05 years higher than men; in South Africa, the  $LE_{50}$  for women was 4.57 years higher than men. The sex differences in  $LE_{50}$  among the other four countries were between 1.47 and 2.92 years. India had the biggest sex difference in the proportion of  $DFLE_{50}$  to  $LE_{50}$  (21.49%), followed by Ghana (15.59%) and Mexico (13.13%). Women were more likely to spend their remaining life with severe disability. Take India for example, the  $LWD_{2,50}$  for women was 13.47 years, which accounted for 52.12% of  $LE_{50}$ ; and the  $LWD_{2,50}$  for men was just 6.97 years, which accounted for 30.38% of  $LE_{50}$ . This situation existed in all six countries to a varying extent.

### *Distribution of LE lived with moderate and severe disability*

Except for Russian men and Chinese,  $LWD_{2,50}$  was obviously higher than  $LWD_{1,50}$ , regardless of relative or absolute values. For example, for men, the  $LWD_{2,50}$  was 1.67–4.20 years higher than  $LWD_{1,50}$ ; for women, the  $LWD_{2,50}$  was 2.78–10.41 years higher than  $LWD_{1,50}$ . As age increased, although the absolute value of  $LWD_2$  remained constant (e.g. China and Russia) or fell (e.g. Ghana, India, Mexico and South Africa; Fig. 1), the proportion of  $LWD_2$  to  $LE$  increased steadily (Fig. 2). In Ghana, India, Mexico and South Africa, these upward trends were especially significant. Meanwhile as age increased,  $LWD_1$  and its proportion to  $LE$  were stable (Figs. 1 and 2). These results showed that most of the  $LWD$  was spent with severe disability, and as the population became older, the proportion of  $LWD_2$  also rose.

## Discussion

The purpose of the present study was to compare DFLE and expected lifetime with moderate and severe disability across six LMIC that were part of SAGE. Disability at old age is an important public health concern, more so in developing countries, because it has huge implications on long-term care needs.<sup>9</sup> Therefore, understanding disability prevalence and DFLE could assist in predicting care needs, and also targeting of efforts to delay onset of disabilities at older ages.<sup>21</sup>

The present findings show striking differences across some of the countries. China had the highest DFLE and lowest  $LE$  with disability. In contrast, India had the lowest DFLE and highest expected lifetime with moderate and severe disabilities. The DFLE for China estimated in the present study was higher than that calculated using 2006 data.<sup>9</sup> In that study, the DFLE at age 60 years was of 13.9 years (both sexes), whereas in the present study, it was 15.7 years for men and 16.2 years for women (see Appendix S2). This disparity might be due to the

**Table 1** Sample characteristic distribution among elderly populations in six countries

	China		Ghana		India		Mexico		Russia		South Africa	
	Male <i>n</i> = 6409	Female <i>n</i> = 6830	Male <i>n</i> = 2379	Female <i>n</i> = 2345	Male <i>n</i> = 3623	Female <i>n</i> = 3527	Male <i>n</i> = 911	Female <i>n</i> = 1395	Male <i>n</i> = 1703	Female <i>n</i> = 2796	Male <i>n</i> = 1638	Female <i>n</i> = 2202
Age (years)												
50–60	46.79	43.29	40.94	39.72	50.71	46.83	49.33	46.93	45.76	42.85	52.10	48.11
60–70	32.50	30.84	27.01	27.84	29.58	31.42	26.28	24.99	31.95	22.86	30.66	30.56
70–80	16.66	20.17	22.00	23.33	15.97	15.83	15.69	19.64	16.50	24.92	11.41	16.03
≥80	4.06	5.69	10.05	9.10	3.74	5.93	8.70	8.45	5.79	9.36	5.83	5.30
Married or cohabiting												
Yes	90.95	78.85	84.97	35.26	91.23	61.40	88.92	59.09	79.77	45.95	80.00	36.61
No	9.05	21.15	15.03	64.74	8.77	38.60	11.08	40.91	20.23	54.05	20.00	63.39
Education												
<Primary school	31.44	51.48	50.27	78.65	42.49	81.42	48.91	61.44	0.39	2.00	41.95	48.76
Primary school	24.01	17.33	12.47	7.51	17.16	9.99	29.78	18.95	4.27	6.32	22.90	22.53
>Primary school	44.54	31.19	37.25	13.84	40.35	8.58	21.31	19.60	95.34	91.68	35.15	28.71
Health												
No disability	89.77	85.67	65.99	50.42	60.38	39.02	68.30	60.78	78.65	72.34	71.49	62.24
Moderate disability	6.21	7.67	12.06	13.51	12.06	12.78	15.86	14.93	10.16	9.45	7.75	8.54
Severe disability	4.02	6.66	21.95	36.07	27.56	48.21	15.84	24.29	11.19	18.21	20.76	29.21

Data presented as percentages.



**Table 2** Life expectancy, disability-free life expectancy, life expectancy with moderate disability and life expectancy with severe disability at age 50 years, and their proportions to life expectancy at 50 years among six countries

Rank	LE <sub>50</sub> (years)		DFLE <sub>50</sub> (years)		LWD <sub>1,50</sub> (years)		LWD <sub>2,50</sub> (years)		pDFLE <sub>50</sub> (%)		pLWD <sub>1,50</sub> (%)		pLWD <sub>2,50</sub> (%)	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1	MEX	MEX	CHI	CHI	MEX	MEX	IND	IND	CHI	CHI	MEX	MEX	IND	IND
	29.05	31.68	23.70	24.40	4.44	5.31	6.97	13.47	87.76	82.55	15.27	16.75	30.38	52.12
2	CHI	CHI	MEX	RUS	IND	GHA	MEX	MEX	RUS	RUS	IND	GHA	SA	GHA
	27.01	29.56	18.51	18.98	2.77	3.25	6.11	10.35	77.83	68.49	12.08	13.77	21.80	33.74
3	IND	RUS	SA	MEX	GHA	IND	GHA	GHA	SA	SA	GHA	IND	MEX	MEX
	22.93	27.71	12.94	16.02	2.63	3.06	4.40	7.95	70.46	59.54	11.89	11.85	21.02	32.67
4	GHA	IND	RUS	SA	RUS	RUS	SA	SA	GHA	GHA	RUS	RUS	GHA	SA
	22.11	25.85	15.30	13.65	2.08	2.98	4.00	7.26	68.19	52.50	10.57	10.74	19.91	31.68
5	RUS	GHA	GHA	GHA	CHI	CHI	RUS	RUS	MEX	MEX	SA	SA	RUS	RUS
	19.66	23.58	15.08	12.38	1.88	2.58	2.28	5.76	63.71	50.58	7.74	8.78	11.60	20.77
6	SA	SA	IND	IND	SA	SA	CHI	CHI	IND	IND	CHI	CHI	CHI	CHI
	18.37	22.93	13.19	9.32	1.42	2.01	1.42	2.58	57.53	36.04	6.97	8.72	5.27	8.73

The values of each indicator are ranked from highest to lowest. CHI, China; DFLE<sub>50</sub>, disability-free life expectancy at age 50 years; F, female; GHA, Ghana; IND, India; LE<sub>50</sub>, life expectancy at age 50 years; LWD<sub>1,50</sub>, life expectancy with moderate disability at age 50 years; LWD<sub>2,50</sub>, life expectancy with severe disability at age 50 years; M, male; MEX, Mexico; pDFLE<sub>50</sub>, proportion of disability-free life expectancy at age 50 years; pLWD<sub>1,50</sub>, proportion of life expectancy with moderate disability at age 50 years; pLWD<sub>2,50</sub>, proportion of life expectancy with severe disability at age 50 years; RUS, Russia; SA, South Africa.

**Table 3** Sex difference (males to females) in Life expectancy, disability-free life expectancy, life expectancy with moderate disability and life expectancy with severe disability at age 50 years, and their proportions

	LE <sub>50</sub>	DFLE <sub>50</sub>	pDFLE <sub>50</sub>	LWD <sub>1,50</sub>	pLWD <sub>1,50</sub>	LWD <sub>2,50</sub>	pLWD <sub>2,50</sub>
China	-2.55	-0.70	0.05	-0.70	-0.02	-1.16	-0.03
Ghana	-1.47	2.70	0.16	-0.62	-0.02	-3.55	-0.14
India	-2.92	3.87	0.21	-0.29	0.00	-6.50	-0.22
Mexico	-2.63	2.49	0.13	-0.87	-0.01	-4.24	-0.12
Russia	-8.05	-3.68	0.09	-0.90	0.00	-3.48	-0.09
South Africa	-4.56	-0.71	0.11	-0.59	-0.01	-3.26	-0.10

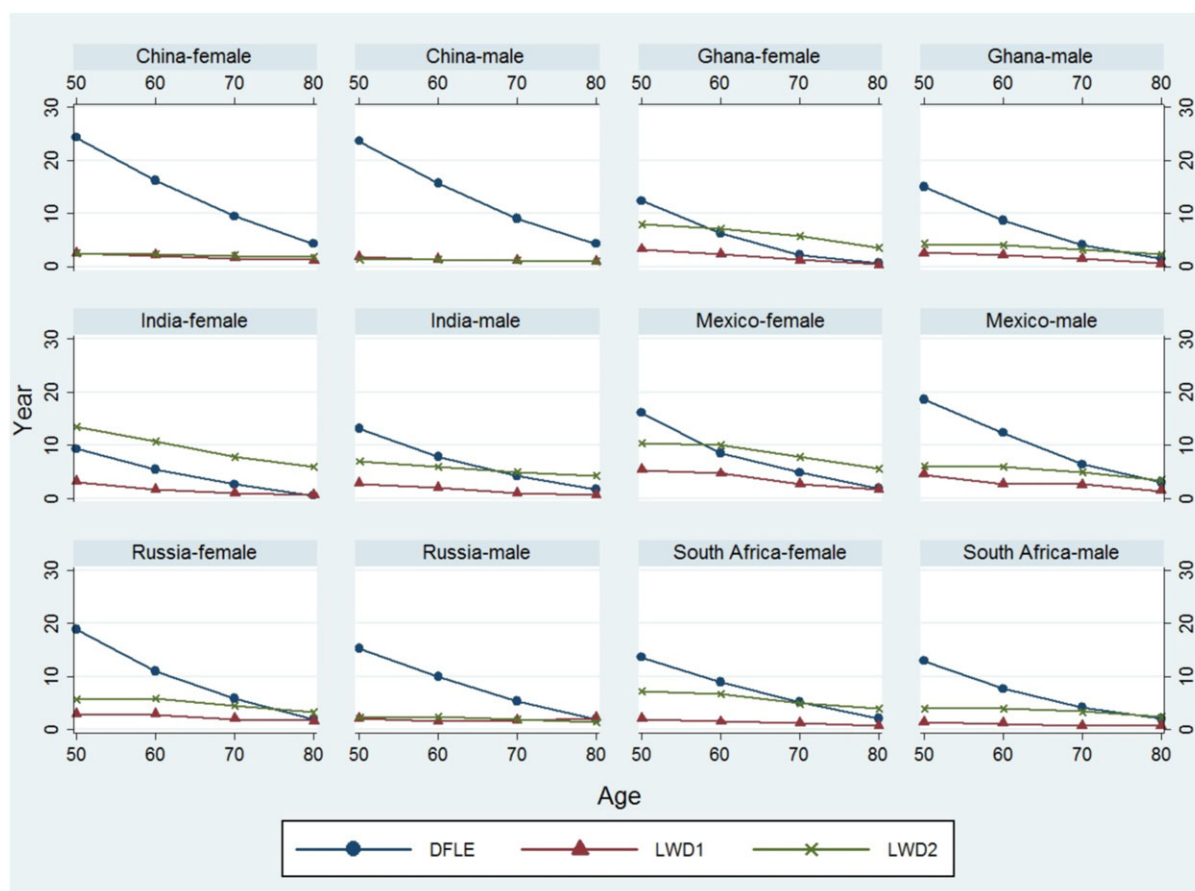
DFLE<sub>50</sub>, disability-free life expectancy at age 50 years; LE<sub>50</sub>, life expectancy at age 50 years; LWD<sub>1,50</sub>, life expectancy with moderate disability at age 50 years; LWD<sub>2,50</sub>, life expectancy with severe disability at age 50 years; pDFLE<sub>50</sub>, proportion of disability-free life expectancy at age 50 years; pLWD<sub>1,50</sub>, proportion of life expectancy with moderate disability at age 50 years; pLWD<sub>2,50</sub>, proportion of life expectancy with severe disability at age 50 years;

compression of morbidity among older people in China, or the different disability measurement used in these two studies.<sup>22</sup> In the case of India, the present results lend support to the Indian Healthy Life Expectancy Projection model, which reported rapid increases in occurrence of disability among older Indians.<sup>23</sup> In general, developing countries are faced with a double burden of communicable and non-communicable diseases. This includes epidemics, such HIV/AIDS in the case of South Africa and malaria in Ghana.<sup>15</sup> The burden of age-related non-communicable diseases is also increasing at an alarming rate in these settings. For example, India has approximately 15% of the global burden of diabetes.<sup>24</sup>

The results from the present study also confirm the “male–female health–survival paradox.”<sup>25</sup> This is evident in that across all the six countries, women live longer than men, but with more disabilities in both absolute and

proportional terms. This phenomenon is explained in part by differential predispositions to biological, social and behavioral factors between the two sexes.<sup>26</sup> Another possible explanation for this relates to methodological challenges; that is, such underreporting of health and functional problems, and as selective non-participation in surveys by men.<sup>25</sup> Health promotion programs related to disability prevention therefore, need to take these sex differences into consideration, and put an emphasis on targeting women. Russia had the highest within-country sex gap for DFLE at age 50 years (4 years), which favored women. This has been attributed to alcoholism among Russian men.<sup>15</sup>

It is important to note that most of the years in old ages are spent with severe disabilities. The only exception is China, where the older adults spent very few years with disability, and there was little differentiation in severity



**Figure 1** The disability-free life expectancy (DFLE), life expectancy lived with moderate disability (LWD<sub>1</sub>) and life expectancy lived with severe disability (LWD<sub>2</sub>) among populations aged 50 years and older by country and sex.

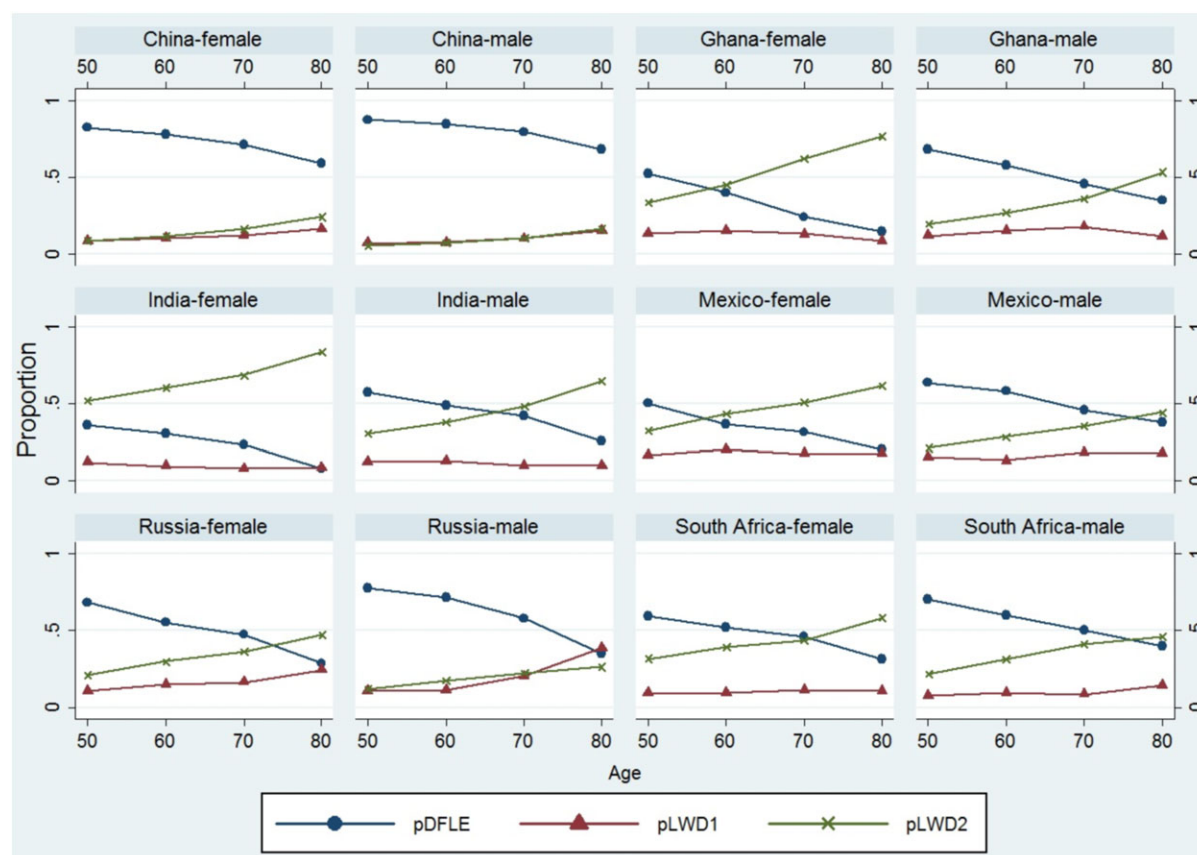
(although for women a small difference can be noticed at the oldest ages). Across all the ages, Indian women spend more years with severe disability. This is disturbing to note, and further investigations are urgently required to understand the underlying determinants and dynamic mechanism of disability, which will inform corresponding countermeasures. The same applies for Ghanaian and Mexican females, where beyond the age of 60 years, the years spent with severe disability are more than DFLE.

The study had some limitations that need to be mentioned. One of the limitations was that the Sullivan method used is based on cross-sectional data, and does not take into account the possibility of recovery from disability to health. Some scholars make the criticism that it tends to overestimate the LE lived with disability.<sup>5</sup> However, Mathers and Robine showed that the Sullivan method is generally acceptable for monitoring relatively smooth long-term trends in health expectancies for populations.<sup>27</sup> More recently, Imai and Soneji statistically proved that, under stationarity assumptions, Sullivan's estimator is unbiased and consistent.<sup>28</sup>

Furthermore, the conclusions in the present study should be generalized with caution. SAGE attempts to collect nationally representative data using appropriate sampling methods, whereas in countries such as China and

India, national representativeness is difficult to achieve.<sup>10</sup> Disparities in sociocultural backgrounds could lead to differential reporting of functional limitations across the six countries. In addition, the conclusions are also associated with the measurement and definition of disability. For example, we defined persons with severe disability as someone who had "severe" or "extreme" difficulties in carrying out at least two ADL items. Most studies in these six countries measure disability in a different way from the present, which undermines the comparability between studies.<sup>9,23,29</sup> For those using ADL to measure disability, we had similar estimates of prevalence of disabled persons, although severe disability was not defined in such studies.<sup>30,31</sup>

The other limitation was the exclusion of institutionalized populations from the WHO SAGE surveys, and consequently from the analysis in the present study. It can generally be suspected that the health status and well-being of the people living in institutions will be different from those living in communities. Therefore, it is important to include them in analyzing DFLE to avoid obtaining biased estimates. Unfortunately, there is no information on the health status of the institutionalized population in some of the countries; for example, South Africa and Ghana. Nevertheless, the effect of excluding institutionalized populations



**Figure 2** The proportions of disability-free life expectancy, life expectancy lived with moderate disability and life expectancy lived with severe disability to life expectancy among populations aged 50 years and older by country and sex. pDFLE, proportion of disability-free life expectancy; pLWD<sub>1</sub>, proportion of life expectancy lived with moderate disability; pLWD<sub>2</sub>, proportion of life expectancy lived with severe disability.

in the study is negligible, because the proportion is small; for example, 0.7% in China<sup>9</sup> and 3% in South Africa.<sup>32</sup>

The study has shed some light on the disparities across the six countries with regard to DFLE at old ages, which shows the need to make specific healthy aging policies for each country. Although the LE extends, the situations in some countries, such as India, which has a low percentage of DFLE in LE, are worrying. Evident sex differences exist in DFLE, and in countries like Russia the difference is even more noticeable, which requires further exploration into the mechanism and corresponding countermeasures. By differentiating the LE lived with disability into different severity, we are able to obtain more accurate information on population health. Calculating DFLE and relevant indicators should be treated as routine.

## Acknowledgment

The authors thank the SAGE survey, which is supported by World Health Organization (WHO) and the US National Institute on Aging (NIA) through Interagency Agreements. We also want to thank all the respondents

who contributed to SAGE and the survey teams in the six countries. This study was supported by National Natural Science Foundation of China (No. 71403005) (website: <http://www.nsfc.gov.cn/>). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript. [Correction added on 28 March 2017, after first online publication: Information regarding funder support from National Natural Science Foundation of China has been added to the Acknowledgment section.]

## Disclosure statement

The authors declare no conflict of interest.

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## Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's web site:

**Appendix S1** Items used to measure activities of daily living in Study on Aging and Adult Health.

**Appendix S2** The disability-free life expectancy, life expectancy lived with moderate disability, life expectancy lived with severe disability, their proportions to life expectancy and their confidence intervals.