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## Article

# Women's mid-life health in Low and Middle Income Countries: A comparative analysis of the timing and speed of health deterioration in six countries

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## ARTICLE INFO

## Keywords:

Ageing  
Grip strength  
Cognition  
Walking speed  
LMICs  
Women  
Health

## ABSTRACT

**Background:** Mid-life is a neglected stage of women's lives, particularly in Low and Middle Income Countries (LMICs). Birth injuries, menopause and manual labour can contribute to health problems in the mid-life.

**Objectives:** This study analyses the relationship between women's health deterioration and age across socio-economic groups in 6 countries (China, Ghana, Mexico, Russia, South Africa and India).

**Methods:** Using constrained cubic splines, I analysed data from the WHO SAGE survey to examine age and wealth patterns in the onset of deterioration in objective proxies of ageing.

**Results:** Results show a clear pattern of deterioration in health in middle-aged women. Ageing processes differ dramatically between rich and poor strata within countries and between countries.

**Discussion:** This study clearly shows that the onset of ageing in women in LMICs begins in the early forties. The paper highlights the need to focus more on mid-life health of women, in particular poorer ones.

## Introduction

Ageing populations, studied extensively in High Income Countries (HICs), are receiving increasing attention in Low and Middle Income countries (LMICs) as life expectancy and population ageing increase, albeit with regional variation (Abegunde, Mathers, Adam, Ortegón, & Strong, 2007, United Nations 2013). However, evidence on the processes of ageing and health deterioration in LMICs remains scanty, mainly due to a lack of data. The majority of research on older populations in LMICs focuses on adults aged 50+ and rarely disaggregates by sex.

From a reductionist point of view, health deterioration includes worsening of physical, cognitive and mental functions. It affects individuals' functional ability and it is usually associated with biological ageing. Ageing tends to be constructed as a process that starts in post-reproductive ages, more often linked to pension age rather than a mental and physical state (WHO 2016). Beginning to study ageing from age 50 is potentially problematic because it is possible that ageing-related processes begin at younger ages, and may exhibit inter- and intra-population variation.

However, we know that health deterioration is also the result of dynamics in the biological, interpersonal and psychosocial sphere (Borrell-Carrió, Suchman, & Epstein, 2004, Lehman, David, & Gruber, 2017). Family and social networks, location, marital status, gender and

wealth are only some of the key components affecting health deterioration and the ageing process. The timing and modality of ageing are often defined by Western standards which define successful ageing and often overstate structural disadvantage to the detriment of individual coping strategies (Kowal & Dowd 2001, Wray 2003). Finally, biomedical and welfare approaches to ageing might not take into account differences in culture, wealth, health, nutritional, fertility and labour experiences (Lehman et al., 2017).

Women's health deterioration experiences are particularly important because of the influence of fertility and menopause histories, as well as their socio-economic status (Poomalar & Arounassalame 2013). Furthermore, ageing progression varies dramatically across socio-economic groups, with the onset of ageing deterioration starting earlier among the poorest (Adams & White 2004, Gruenewald et al. 2012a, 2012b). There is a need to start looking at when and how women age in LMICs.

The aim of this study is to comparatively analyse the patterns of age-related health deterioration in women in six LMICs, and is guided by three research questions:

- Is there evidence of the onset of health deterioration within mid-life among women in LMICs?
- How and in what ways does the onset of health deterioration in women vary between LMICs?

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<https://doi.org/10.1016/j.ssmph.2018.100341>

Received 16 July 2018; Received in revised form 10 October 2018; Accepted 10 December 2018

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- Are there between country variations in the onset of health deterioration in women related to their wealth status?

It is important to highlight patterns as mid-life onset of health deterioration is likely to vary across settings. In LMICs, compared to HICs, women reaching mid-life can expect to have started childbearing earlier, to have a higher fertility, a higher number of pregnancies that have resulted in either miscarriage, abortion or stillbirths (and more pregnancies resulting in infant deaths), and less access to antenatal and post-natal care. However, health research on women in LMICs has focused mainly on reproductive health and reproductive ages (15 to 49 years). We have little understanding of changes in women's mental and physical health throughout the lifecycle, or when health deterioration starts (and how rapidly), and how it differs between and within countries and across socio-economic groups.

Access to health services, gender norms, reproductive experiences and biological differences can all contribute to the timing and speed of health deterioration for women (Elias & Sherris 2003). Age-related health problems can be perceived by women as a fact of life and women might not feel the need to seek care (Elias & Sherris 2003, Jejeebhoy, Koenig, & Elias, 2003, Hammoudeh *et al.* 2017).

Answering the questions set by this study has important implications for understanding ageing in LMICs, currently obscured by a focus only on older populations. I focus on women as I am interested in looking at the range of different patterns of different ageing related outcomes across different levels of fertility and development as well as between different wealth groups. A growing body of literature has shown the detrimental cumulative effect of low Socio-Economic Status (SES) on biological systems (Seeman, Epel, Gruenewald, Karlamangla, & McEwen, 2010). This effect may be further exacerbated for women in some settings where their status is lower and often at a disadvantage compared to men. In addition, the overall contextual dynamics highlight to account for body functions as well as contextual and personal factors (WHO, 2002). Age and wealth in this study are the key personal factors, while context is only accounted for at country level (residence was considered but no significant difference was found). I chose wealth over educational level as it is a relative measure which would avoid cross-comparative issues related to differences in educational system across cohorts and educational systems. In addition the analysis showed more significant differences across wealth groups than educational levels.

To understand how processes of age-related health deterioration are experienced, it is necessary to broaden the age range of ageing research. There is no established definition of mid-life, a poorly defined age range that usually relies on the data available and can include a single value around the age of 40 or 50 (Cooper, Mishra, Clennell, Guralnik, & Kuh, 2008, Upchurch, Stein 2015), age ranges of 35–55 years or 40–60 years, 40 to 50 (Sowers *et al.* 2007) or even 45 to 68 years old depending on data availability (Rantanen, Guralnik, & Foley, 1999). In this study, mid-life is defined as 35 to 65 years in order to account for different levels of life expectancy across the 6 countries. Choosing to use the lower age of 35 is important for two reasons. Firstly, in order to be able to understand health deterioration before the decline becomes steeper. Secondly, because the age at menopause can have a considerable impact on health deterioration, and evidence shows that age at menopause is lower in LMICs compared to HICs (Blümel *et al.*, 2006).

The comparative analysis includes six LMICs (China, Ghana, India, Mexico, Russia and South Africa) and exploits the Survey on AGEing and Adult Health (SAGE), a unique data set that has direct measures of physical and cognitive functioning that have been robustly related to ageing and to poorer outcomes in later life: grip strength, cognitive functioning and walking speed. While the set of outcomes relate mostly to biomedical measures, they represent a wide range of body functioning which include both physical and mental health and that have proven to be objective measures of health (WHO, 2002). The six countries represent heterogeneous cultural and socio-economic

settings. No previous study has considered these measures and their patterns by age and wealth of women across world regions.

#### *Women's health deterioration in LMICs*

The literature on the three key health measures considered in this study shows a lack of agreement and generally an overwhelming predominance of studies in HICs.

A systematic review of grip strength levels and patterns revealed that there are consistent differences between HICs and LMICs with higher levels in HICs due to better nutrition, taller average height and better child growth (Dodds *et al.*, 2016). However the review analysed studies relying on different datasets across several countries making the comparison less robust because notions of frailty and the methods used to measure grip strength were not fully comparable. In this study, the use of a standardised grip strength tool across countries, overcomes this problem.

Evidence on the age at onset of grip strength decline in LMICs is limited. Two studies from the USA have shown that grip strength declines for women at around age 40 but men lose strength at a faster pace relative to their peak (Metter, Conwit, Tobin, & Fozard, 1997, Nahhas *et al.* 2010). Where menopause data are available the evidence shows that whether the woman is menopausal or not can significantly contribute to the speed of the grip strength decline (Cipriani *et al.* 2012, da Câmara, Zunzunegui, Pirkle, Moreira, & Maciel, 2015);. Women have an early onset of loss of muscle strength associated with onset of menopause, aggravated in contexts where hormonal replacement therapy (HRT) is not administered (Kurina *et al.* 2004). UK studies show that women experience a dramatic decline in muscle strength during menopause (Phillips, Rook, Siddle, Bruce, & Woledge, 1993, Kurina *et al.*, 2004).

A similar pattern of physical deterioration applies to walking speed, although its onset is later than grip strength, and walking speed is a predictor of the onset of physical dependence (Shinkai *et al.*, 2000). In one of the few studies that compared the ageing process for both grip strength and walking speed, the onset occurs earlier for grip strength however the deterioration of walking speed accelerates with age, especially for women (Cooper *et al.* 2011).

We know that in HICs physical and mental ability declines in mid-life predict disability in later life (Rantanen *et al.*, 1999, Kurina *et al.*, 2004). The timing of the onset of decline in cognitive functions varies from 50 to 70 years (Murray, Kory, & Clarkson, 1969, Himann, Cunningham, Rechnitzer, & Paterson, 1988). Comparative analysis of cognitive functions reveals the strong influence of childhood experiences (eg: education, socio-economic status, exposure to knowledge) on cognitive functions (Skirbekk, Loichinger, & Weber, 2012). This is particularly true for older generations in LMICs with large inter-generational education gaps. An international comparison showed how cognitive functions in India slowed down at slower pace than other middle income countries such as China and Mexico. This could be due to cohorts that have survived high levels of mortality and poverty and where the population at older ages could be the result of a selection effect (Skirbekk *et al.* 2012).

The literature shows inconclusive patterns of onset and speed of ageing and highlights the need for more comparative analysis and understanding. A challenge to the comparative analysis of measures of health is the correlation to nutrition, labour patterns, disease patterns and physical exercise which could affect the onset and speed of health deterioration, and we know little about how this manifests among non-sedentary populations in LMICs (Chilima & Ismail, 2001).

#### **Data**

I use the first wave of the WHO longitudinal Study on global AGEing and adult health (SAGE), conducted between 2007 and 2010 in China, Ghana, India, Mexico, the Russian Federation and South Africa. The

data are a unique source of information as they allow the comparison of a sample of individuals aged 50+ with a weighted subsample of 18 to 49 year olds.

Wave 1 collected a combined sample of  $n=23,814$  (Kowal et al., 2012). The data were collected using a stratified multistage cluster design in each country. All primary sampling units (PSU) were stratified by urban and rural locality. For the purposes of this study only wave 1 was used to make the most of the full sample and to avoid attrition as well as cross-comparative issues due to changes in questions. The sample for India is nationally representative and was implemented in six states (Assam, Karnataka, Maharashtra, Rajasthan, Uttar Pradesh, and West Bengal). Analogously, in China, SAGE covered eight provinces / municipalities (Guangdong, Hubei, Jilin, Shaanxi, Shandong, Shanghai, Yunnan and Zhejiang) (SCDC, 2012, IIPS, 2013).

I use two measures of physical health and one measure of mental health performance, frequently used as proxies of ageing: grip strength, cognitive functioning and walking speed.

Grip strength is the mean of the best result obtained in each hand squeezing a Smedley's hand dynamometer where the dominant hand is reported by the interviewer. It is widely regarded as an excellent predictor of disability and worse health at older ages (Sayer et al., 2006). When standardised it produces a reliable objective measure of health status (Rantanen et al., 1999, Sayer et al., 2006, Taekema, Gussekloo, Maier, Westendorp, & de Craen, 2009).

The cognition score is a derived measure created from the mean of the scores for verbal fluency (VF), verbal recall (VR) and Forward and Backwards Digit Span (FDS & BDS) tests. To measure cognition SAGE included multiple assessments (immediate and delayed verbal recall, verbal fluency, forward and backward digit span). Cognition is a composite measure summarising scores of cognitive functions and impaired cognition is a good predictor of dementia later in life (Carroll, Kowal, Naidoo, & Chatterji, 2012).

Walking speed was calculated as the mean time of two repeated walks of four meters at normal and rapid speed; the higher the value the slower the speed. It is an objective predictor of ageing and disability and is strongly associated with frailty (Castell et al., 2013). For this study I am showing the results for normal speed only because no significant differences were reported between normal and fast walking.

Potentially, the quality of these measures could be affected by frail older adults being unable to participate in the assessment. Respondents were asked not to participate in the grip strength test if they had severe pain or had been injured or operated on at the hand or wrists in the 6 months prior to interview. Participants were only asked to perform the walking test if they felt comfortable in walking without risking a stumble (Kowal et al., 2012). Analysis I conducted of the non-responses showed a random distribution of missing cases; the number of missing cases is generally very low with walking speed (whether refused or cannot walk) for example ranging from 2% in India to 6% in Mexico. In general the data are deemed of good quality by the tests conducted by the WHO team in charge of the data collection and by scholars that have used the data (Kowal et al., 2010, Carroll et al., 2012, Basu, 2013, Biritwum et al., 2013, Gildner, Liebert, Kowal, & Snodgrass, 2014). SAGE aims to be comparable to the US Health and Retirement Study, the English Longitudinal Study on Ageing, and the Collaborative Research on Ageing in Europe (COURAGE in Europe) Project. For this reason most health measurements are comparable to those of High Income countries. However, caution is needed when interpreting across studies beyond SAGE as not all standard of measure might have been applied thoroughly such as the flatness of the floor when measuring walking speed (Kowal et al., 2012, Capistrant, Glymour, & Berkman, 2015).

A broader concern for a paper on age-related health in LMICs relates to the quality of age reporting (Randall & Coast, 2016). A review of the quality of age data in the Ghanaian SAGE revealed low levels of age misreporting, but some evidence of age heaping, particularly for men at older ages (Biritwum et al., 2013). I analysed the age distributions

across the six countries, and identified no significant issues with age heaping.

A cross-validation of the data was conducted looking at the patterns of distributions across all countries and the correlations between all three variables and across all countries. In addition I have cross-checked the relationships between the outcomes and key variables (e.g.: subjective health, chronic diseases, whether reported any type of disability) commonly correlated to observe whether the direction was as expected.

The level of association between the measures is as expected with walking speed being significantly negatively correlated to grip strength and cognition and grip strength and cognition being positively associated. As for the other variables, grip strength is negatively associated with chronic diseases and more likely to go down if the individual reported bad health or a disability. The same is true for cognition aside from subjective health where there is no significant association. Analogously the opposite is true for walking speed where walking speed goes up if reporting bad health, disability or chronic diseases. In light of these results, the checks already made with levels and patterns of missingness and the work done both by the SAGE team and the key literature, we can be confident that the data are of good quality.

The choice of outcomes represents a compromise between wanting to show objective measures of health, that we know are affected by environmental, ecological and biological factors, that have a proven effect on the ageing and health process later on in life, that represent a mixture of body functions (e.g.: cognitive vs mobility) and quality of data being used. The measures provided the most robust distributions with the smallest level of missingness.

### Settings

Comparative analysis of a range of countries allows us to test the patterns of the onset of ageing over a diverse range of countries with different levels of economic and demographic development as well as diverse regional and cultural settings. Diverse settings permit testing of the same assumptions under different conditions. The six countries are all either Upper (UMI) or Lower Middle (LMI) Income countries who have either completed the demographic transition (eg: China, Russia) or where the demographic transition is well underway (eg: Ghana) and fertility is projected to be at replacement level (TFR = 2.1) before 2100.

With the exception of South Africa, all included countries have a life expectancy above 60 years (Table 1), and the percentage of population aged 60+ is projected to more than double in all countries except Russia where the process of population ageing is well underway. While not fully representative of the wide range of issues in women's health in LMICs, they represent a range of fertility (3.9 in Ghana to 1.6 in China). In all countries ischemic heart disease is in the top three causes of mortality, underscoring the transition to non-communicable diseases in all countries (Institute for Health Metrics, 2017). With childbearing starting at earlier ages in the past, this analysis includes cohorts of women who have had higher and earlier fertility in resource constrained contexts. With the exception of South Africa, all countries had rates of maternal mortality up to three times higher than current levels in the 1990s, which is when many of the women in our sample would have begun childbearing (UN Statistics Division, 2017). Cohorts of women in my sample include women who survived periods of very high fertility who experienced unprecedented improvements in maternal health at a time of a progressive decline in fertility levels. This is important when interpreting the age patterns as they represent different lifecourse approaches which can have several repercussions on the outcomes later on in life.

### Methods

I have used bivariate linear regression to assess the patterns of the relationship between age and the three outcomes: grip strength,

**Table 1**

Demographic and economic background in SAGE countries.

Source: World Bank, UN population Division, Institute for Health Metrics 2017.

	GDP per capita	TFR	Female Life expectancy	% population aged 60+ 2015–2050	MMR	Gini index <sup>a</sup>	% health expenditure public as % GDP
China (UMI)	8027	1.6	77	15.2–36.5	27	42.16	3.1
Ghana (LMI)	1370	3.9	62	5.3–9.7	319	42.77	2.1
India (LMI)	1598	2.4	69	8.9–19.4	174	35.15	1.4
Mexico (UMI)	9005	2.2	79	9.6–24.7	38	48.20	3.3
Russia (UMI)	9093	1.7	76	20.0–28.8	25	41.59	3.7
South Africa (UMI)	5724	2.4	59	7.7–15.4	138	63.38	4.2

TFR = Total Fertility Rate

MMR = Maternal Mortality Ratio

<sup>a</sup> Data refers to different years 2005 Ghana, 2011 India and South Africa, 2012 China, Russia, 2014 Mexico

cognitive score and walking speed. Given the non-linear nature of the relationship between age and the outcomes, I have used restricted cubic splines to analyse the age patterns of the health outcomes. Restricted cubic splines were chosen because of the flexibility of the distribution. They also assume that the two tails are constant, which is in line with the assumptions I make on the distribution of the health outcomes variables (Durrleman & Simon, 1989). The constrained cubic splines allow me to analyse the distribution in the key age group between 35 and 65 where it is assumed the major changes occur (Buis, 2009). Constrained cubic splines were the best fit among the various iterations of polynomial transformation (polynomial, cubic and quadratic) as well as when fitting linear vs hockey stick regression. The best fit was estimated using Bayesian Information Criteria (Sosa-Escudero & Bera, 2008). A more complex model was used to control for key socio-economic factors such as residence, education, marital status among others. However only the results of the analysis of age and wealth are showed in this paper for the sake of simplicity and for comparative purposes as well. The results of the more multivariate model would not add anything significant to the discussion and show that the age patterns are not influenced by other factors.

The graphic representation of the cubic splines permits identification of the rates of decline of the three ageing measures across all age groups. This was the most suitable approach given the data are cross-sectional and do not measure changes across time. The number of knots for the splines was chosen based on the distributions of the outcome variables. When using constrained cubic splines what matters is the number of knots rather than their position as long as they are evenly spaced within a considerable section of the distribution (Durrleman & Simon, 1989).

The onset of the decline in performance is calculated with the average marginal effects of the predicted values obtained from the bivariate regression of the restricted splines and the outcome variables.

$$\text{Marginal Effect of } X_k = \lim_{\Delta} [\Pr(Y = 1|X, X_k + \Delta) - \Pr(y = 1|X, X_k)]/\Delta$$

Where Y is one of the continuous outcome variables and  $X_k$  is Age. The marginal effect for continuous variables measures the instantaneous rate of change. More specifically the marginal effect is located by looking at the single age distribution of the marginal effects calculated as the partial derivative of the outcome variable for a change in one unit of age. The break point is chosen as the age value where the outcome variable changes direction or there are increases in the speed of worsening of the outcome. For each value the significance of the marginal effect was assessed.

I calculated wealth using principle component analysis of asset indicators using different weights by country and area of residence (rural and urban) to account for relative weights of single assets in different settings. The variable is then recoded into quintiles and is commonly used in LMICs settings where measures such as income or expenditure are either unavailable or not of suitable quality (Filmer & Pritchett, 2001). For the purposes of this study I only look at the comparison of

the bottom two quintiles (poor) and top two (rich).

The within country significance was calculated using t-tests derived from the OLS. Given that these are all independent samples, the between-country significance of the average age at the onset of deterioration was calculated using one way ANOVA for the bivariate relationship and ANCOVA when wealth was included. The statistical analysis was conducted using STATA 14 (StataCorp., 2015).

The restricted cubic splines for age were included as covariates on three separate ordinary least square regression models with grip strength, cognition and walking speed as the outcomes. Sampling weights were used. The models were run separately for each country given the small number of countries, the different years at which the data were collected and the diversity of settings. I run separate models for the poor (poorest and poor) and rich (richest and rich). The results show patterns by age for each outcome and the cut off points (age) for the change in distributions.

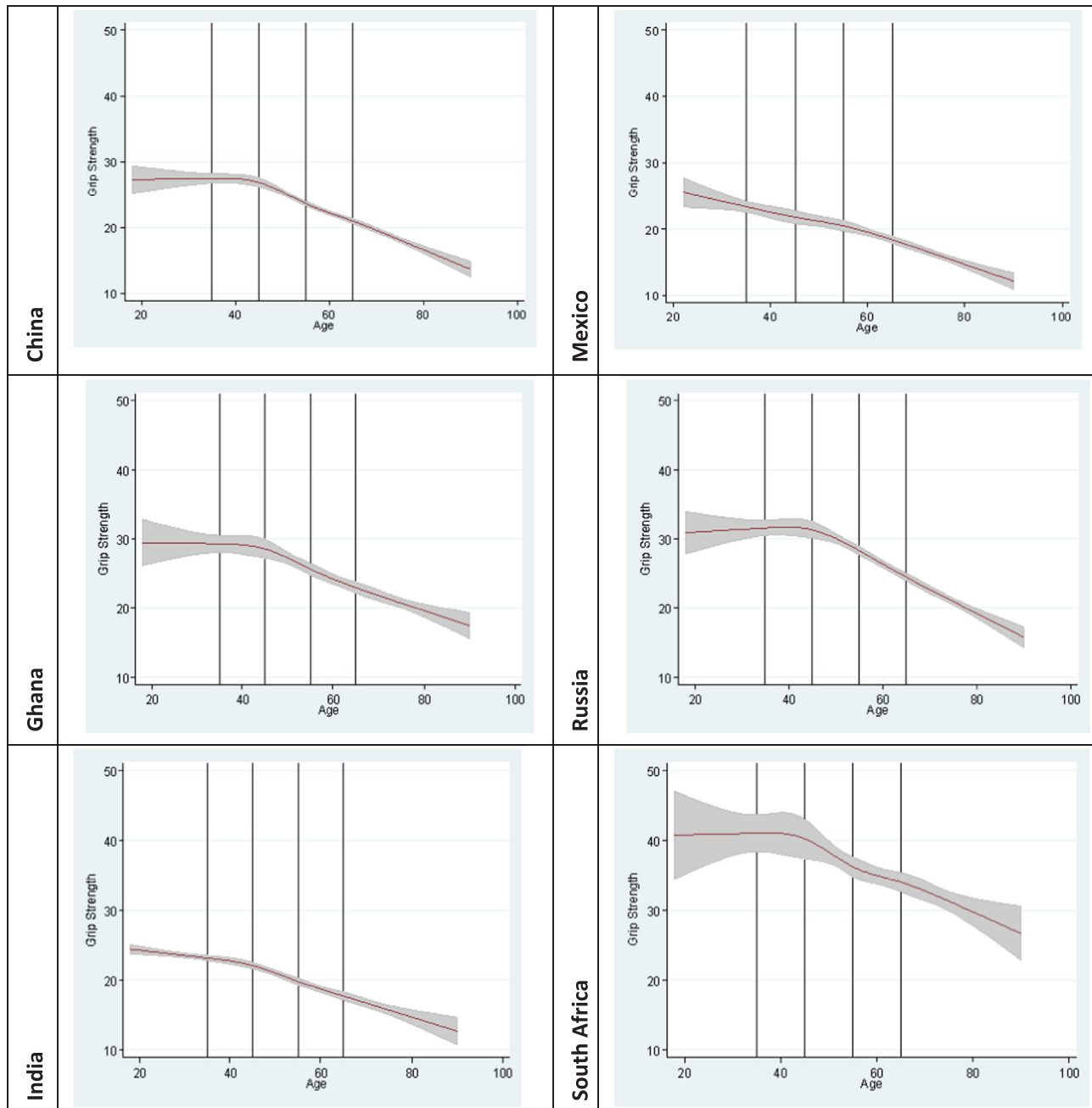
The study has several limitations. The data are cross-sectional, meaning that it is not possible to follow individuals as they age and many prior life course events (eg: fertility, menopause) are missing. However, by considering different ages across the surveys, I capture some cohort effects. In addition, the data do permit comparison of 50+ individuals with younger ages, information which is not usually available. This analysis is not meant to explore causal patterns and it can only speculate on the likely reasons behind the patterns. In addition, the countries included in this analysis are highly heterogeneous making the comparison at times challenging. However, the results are of significance in as much as patterns are generated across different settings and differences are explained within those dissimilarities. Finally, only biomedical measures are included. However, including variables within a wider biopsychosocial model would be beyond the scope of the paper and also compromise the objectivity of some of the measures. I consider this the first step towards future research in the field.

## Results

The samples included in this study are generated using the same survey methodology but vary in size (Table 2). China and India have the biggest samples while Mexico has the smallest. India has the youngest population with a mean age of 56.2. Literacy levels are usually high aside from India (59.2% of women) and Ghana (62.3). The percentage of people reporting a chronic disease is highest in Russia (74.0%) where there is also the highest prevalence of people reporting being in bad or poor health (28.7%). The level of chronic diseases could also be linked to the life expectancy and the state of the health systems due to both fewer people at risk with low life expectancy and fewer having access to healthcare in low resource settings. The level of reporting for chronic and bad health are all linked to health systems access to services, cultural norms and resources available. It is therefore important to compare levels of different variables across the spectrum of objective measures.

**Table 2**  
Sample characteristics SAGE women data wave 1, 2007–10.

	Mean age	Literacy rate	% individuals with chronic disease	% individuals reporting bad/poor health	Combined sample
China	60.4	92.5	47.9	22.5	7637
Ghana	61.0	62.3	31.2	18.8	2379
India	56.2	59.3	27.8	15.6	6873
Mexico	62.9	93.5	54.4	16.2	1692
Russia	63.1	99.6	74.0	28.7	2806
South Africa	60.6	93.4	43.4	17.8	2427



**Fig. 1.** Women's grip strength (y axis) cubic splines by age (x axis) and country Sage data Wave 1 2007–10.

*Grip strength*

Grip strength trends by age (Fig. 1) and onset age of grip strength decline (Table 3) are assessed. The vertical black lines in the graphs set the knots for the cubic splines. Most countries show a similar pattern of

grip strength across age: up until age 45 grip strength increases or is more or less stable after which it declines. In Mexico the decline in grip strength appears to be steady throughout the observed age range. Levels of grip strength are higher in Ghana, Russia and South Africa, in line with prior research which underscores the need to control for



**Table 3**  
Onset age of decline in grip strength in women, Sage data wave 1 2007–10.

Country	Age of onset (Std error)
China	50 (0.33)
Ghana	48 (2.27)
India	42 (1.25)
Mexico	53 (2.04)
Russia	55 (0.97)
South Africa	50 (1.4)

**Table 4**  
Age at onset of decline in grip strength in women, Sage data wave 1 2007-10, by wealth groups.

Country	Age of onset (Std error)	
	Poor	Rich
China	49 (1.20)	51 (1.51)
Ghana	44 (4.3)	52 (1.8)
India	40 (0.9)	48 (1.2)
Mexico	52 (5.9)	60 (1.2)
Russia	46 (4.5)	56 (1.4)
South Africa	48 (3.8)	61 (4.3)

nationality when doing cross-country analysis as genetics, environment, nutrition and labour practices all influence grip strength levels (Dodds et al., 2016). In China, India and Mexico, height and weight are likely influences on grip strength levels.

The onset of grip strength decline (Table 3) varies across countries, ranging from 42 years in India to 55 years in Russia. Analysis of the differences between countries (ANOVA) shows that they are significantly different ( $p < 0.001$ ) with an average of age of onset of 48.25 years.

Onset of grip strength decline by wealth (Table 4) ranges between 13 years (South Africa) and 2 years (China). This might reflect wider inequalities in health as well as different experiences in reproductive health with poorest groups usually having more children and also more likely to have less access to health care and be involved in higher risk manual labour. The difference across countries of the two groups (ANCOVA) is also significant ( $p < 0.001$ ) with an overall average of 46.5 years and 54.7 years for poor and rich quintiles, respectively.

#### Cognitive functions

Cognitive functions trends show a linear pattern in China, Ghana and India (Fig. 2). Whereas, in the remaining countries the pattern is linear followed by a steady decline. The overall level is higher for China and Russia where the average educational level is also higher.

The onset of cognitive function decline (Table 5) is in the fifties for all countries. The onset values do not mirror country-level differences in levels of education and the cross-country differences are highly significant ( $p < 0.001$ ) with an overall average of 48.4 years.

The gap in cognitive function between wealth groups ranges from 19 years in India to just 1 year in South Africa (Table 6). This national level result does not reflect within-country disparities, crudely assessed with the GINI coefficient (Table 1), and suggests that the inequalities within cognition might be more the result of different educational systems rather than economic wealth. On the other hand the standard errors are quite large in particular in South Africa, suggesting potentially weaker results. There is also an issue of life course experiences which impact cognitive functions. In most countries, older generations might have experiences childhoods with poverty and deprivation with implications for education and later life cognitive functions (Skirbekk et al., 2012). The cross-country comparison is also significant ( $p < 0.0001$ ) with an average of 56.5 years for poor and 65.3 years for

rich women.

#### Walking speed

Walking speed, expressed as time to walk 4 m, generally follows an exponential trend (Fig. 3). It is usually stable until the 50s or 60s and then the time to complete the distance increases dramatically. The only exception is South Africa, which has a high level of uncertainty, making its trend not highly significant.

For the onset of the decline in walking speed (Table 7) the difference between countries is relatively small with the earliest onset in Ghana (47) and the oldest in Mexico (56). Ghana is the only country with a higher level to start with and it is quite possibly the result of a generally a slower pace at walking rather than a higher level of frailty, although this has not been tested. The overall values are homogenous across the remaining countries. The cross-country comparison is also significant ( $p < 0.001$ ) with an overall mean of 49.3 years.

The differences in the onset of decline of walking speed by wealth groups within countries are relatively small (Table 8) compared to grip strength and cognition. They vary from just 1 year in South Africa to 12 years in Mexico. In general for poorer strata of the population the onset is mostly in the 40 s while for the richest is mostly in the 50 s. The cross-country comparison is significant ( $p < 0.05$ ) with averages of 48.6 for poor and 56.2 for the rich. The relatively small gap in South Africa could be due to higher levels of sedentary behaviours compared to other countries; South Africa has a rate of physical inactivity for women at all ages at over 56% compared to 32% in China or 16% in India (Hallal et al., 2012).

#### Discussion and conclusions

This study is the first to consistently compare age-related health declines for women across a wide range of LMICs. I used methods that allow me to specify the country-specific age at which ageing starts to accelerate and functioning deteriorates. Validated measures of wealth enable me to identify differences between richer and poorer women in each country.

The analyses reveal how physical – and to a lesser extent mental – declines in health occur early during the mid-life (35–65) in women. The very limited information available in the literature could lead us to the conclusion that LMICs might have early onsets of health deterioration than HICs (Dodds et al., 2016). Grip strength declines can be identified from age 40, although there are significant differences between countries in the level and speed of decline. Cognitive functions follow more of a linear pattern with dramatic differences by level of wealth. Walking speed deterioration occurs later on in life but its pace and onset are strongly linked to socio-economic differences within countries.

The two countries that show the fastest acceleration of the deterioration in functions and the earliest onset among women - Ghana and India – are also countries with recent histories of poor reproductive health indicators (e.g.: high fertility and high maternal mortality). This highlights the need for a deeper understanding of the relationship between reproductive histories and health deterioration. The results suggest that studies relying on one proxy of ageing are insufficient because not all functions are correlated to population-level indicators issues (e.g.: cognition and education, walking speed and sedentarity).

Inequalities in health deterioration are observed in all regions with poorer strata of the population experiencing an earlier onset of health deterioration. This could further exacerbate health problems which are more common among the poorest groups of the population.

Relative differences in the wealth in each of the outcomes can be due to cultural, labour and physical activity differentials across countries (Andersen-Ranberg, Petersen, Frederiksen, Mackenbach, & Christensen, 2009). While initial grip strength has different levels linked to body structures and labour patterns, it does show a general

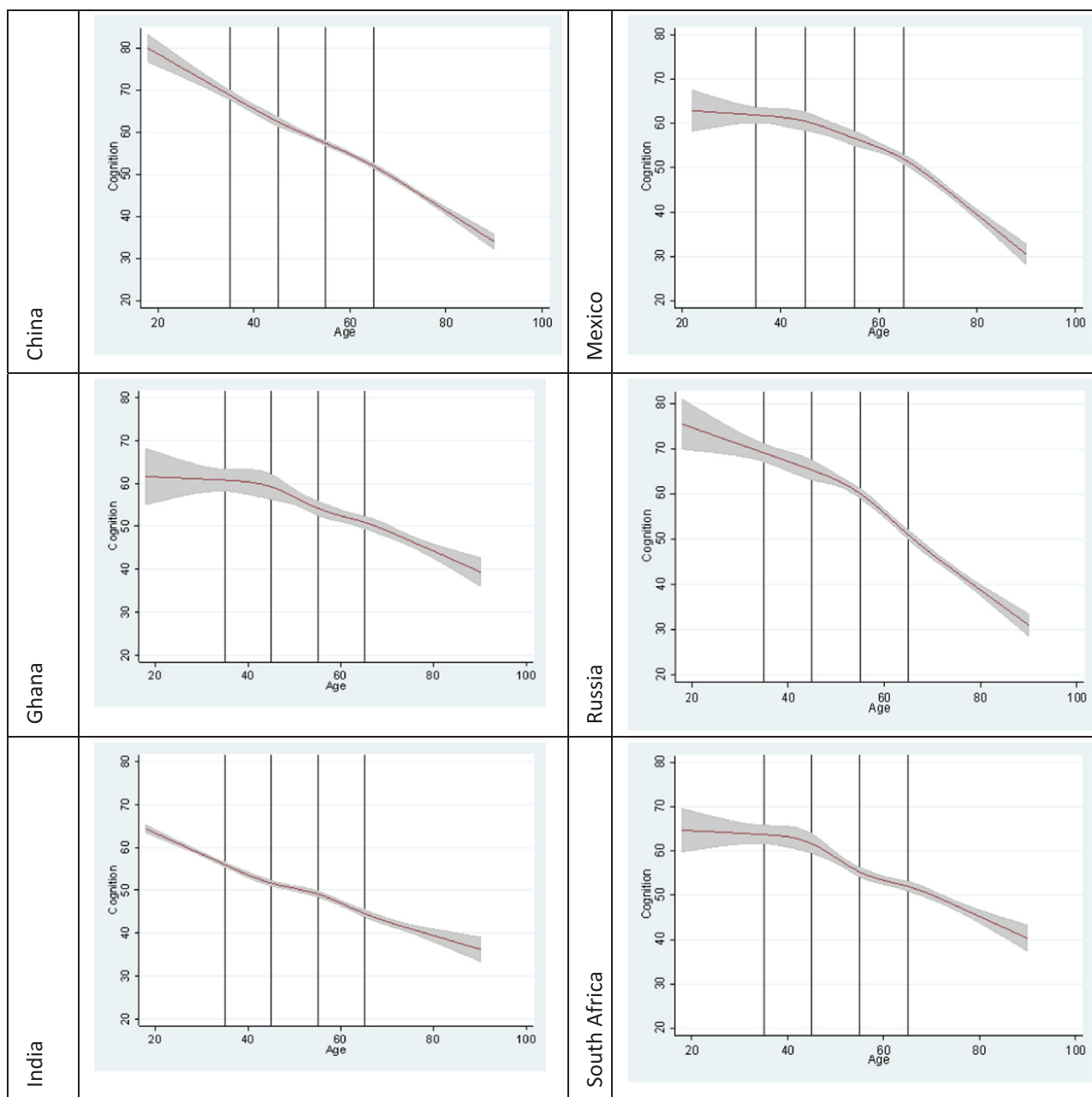


Fig. 2. Cognitive functioning (y axis) cubic splines by age (x axis) Sage data Wave 1, 2007–10 by country and gender.

**Table 5**  
Onset age of decline in cognition, SAGE project wave 1 2007–2010.

Country	Age of onset (Std error)
China	50 (0.7)
Ghana	57 (5.3)
India	61 (0.31)
Mexico	62 (3.2)
Russia	55 (4.4)
South Africa	50 (1.0)

**Table 6**  
Wealth and age of onset of cognition decline, SAGE project wave 1 2007–2010.

Country	Age of onset (Std error)	
	Poor	Rich
China	48 (3.2)	60 (1.35)
Ghana	55 (1.7)	58 (2.1)
India	49 (4.4)	68 (1.8)
Mexico	59 (3.1)	66 (3.5)
Russia	53 (3.17)	66 (2.9)
South Africa	50 (3.6)	51 (2.9)

onset in the 40s. The differences across wealth groups might be attributed to differential labour patterns (Dodds et al., 2016).

The relatively smaller gap between rich and poor strata for walking speed in some of countries (e.g.: South Africa) or the lack of significance in this measure in some of the values could be due to rising levels of

obesity in particular among wealthier groups possibly due, among other things, to higher car use (Monteiro, Moura, Conde, & Popkin, 2004).

This is further reiterated in the patterns of cognitive functions across age groups highlighting significant inequalities between wealth groups. This could have significant implications for health and social care

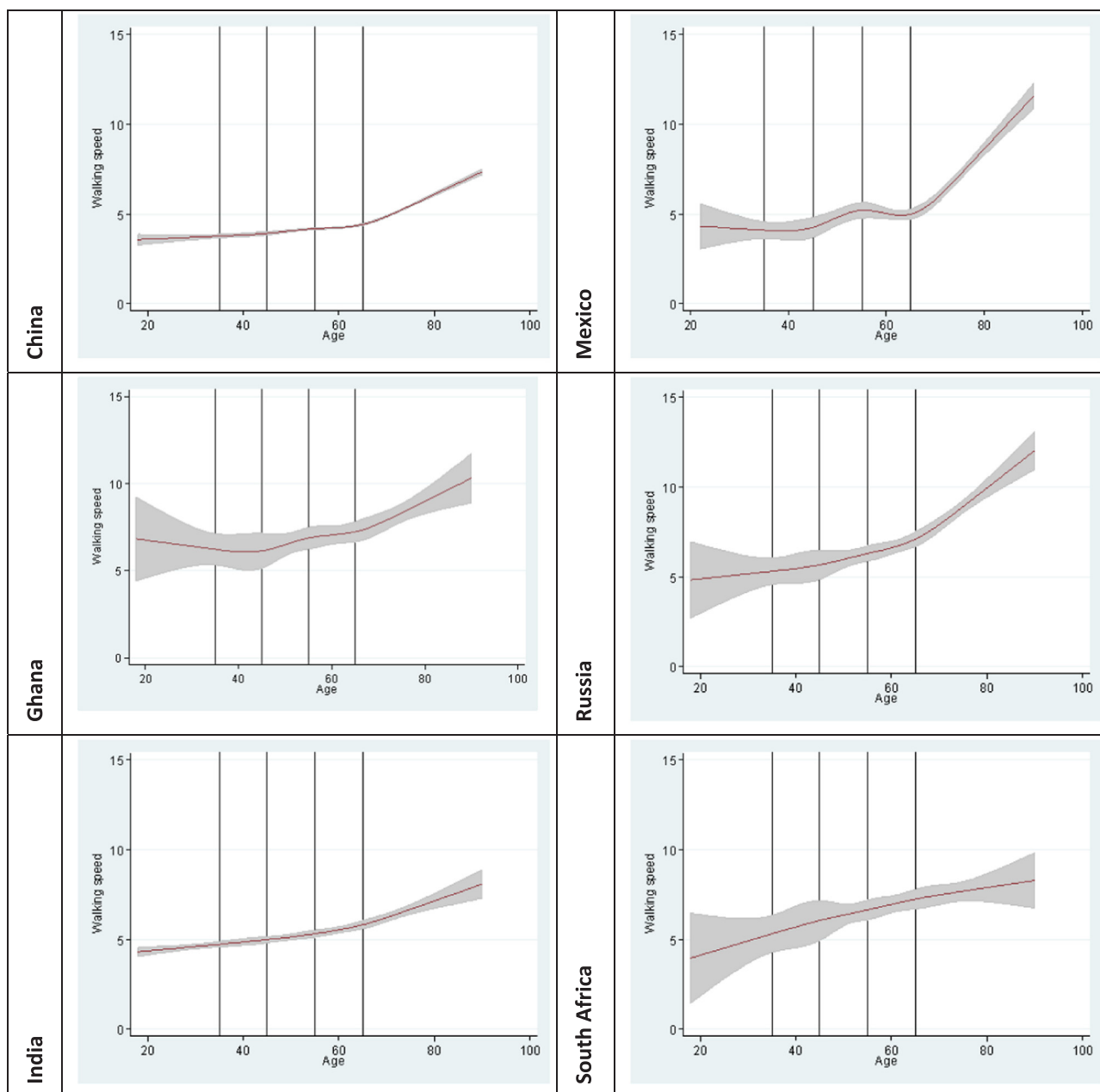


Fig. 3. Women's walking speed (y axis) cubic splines by age (x axis) Sage data Wave 1 2007-10 by country.

**Table 7**  
Onset age of decline in walking speed, females, Sage project 2007–2010.

	Age (SE)
China	48 (0.2)
Ghana	47 (3.9)
India	49 (0.6)
Mexico	56 (0.7)
Russia	54 (0.4)
South Africa	49 (1.6)

**Table 8**  
Women's Wealth and walking speed, SAGE project 2007–2010.

	Poor	Rich
China	46 (0.4)	57 (0.1)
Ghana	NS	NS
India	46 (0.9)	55 (0.2)
Mexico	53 (1.9)	65 (0.6)
Russia	49 (2.9)	54 (0.7)
South Africa	49 (1.4)	50 (1.2)

NS = Not significant

systems given the increase in the prevalence of dementia in LMICs (Abegunde et al., 2007).

A careful interpretation of these results needs to account for the fact that socio-economic characteristics can influence and are influenced by the speed of ageing as well. Health deterioration can be worsened by poor economic settings and it is often the case that economic adversity

throughout the lifecourse has a negative impact on the health of older people (Kubzansky, Kawachi, & Sparrow, 1999, Grundy & Holt, 2001, Benzeval, Green, & Leyland, 2011, Gruenewald et al. 2012a, 2012b). Ultimately, caution needs to be applied throughout the results of this paper given the limitations of the data which I described in the data section but also given that the analysis does not allow us to make any



causal inference. The possible associations are based on assumptions looking at the literature and evidence which is mainly coming from HICs.

The cross-country comparison, while highlighting very different patterns, also highlights similarities with some grouping visible (e.g.: Ghana and India vs China and South Africa). The significance of the within and between countries significance was further reiterated by the analysis run on the mean averages across countries with the Anova analysis.

The study highlights a series of patterns which could lead to important policy implications if further research in the field is conducted. One first example is the need to investigate more the impact that decades of high fertility and low resourced health systems in the field of maternal and reproductive health care might have done to the health of women who are now in the post-reproductive era. This impact could be evident in the results for Ghana and India. However, we can only speculate this as we don't have data that link fertility to health outcomes later on in life as these were not included in SAGE.

The analyses show an early onset of health deterioration. This suggests that interventions to prevent, delay or reduce disability in older age should begin early in midlife. Cost effective interventions are needed in order to deal with a fast growing ageing population in LMICs. Simple grip strength tests for example can identify early signs of ageing, and muscle strengthening exercises used to restore some strength (Rantanen, Guralnik et al. 1999). Community based exercise in Australia has been shown to increase strength and balance in older individuals (Barnett, Smith, Lord, Williams, & Baumand, 2003). Routine tests conducted by community health workers could be beneficial in trying to prevent accelerated health deterioration.

The shortcomings of these analyses demonstrate the need to collect data across the lifecourse in order to understand the timing and speed of age-related changes. The age of onset of health deteriorates might overlap with the end of women's reproductive lives, which is generally not reflected in available data. For example, standard Demographic and Health Surveys usually sample women aged 15–49 years whereas ageing surveys tend to sample from age 50 and above. This means that datasets miss the beginning of the transition to health deterioration and many of the determinants that cumulatively could affect the speed at which women age. The analyses presented here also demonstrate the need to use more than one measure of health in order to determine different stages in the onset of deterioration.

There is also a need to explore the biomedical outcomes within a wider holistic approach which makes sure interventions are not simply at health care level but also at community and household level. The healthy ageing strategies which have seen cost-effective approaches in HICs could be replicated in this kind of settings (WHO, 2016). Above all there is a need to address women's needs in a culturally sensitive manner that would allow them to access the services available and increase their knowledge on how to stay healthy. There is a wealth of literature on how to do so the question is now how to implement it.

In the absence of longitudinal data, there is a need to integrate contextual macro data with individual-level data. For example, to better understand declines in cognition there is a need to conduct analyses which account for educational system changes across cohorts and the gap between wealth groups.

There is growing recognition in HICs that healthcare of women beyond age 40 is important; this recognition is largely absent in LMICs (Lusti-Narasimhan & Beard, 2013, Aboderin, 2014). The lack of preventative care among women in middle age could further exacerbate age-related health issues that women in LMICs already face.

This paper contributes to the evidence base on women's ageing-related health deterioration in LMICs. Previous studies have highlighted differences in levels of some of these measures but have not considered onset or socio-economic differentials (Andersen-Ranberg et al., 2009, Dodds et al., 2016). Ultimately we need better understanding of the concept of "middle-age" and how it differs within and between

contexts. Given increasing life expectancies there is a need to understand how women might be additionally burdened by age-related health deteriorates which could mean being in ill-health for longer as they age.

## Conflict of interest

I declare no conflict of interest and all funding has been acknowledged.

## Ethics

Ethical approval not needed for this paper: only secondary data used.

## Acknowledgments

This research was funded by the Titmuss Meinhardt fund at the LSE. I am grateful to Nele Van Der Wielen for her data editing, to the Social Policy reading group, Lucinda Platt, Ernestina Coast and Cate Henderson for comments in an earlier version of this paper.

## References

- Abegunde, D. O., Mathers, C. D., Adam, T., Ortegon, M., & Strong, K. (2007). The burden and costs of chronic diseases in low-income and middle-income countries. *The Lancet*, *370*(9603), 1929–1938.
- Aboderin, I. (2014). Sexual and reproductive health and rights of older men and women: Addressing a policy blind spot. *Reproductive Health Matters*, *22*(44), 185–190.
- Adams, J. M., & White, M. (2004). Biological ageing: A fundamental, biological link between socio-economic status and health? *European Journal of Public Health*, *14*.
- Andersen-Ranberg, K., Petersen, I., Frederiksen, H., Mackenbach, J. P., & Christensen, K. (2009). Cross-national differences in grip strength among 50+ year-old Europeans: Results from the SHARE study. *European Journal of Ageing*, *6*(3), 227–236.
- Barnett, A., Smith, B., Lord, S. R., Williams, M., & Baumand, A. (2003). Community-based group exercise improves balance and reduces falls in at-risk older people: A randomised controlled trial. *Age and Ageing*, *32*(4), 407–414.
- Basu, R. (2013). Effects of education and income on cognitive functioning among Indians aged 50 years and older: Evidence from the Study on global AGEing and adult health (SAGE) Wave 1 (2007–10). *WHO South-East Asia Journal of Public Health*, *2*, 156–164.
- Benzeval, M., Green, M. J., & Leyland, A. H. (2011). Do social inequalities in health widen or converge with age? Longitudinal evidence from three cohorts in the West of Scotland. *BMC Public Health*, *11*.
- Biritwum, R.B., Mensah G., Mimiucui N., Yawson A.E., Naidoo N., Chatterji S. and Kowal P. (2013). "Household characteristics for older adults and study background from SAGE Ghana Wave 1." 2013.
- Blümel, J. E., Chedraui, P., Calle, A., Bocanera, R., Depiano, E., Figueroa-Casas, P., Gonzalez, C., Martino, M., Royer, M., Zuñiga, C., Dulon, A., Espinoza, M. T., Futchner, C., Mostajo, D., Soto, E., Marco, A. A., Aravena, H., Busquets, M., Campodónico, I., Germain, A., Alba, A., Baron, G., Gomez, G., Monterrosa, A., Onatra, W., Broutin, G., Manzano, B., Gabriela, A., Hidalgo, L., Leon, P., Orbea, M., Sanchez, H., Vallejo, S., Vallecillo, G., Hernandez-Bueno, J. A., Motta, E., Andrade, R., Tserotas, K., Gonzalez, C. M., Benitez, Z., Calle, E., Danckers, L., Del Castillo, A., Izaguirre, H., Ojeda, E., Rojas, J., Bencosme, A., & Lima, S. (2006). Age at menopause in Latin America. *Menopause*, *13*(4), 706–712.
- Borrell-Carrió, F., Suchman, A. L., & Epstein, R. M. (2004). The biopsychosocial model 25 years later: Principles, practice, and scientific inquiry. *The Annals of Family Medicine*, *2*(6), 576–582.
- Buis, M.L. (2009). "Using and interpreting restricted cubic splines," German Stata Users' Group Meetings 2009, Stata Users Group., Stata.
- Capistrant, B. D., Glymour, M. M., & Berkman, L. F. (2015). Assessing mobility difficulties for cross-national comparisons: Results from the World Health Organization Study on global ageing and adult health. *Journal of the American Geriatrics Society*, *62*(2), 329–335.
- Carroll, B. A., Kowal, P., Naidoo, N., & Chatterji, S. (2012). *Measuring cognitive status in older age in lower income countries: Results from a pilot of the Study on global AGEing and adult health (SAGE)* (SAGE Working Paper No 3) Geneva: World Health Organization.
- Castell, M.-V., Sánchez, M., Julián, R., Queipo, R., Martín, S., & Otero, Á. (2013). Frailty prevalence and slow walking speed in persons age 65 and older: Implications for primary care. *BMC Family Practice*, *14*(1), 86.
- Chilima, D. M., & Ismail, S. J. (2001). Nutrition and handgrip strength of older adults in rural Malawi. *Public Health Nutrition*, *4*(01), 11–17.
- Cipriani, C., Romagnoli, E., Carnevale, V., Raso, I., Scarpiello, A., Angelozzi, M., Tancredi, A., Russo, S., De Lucia, F., Pepe, J., & Minisola, S. (2012). Muscle strength and bone in healthy women: Effect of age and gonadal status. *Hormones*, *11*(3), 325–332.
- Cooper, R., Hardy, R., Aihie Sayer, A., Ben-Shlomo, Y., Birnie, K., Cooper, C., Craig, L., Deary, I. J., Demakakos, P., Gallacher, J., McNeill, G., Martin, R. M., Starr, J. M., Steptoe, A., & Kuh, D. (2011). Age and gender differences in physical capability levels

- from mid-life onwards: The harmonisation and meta-analysis of data from Eight UK Cohort studies. *PLoS One*, **6**(11), <https://doi.org/10.1371/journal.pone.0027899>.
- Cooper, R., Mishra, G., Clennell, S., Guralnik, J., & Kuh, D. (2008). Menopausal status and physical performance in midlife: Findings from a British birth cohort study. *Menopause*, **15**(6), 1079–1085.
- da Câmara, S. M. A., Zunzunegui, M. V., Pirkle, C., Moreira, M. A., & Maciel, Á. C. C. (2015). Menopausal status and physical performance in middle aged women: A cross-sectional community-based study in Northeast Brazil. *PLoS One*, **10**(3), e0119480.
- Dodds, R. M., Syddall, H. E., Cooper, R., Kuh, D., Cooper, C., & Sayer, A. A. (2016). Global variation in grip strength: A systematic review and meta-analysis of normative data. *Age and Ageing*, **45**(2), 209–216.
- Durrleman, S., & Simon, R. (1989). Flexible regression models with cubic splines. *Statistics in Medicine*, **8**(5), 551–561.
- Elias, C., & Sherris, J. (2003). Reproductive and sexual health of older women in developing countries: Women and their healthcare providers face unique needs and challenges. *BMJ: British Medical Journal*, **327**(7406), 64–65.
- Filmer, D., & Pritchett, L. H. (2001). Estimating wealth effects without expenditure data—or tears: An application to educational enrollments in States of India. *Demography* (pre-2011), **38**(1), 115–132.
- Gildner, T. E., Liebert, M. A., Kowal, P., & Snodgrass, J. J. (2014). Associations between sleep duration, sleep quality, and cognitive test performance among older adults from six middle income countries: Results from the study on global ageing and adult health (SAGE). *Journal of Clinical Sleep Medicine*, **10**(6), 613–621.
- Gruenewald, T. L., Karlamangla, A. S., Hu, P., Stein-Merkin, S., Crandall, C., & Koretz, B. (2012a). History of socioeconomic disadvantage and allostatic load in later life. *Social Science & Medicine*, **74**.
- Gruenewald, T. L., Karlamangla, A. S., Hu, P., Stein-Merkin, S., Crandall, C., Koretz, B., & Seeman, T. E. (2012b). History of socioeconomic disadvantage and allostatic load in later life. *Social Science & Medicine*, **74**(1), 75–83.
- Grundy, E., & Holt, G. (2001). The socioeconomic status of older adults: How should we measure it in studies of health inequalities? *Journal of Epidemiology Community Health*, **55**.
- Hallal, P. C., Andersen, L. B., Bull, F. C., Guthold, R., Haskell, W., & Ekelund, U. (2012). Global physical activity levels: Surveillance progress, pitfalls, and prospects. *The Lancet*, **380**(9838), 247–257.
- Hammoudeh, D., Coast, E., Lewis, D., van der Meulen, Y., Leone, T., & Giacaman, R. (2017). Age of despair or age of hope? Palestinian women's perspectives on midlife health. *Social Science & Medicine*, **184**, 108–115.
- Himann, J. E., Cunningham, D. A., Rechnitzer, P. A., & Paterson, D. H. (1988). Age-related changes in speed of walking. *Medicine and Science in Sports and Exercise*, **20**(2), 161–166.
- IIPS (2013). *Study on global AGEing and adult health (SAGE) Wave 1 INDIA*. Mumbai: IIPS.
- Jejeebhoy, S., Koenig, M., & Elias, C. (2003). Community interaction in studies of gynaecological morbidity: Experiences in Egypt, India and Uganda. In S. Jejeebhoy, M. Koenig, & C. Elias (Eds.). *Investigating reproductive tract infections and other gynaecological disorders: A multidisciplinary research approach* (pp. 140) .
- Kowal, P., Biritwum, R., Haldia, K., Isingo, R., Kumogola, Y., Mathur, A., Naidoo, N., Urassa M. and Chatterji S., (2012). WHO Study on global AGEing and adult health (SAGE): Summary results of a pilot in three countries. SAGE working paper 2. WHO. Geneva, Switzerland.
- Kowal, P., Chatterji, S., Naidoo, N., Biritwum, R., Fan, W., Ridaura, R. L., Maximova, T., Arokiasamy, P., Phaswana-Mafuya, N., Williams, S., Snodgrass, J. J., Minicuci, N., D'Este, C., Peltzer, K., & Boerm, J. T. (2012). Data Resource Profile: The World Health Organization Study on global AGEing and adult health (SAGE). *The International Journal of Epidemiology*, **41**(6), 1639–1649.
- Kowal, P., & Dowd, J. (2001). *Definition of an older person. Proposed working definition of an older person in Africa for the MDS Project*. Geneva: World Health Organization.
- Kowal, P., Kahn, K., Ng, N., Naidoo, N., Abdullah, S., Bawah, A., Binka, F., Chuc, N. T. K., Debpuur, C., Ezeh, A., Xavier Gómez-Olivé, F., Hakimi, M., Hirve, S., Hodgson, A., Juvekar, S., Kyobutungi, C., Menken, J., Van Minh, H., Mwanyangala, M. A., Razzaque, A., Sankoh, O., Kim Streatfield, P., Wall, S., Wilopo, S., Byass, P., Chatterji, S., & Tollman, S. M. (2010). Ageing and adult health status in eight lower-income countries: The INDEPTH WHO-SAGE collaboration. *Global Health Action*, **3**(1), 5302.
- Kubzansky, L. D., Kawachi, I., & Sparrow, D. (1999). Socioeconomic status, hostility, and risk factor clustering in the Normative Aging Study: Any help from the concept of allostatic load? *Annals of Behavioral Medicine*, **21**.
- Kurina, L. M., Gulati, M., Everson-Rose, S. A., Chung, P. J., Karavolos, K., Cohen, N. J., Kandula, N., Lukezic, R., Dugan, S. A., Sowers, M., Powell, L. H., & Pickett, K. E. (2004). The effect of menopause on grip and pinch strength: Results from the Chicago, Illinois, Site of the study of women's health across the nation. *American Journal of Epidemiology*, **160**(5), 484–491.
- Lehman, B. J., David, D. M., & Gruber, J. A. (2017). Rethinking the biopsychosocial model of health: Understanding health as a dynamic system. *Social and Personality Psychology Compass*, **11**(8), e12328.
- Lusti-Narasimhan, M., & Beard, J. (2013). *Sexual health in older women*. *Bulletin of the World Health Organization*, **91**, World Health Organization707–709.
- Metter, J., Conwit, R., Tobin, J., & Fozard, J. L. (1997). Age-associated loss of power and strength in the upper extremities in women and men. *Journal of Gerontology: Biological Science*, **52A**(5), 267–276.
- Monteiro, C. A., Moura, E. C., Conde, W. L., & Popkin, B. M. (2004). Socioeconomic status and obesity in adult populations of developing countries: A review. *Bulletin of the World Health Organization*, **82**, 940–946.
- Murray, M. P., Kory, R. C., & Clarkson, B. H. (1969). Walking patterns in healthy old men. *Journal of Gerontology*, **24**(2), 169–178.
- Nahhas, R. W., Choh, A. C., Lee, M., Cameron Chumlea, W. M., Duren, D. L., Siervogel, R. M., Sherwood, R. J., Towne, B., & Czerwinski, S. A. (2010). Bayesian longitudinal plateau model of adult grip strength. *American Journal of Human Biology*, **22**(5), 648–656.
- Phillips, S. K., Rook, K. M., Siddle, N. C., Bruce, S. A., & Woledge, R. C. (1993). Muscle weakness in women occurs at an earlier age than in men, but strength is preserved by hormone replacement therapy. *Clinical Science*, **84**(1), 95–98.
- Poomalar, G. K., & Arounassalam, B. (2013). The quality of life during and after menopause among rural women. *Journal of Clinical and Diagnostic Research: JCDR*, **7**(1), 135–139.
- Randall, S., & Coast, E. (2016). The quality of demographic data on older Africans. *Demographic Research*, **34**(5), 143–174.
- Rantanen, T., Guralnik, J. M., Foley, D., et al. (1999). Midlife hand grip strength as a predictor of old age disability. *JAMA*, **281**(6), 558–560.
- Sayer, A. A., Syddall, H. E., Martin, H. J., Dennison, E. M., Roberts, H. C., & Cooper, C. (2006). Is grip strength associated with health-related quality of life? Findings from the Hertfordshire Cohort Study. *Age and Ageing*, **35**(4), 409–415.
- SCDC (2012). *Study on global AGEing and adult health (SAGE) Wave 1 China National Report*. Shanghai: S.M.C.F. D.C. Prevention.
- Seeman, T., Epel, E., Gruenewald, T., Karlamangla, A., & McEwen, B. S. (2010). Socioeconomic differentials in peripheral biology: Cumulative allostatic load. *Annals of the New York Academy of Sciences*, **1186**(1), 223–239.
- Shinkai, S., Watanabe, S., Kumagai, S., Fujiwara, Y., Amano, H., Yoshida, H., Ishizaki, T., Yukawa, H., Suzuki, T., & Shibata, H. (2000). Walking speed as a good predictor for the onset of functional dependence in a Japanese rural community population. *Age and Ageing*, **29**(5), 441–446.
- Skirbekk, V., Loichinger, E., & Weber, D. (2012). Variation in cognitive functioning as a refined approach to comparing aging across countries. *Proceedings of the National Academy of Sciences of the United States of America*, **109**(3), 770–774.
- Sosa-Escudero, W., & Bera, A. K. (2008). Tests for unbalanced error-components models under local misspecification. *Stata Journal*, **8**, 68–78.
- Sowers, M., Zheng, H., Tomey, K., Karvonen-Gutierrez, C., Jannausch, M., Li, X., Yosef, M., & Symons, J. (2007). Changes in body composition in women over six years at midlife: Ovarian and chronological aging. *The Journal of Clinical Endocrinology Metabolism*, **92**(3), 895–901.
- StataCorp. (2015). *Stata Statistical Software: Release 14*. College Station, TX, StataCorp LP.
- Taekema, D. G., Gussekloo, J., Maier, A. B., Westendorp, G. J., & de Craen, A. J. M. (2009). Handgrip strength as a predictor of functional, psychological and social health. A prospective population-based study among the oldest old. *Age and Ageing*, **39**(3), 331–337.
- UN Statistics Division (2017). “MDG Indicators.” Retrieved 22/09/2017, from <<https://mdgs.un.org/unsd/mdg/Data.aspx>>.
- United Nations (2013). *World population ageing 2013*. New York, NY: UN.
- Upchurch, D. M., Stein, J., Greendale, G. A., Chyu, L., Tseng, C.-H., Huang, M.-H., Lewis, T. T., Kravitz, H. M., & Seeman, T. (2015). A longitudinal investigation of race, socioeconomic status, and psychosocial mediators of allostatic load in midlife women: Findings from the study of women's health across the nation. *Psychosomatic Medicine*, **77**(4), 402–412.
- WHO (2002). *Towards a common language for functioning, disability and health ICF*. Geneva: WHO.
- WHO (2016). *Multisectoral action for a life course approach to healthy ageing: Draft global strategy and plan of action on ageing and health* (WHO)Geneva: WHO.
- Wray, S. (2003). Women growing older. *Sociology*, **37**(3), 511–527.