BMJ Open

The association between obesity and severe disability among adults aged 50 or over in nine high-income, middle-income and low-income countries: a cross-sectional study

Ai Koyanagi,[1,2] Maria Victoria Moneta,[1,2] Noe Garin,[1,2,3] Beatriz Olaya,[1,2] Jose Luis Ayuso-Mateos,[2,4,5] Somnath Chatterji,[6] Matilde Leonardi,[7] Päivi Sainio,[8] Aleksander Galas,[9] Josep Maria Haro[1,2]

To cite: Koyanagi A, Moneta MV, Garin N, *et al*. The association between obesity and severe disability among adults aged 50 or over in nine high-income, middle-income and low-income countries: a cross-sectional study. *BMJ Open* 2015;**5**:e007313. doi:10.1136/bmjopen-2014-007313

▸ Prepublication history and additional material is available. To view please visit the journal (http://dx.doi.org/10.1136/bmjopen-2014-007313).

Received 26 November 2014
Revised 24 February 2015
Accepted 9 March 2015

For numbered affiliations see end of article.

Correspondence to
Dr Ai Koyanagi;
a.koyanagi@pssjd.org

ABSTRACT

Objective: The association between obesity and disability may differ between high-income and low-income/middle-income countries but there are no studies comparing this association between these settings. The aim of the study was to assess this association in nine countries using nationally-representative data from the Collaborative Research on Ageing in Europe (COURAGE) study and the WHO's Study on global AGEing and Adult Health (SAGE).

Design: Population-based cross-sectional study

Setting: The survey was conducted in China, Finland, Ghana, India, Mexico, Poland, Russia, South Africa and Spain between 2007 and 2012.

Participants: 42 116 individuals 50 years and older. The institutionalised and those with limited cognition were excluded.

Primary outcome measure: Disability was defined as severe or extreme difficulty in conducting at least one of six types of basic activities of daily living (ADL).

Results: The mean body mass index (BMI) ranged from 20.4 kg/m^2 in India to 30.7 kg/m^2 in South Africa. Compared to normal BMI (18.5–24.9 kg/m^2), BMI≥35 kg/m^2 was associated with significantly higher odds for ADL disability in Finland (OR 4.64), Poland (OR 2.77), South Africa (OR 2.19) and Spain (OR 2.42). Interaction analysis showed that obese individuals in high-income countries were more likely to have ADL limitations than those in low-income or middle-income countries.

Conclusions: The higher odds for disability among obese individuals in high-income countries may imply longer life lived with disability due to factors such as the decline in cardiovascular disease mortality. In South Africa, this may have been due to the exceptionally high prevalence of class III obesity. These findings underscore the importance of obesity prevention to reduce the disability burden among older adults.

Strengths and limitations of this study

- We studied the association between obesity and disability in nine high-income, middle-income and low-income countries using large nationally-representative data sets with information obtained by standardised questionnaires and measured body mass index. This is the first study to examine this association in a variety of settings.
- Obese individuals in high-income countries were more likely to have disability than those in low-income or middle-income countries. This may be related to factors such as the decline in cardiovascular disease mortality and the resulting longer life lived with disability in high-income countries.
- Self-report of disability may have been subject to reporting bias and personal perception of disability may have varied across settings.
- The exclusion of those with limited cognitive function and the institutionalised may have resulted in the exclusion of those with severe activities of daily living (ADL) impairment resulting in a potential underestimation of the association between obesity and ADL limitations.
- Owing to the cross-sectional nature of the study, causality cannot be inferred.

INTRODUCTION

The obesity epidemic has affected both developing and developed countries alike,[1] and the prevalence and incidence are projected to rise in the future.[2] Obese individuals are at higher risk for chronic conditions such as cardiovascular disease (CVD), hypertension, dyslipidaemia, diabetes and arthritis,[3] and these conditions often underlie disability among older individuals.[4] The increase in obesity and obesity-related chronic diseases in the current context of global population ageing is likely to increase disability among older adults in the future.[5] This is a major challenge for the healthcare, social and welfare services worldwide in terms of the healthcare costs,[6] patients' quality of life and the burden for the caregivers.[5]

In resource-rich settings, better prevention and medical management of obesity-related chronic conditions might have counteracted some of the ill-effects of obesity on health. In the USA, with the exception of diabetes, cardiovascular risk factors such as hypertension and high cholesterol have decreased among the obese population probably due to factors such as wider use of antihypertensive and lipid-lowering medication.[7] Furthermore, mortality among obese individuals has declined,[8] and CVD mortality, the major obesity-related cause of death, has declined remarkably.[9] However, this may not necessarily have translated into less disability among obese people. A reduction in CVD mortality and/or case fatality rates due to better medical care may mean that obese individuals, who in previous decades would have died at younger ages, may be living longer at the cost of more disability due to the sequelae of CVD, or other disabling conditions such as arthritis.[10] A study in the USA among adults aged ≥60 years has shown a significant trend for a higher proportion of obese individuals to be living with disability compared to their normal-weight counterparts in more recent years when data of the National Health and Nutrition Examination Survey (NHANES) in 1988–1994 (time 1) and 1999–2004 (time 2) were compared.[11] In this US study, compared to normal-weight individuals, obese people had a 1.78 times higher odds for functional impairment at time 1 but this increased to 2.75 at time 2. The comparable figures for impairments in activities of daily living (ADL) were 1.31 and 2.05, respectively. Moreover, another US study showed that compared to normal weight, mild obesity (body mass index (BMI) 30.0–34.9 kg/m^2) increases life expectancy with ADL disability by 2.0 and 3.2 years among males and females, respectively.[12]

The association between obesity and disability is largely unknown in most low-income and middle-income settings. In contrast to developed countries, limitations in medical resources may imply less prevention and control of obesity-related conditions, and thus, more disability, but higher CVD mortality and/or case-fatality rates[13] may mean that they are less likely to live long with disability. In addition, individuals in many developing country settings may have had a shorter period of exposure to obesity as the obesity epidemic generally occurred later than in developed countries.[1] This may influence the difference in the association between obesity and disability as obesity also leads to negative health outcomes through its cumulative effects.[14]

To date, there are no multicontinent studies that compare the association between obesity and disability among older adults between countries with different medical resources and at different stages of the demographic, nutritional and socioeconomic transition. Understanding the association between obesity and disability is important to plan future prevention programmes. This information is particularly important for developing country settings where rehabilitation services are limited and where obesity and disability is increasing in parallel with the rapid demographic changes. We analysed nationally-representative data on adults aged ≥50 years from nine countries in Asia, Africa, Europe and Latin America, using the Collaborative Research on Ageing in Europe (COURAGE) and the WHO Study on global AGEing and adult health (SAGE) data sets.

METHODS AND PROCEDURES

Data analysis of the COURAGE and SAGE surveys was performed. The details of the two surveys have been published elsewhere.[15 16] In brief, the two surveys followed the same protocol to collect information on health status, quality of life, disability and well-being among adult populations using standardised questionnaires. Multistage clustered sampling design was employed to generate nationally-representative samples. The sample consisted of non-institutionalised adults ≥18 years of age with oversampling of those aged ≥50 years. The COURAGE survey was conducted between 2011 and 2012 in Finland, Poland and Spain, and the SAGE survey was conducted between 2007 and 2010 in China, Ghana, India, Mexico, Russia and South Africa. The response rate ranged from 51% (Mexico) to 93% (China). All data were collected through face-to-face interviews and measurements by trained interviewers. Height and weight were measured with the use of a stadiometer and a routinely calibrated electronic weighting scale, respectively. Sampling weights were generated to adjust for the population structure reported by the National Institute of Statistics and the United Nations Statistical Division for the COURAGE and SAGE surveys, respectively. Informed consent was obtained from all participants.

Variables

BMI was calculated as weight in kilograms divided by height in metres squared. BMI was categorised as <18.5 kg/m^2 (underweight), 18.5–24.9 kg/m^2 (normal weight), 25.0–29.9 kg/m^2 (overweight), 30.0–34.9 kg/m^2 (obesity class I), 35.0–39.9 kg/m^2 (obesity class II), and ≥40.0 kg/m^2 (obesity class III).[3] Although disability may be defined in various ways, we focused on limitation in ADL as it represents the severest of the disability measures, and is an indicator of the ability to live independently.[17] ADL disability was assessed by standard basic ADL questions[18–20] which included six questions with the introductory phrase "overall in the last 30 days, how much difficulty did you have' followed by: in washing your whole body?; in getting dressed?; with moving around inside your home?; with eating (including cutting up your food)?; with getting up from lying down?; with getting to and using the toilet? Answer options were none, mild, moderate, severe, extreme/cannot do. ADL disability was a dichotomous variable where those who answered severe or extreme/cannot do to any of the six questions were considered to have limitations in ADL. We defined ADL disability using the most extreme categories to improve specificity and also to focus on disability that

is more likely to be clinically relevant. The presence of five chronic medical conditions (angina, arthritis, hypertension, diabetes and stroke) was based on self-report on whether the participant had ever been diagnosed to have these conditions. The selection of other covariates used for adjustment were based on past literature and included sex, age, highest level of education completed (≤primary, secondary, ≥tertiary), wealth quintiles based on country-specific income, marital status ((currently married/cohabiting) or not married (never married/separated/divorced/widowed)) and smoking status (never, current smoker, quit).[19]

Statistical analysis

The analysis was restricted to adults over age 50 years. We focused on individuals aged 50 years or older as the prevalence of chronic diseases and disabilities is high in this age group.[4]

Multivariable logistic regression analyses were performed to assess the association between BMI (independent variable) and limitations in ADL (dependent variable). Those with BMI<18.5 kg/m^2 were excluded from this part of the analysis as the aim of our study was to compare normal weight and higher BMI in terms of the association between BMI and ADL limitations. This resulted in 0.5% (Finland) to 38.8% (India) of the participants to be omitted from this part of the analysis. Obesity class II and III were collapsed due to small numbers of class III obesity in most countries. The first model adjusted for sex, age, education, marital status, wealth and smoking. Since the effect of the highest BMI category (BMI≥35 kg/m^2) on disability could have been affected by the proportion of those with extreme obesity, we also conducted an additional analysis by deleting those with BMI≥40 kg/m^2 to allow for comparability between countries. Furthermore, in order to assess whether the association between BMI and ADL disability differs by income level of the countries, we created a dichotomised variable coded 0 for low-income and middle-income countries (China, Ghana, India, Mexico, Russia and South Africa) and 1 for high-income countries (Finland, Poland and Spain) based on the World Bank classification (http://data.worldbank.org/country/). Although Russia is currently classified as a high-income country, it was a middle-income country at the time of the survey. We included the product term of BMI category and income level of country in the adjusted model using pooled data of all countries. We also constructed a model which used a BMI category which collapsed obesity class I and class II+ for the interaction analysis as the prevalence of class II+ obesity was low and this could have lead to unstable estimates. The last model included the five chronic medical conditions (angina, arthritis, hypertension, diabetes and stroke) in addition to the covariates in the first model to assess the mediating effect of these conditions on the association between BMI and ADL disability. In addition, in order to assess the effect of having excluded 38.8% of the sample from India due to the restriction to individuals with BMI ≥18.5 kg/m^2, we conducted sensitivity analyses by including those who were underweight in the analysis for India and the overall sample with the interaction term. We also conducted sensitivity analyses by using a definition of ADL disability including the moderate category in the definition for the six questions on ADL (ie, not only severe and extreme but also moderate) to assess whether the results change when less extreme categorisations are used. The sample weighting and the complex study design were taken into account in all analyses to generate nationally representative estimates. We analysed data with Stata V.12.1 (Stata Corp LP, College Station, Texas, USA). The level of statistical significance was set at p<0.05.

RESULTS

Baseline characteristics of the analytical sample are demonstrated in table 1.

The median age ranged from 60 to 65 years. In all countries except Ghana and India, there were more females than males. The mean BMI ranged from 20.4 kg/m^2 in India to 30.7 kg/m^2 in South Africa. The prevalence of obesity (ie, BMI≥30 kg/m^2) was lowest in the Asian countries (India 2.5% and China 5.8%). In contrast, over 30% were obese in South Africa (46.9%), Poland (35.3%), Russia (34.5%) and Spain (31.9%). In South Africa, 11.6% had class III obesity. In all countries, arthritis and/or hypertension were the most common chronic conditions. The prevalence of ADL disability ranged from 1.6% (China) to 16.6% (Poland). The frequency distribution of all five categories (none, mild, moderate, severe and extreme) of the six questions on ADL by BMI categories and countries are shown in online supplementary appendix table A1.

Figure 1 illustrates the prevalence of ADL limitations by BMI category. A clear dose-dependent relationship between BMI and ADL limitations was observed in Finland, Poland and Spain. The prevalence (95% CI) of limitations in ADL when using lower cut-offs for Asia were 1.6% (1.2% to 2.2%), 1.4% (1% to 1.9%) and 1.4% (0.8% to 2.2%) for BMI 18.5–22.9 kg/m^2, 23.0–27.4 kg/m^2, and ≥27.5 kg/m^2, respectively in China. The corresponding figures for India were 10.7% (8.7% to 13%), 11.8% (9% to 15.3%) and 10.1% (6.7% to 15%). The association between BMI and ADL limitations estimated by multivariable logistic regression is shown in table 2. With the exception of China, a trend for higher BMI to have stronger associations with ADL limitations compared to normal weight was observed in most countries although this association was not significant in some. In China, a non-significant trend for a decrease in the odds for ADL disability with higher BMI was observed.

Obesity class II+ was associated with a significant 4.64 (Finland), 2.77 (Poland), 2.42 (Spain) and 2.19 (South Africa) times higher odds for ADL disability compared to normal weight. Additional analysis by excluding those with BMI≥40 kg/m^2 resulted in a loss of significance for obesity class II+ only in South Africa (data not shown).

Table 1 Baseline characteristics of the study sample (over 50 years of age) by country

		COURAGE survey			SAGE survey					
Characteristics	**Categories**	**Finland N=1452**	**Poland N=2910**	**Spain N=3625**	**China N=13175**	**Ghana N=4305**	**India N=6560**	**Mexico N=2313**	**Russia N=3938**	**South Africa N=3838**
BMI (kg/m^2)	<18.5 (underweight)	0.5	1.1	0.6	4.3	15.2	38.8	0.6	1.1	3.1
	18.5–24.9 (normal weight)	31.3	24.1	22.4	60.4	55.1	48.1	21.4	23.7	23.7
	25.0–29.9 (overweight)	41.3	39.5	45.1	29.5	19.7	10.6	49.4	40.8	26.3
	30.0–34.9 (obesity class I)	19.1	25.6	23.7	4.9	6.3	1.7	21.1	22.8	22.6
	35.0–39.9 (obesity class II)	5.6	7.0	6.1	0.5	2.5	0.3	5.7	9.6	12.7
	≥40.0 (obesity class III)	2.3	2.7	2.1	0.4	1.1	0.5	1.9	2.1	11.6
	Mean (SD)	27.7 (6.2)	28.4 (6.8)	28.4 (6.7)	24.1 (7.5)	23.3 (10.2)	20.4 (7.9)	28.2 (8.5)	28.5 (7.8)	30.7 (17.2)
Age (years)	50–54	16.8	18.4	16.1	21.7	20.1	23.6	26.3	23.1	28.4
	55–59	16.5	19.9	16.1	23.2	19.6	25.0	21.7	22.1	21.5
	60–64	21.4	20.6	15.3	17.2	14.8	16.5	14.3	11.5	16.9
	65–69	14.0	12.3	12.9	14.7	12.7	14.4	11.2	13.1	13.7
	70–74	12.5	11.1	14.5	11.1	14.5	10.7	7.8	10.4	8.3
	≥75	18.7	17.7	25.2	12.1	18.3	9.8	18.6	19.8	11.2
	Median (25th-75th centile)	63 (57–72)	62 (56–71)	65 (57–75)	61 (55–69)	62 (55–72)	60 (55–68)	60 (54–70)	61 (55–72)	60 (54–67)
Sex	Male	46.0	43.5	46.4	49.8	52.4	51.0	46.8	38.9	44.1
Education	≥Tertiary	25.9	15.7	10.8	4.5	3.6	5.1	8.1	18.2	5.7
	Secondary	56.9	59.3	25.6	32.5	21.1	18.8	12.3	74.2	22.8
	≤Primary	17.2	25.0	63.6	63.0	75.3	76.1	79.6	7.5	71.4
Marital status	Married/cohabiting	64.7	68.1	62.4	85.0	59.3	76.9	73.0	58.3	55.9
Smoking	Never	35.4	44.6	53.3	64.1	75.1	45.3	60.7	69.6	66.8
	Current smoker	17.4	26.1	19.8	29.3	10.7	50.0	20.3	21.3	23.8
	Quit	47.2	29.3	26.9	6.6	14.2	4.7	19.1	9.0	9.4
Chronic conditions	Angina	11.2	13.8	6.2	7.9	3.6	5.5	2.7	32.3	5.2
	Arthritis	45.2	31.5	28.7	22.0	13.8	18.2	9.0	30.2	24.7
	Diabetes	12.9	13.6	16.3	6.6	3.8	6.9	17.6	7.0	9.2
	Hypertension	40.8	52.4	40.7	26.8	14.2	17.0	30.3	52.8	30.3
	Stroke	4.7	4.9	4.7	3.0	2.8	2.0	4.3	4.8	4.0
ADL limitations	Washing whole body	2.0	5.9	4.1	0.8	2.0	3.3	2.1	4.8	2.1
(past 30 days)	Getting dressed	1.3	5.4	3.8	0.5	1.9	2.9	2.9	2.9	1.9
	Moving around inside home	1.4	4.6	3.3	0.5	3.4	3.8	3.0	3.2	3.1
	Eating	0.6	2.6	1.5	0.5	0.9	3.9	1.8	1.8	1.5
	Getting up from lying down	2.8	14.4	7.6	0.6	4.4	4.8	5.4	5.2	5.5
	Getting to and using the toilet	0.5	2.9	1.8	0.7	3.4	6.0	1.7	2.6	2.5
	Any ADL disability*	4.6	16.6	10.7	1.6	7.8	12.3	9.0	8.0	8.2
Response rate		53	67	70	93	80	68	51	83	77

Data are per cent unless otherwise stated. Sampling weights were used for all estimates.
*Any ADL disability referred to having at least one of the six types of ADL limitations (ie, washing whole body, getting dressed, moving around inside home, eating, getting up from lying down, and getting to the toilet).
<5% of the data for each variable in each country were missing with the exception of BMI (Finland 6.3%, Spain 6.3%, China 6.1%, Mexico 11.9%, Russia 11.2%, South Africa 7%), education (South Africa 15.7%) and smoking (South Africa 5.2%).
ADL, activities of daily living; BMI, body mass index; COURAGE, Collaborative Research on Ageing in Europe; SAGE, WHO Study on global AGEing and adult health.

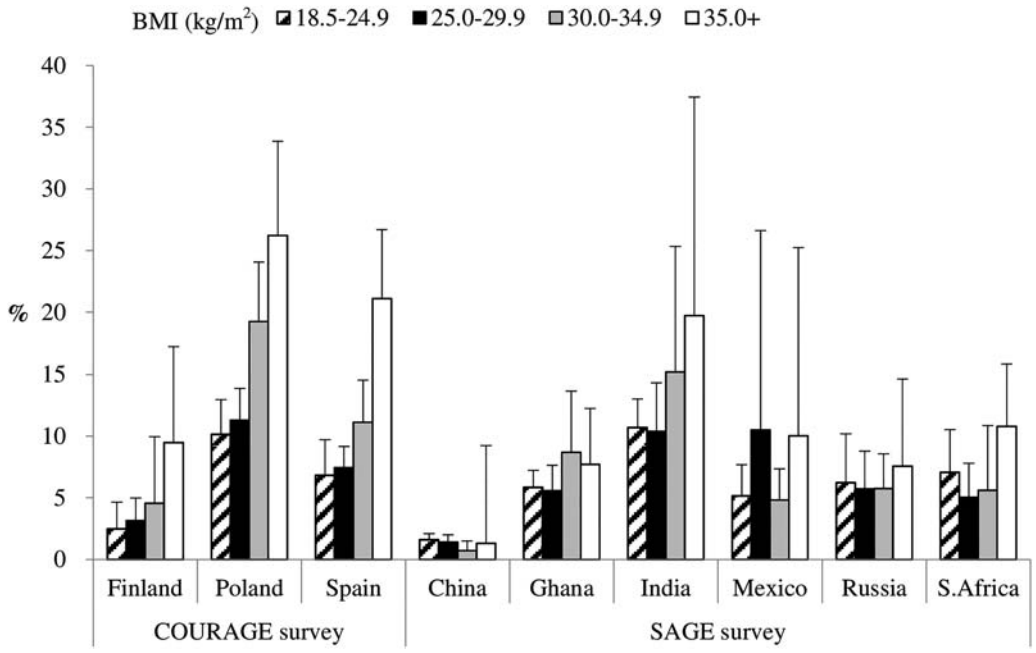

Figure 1 Prevalence of limitations in activities of daily living (ADL) by BMI category and country. S Africa South Africa; BMI, body mass index; COURAGE, Collaborative Research on Ageing in Europe; SAGE, WHO Study on global AGEing and adult health. ADL disability was assessed by six standard basic ADL questions on difficulties in the past 30 days with washing whole body, getting dressed, moving inside home, eating (including cutting food), getting up from lying down, and getting to and using the toilet. The answer options to these six questions were none, mild, moderate, severe and extreme/cannot do. ADL disability was a dichotomous variable where those who answered severe or extreme/cannot do to any of the six questions were considered to have limitations in ADL. Data presented in figure are per cent. Sampling weights were used to calculate the prevalence. Bar denotes upper end of 95% CI.

The overweight and obesity class I categories were also associated with a significant risk for ADL limitation in Mexico (OR 2.57) and Poland (OR 1.91), respectively. Female gender in Spain, and lower education in Spain, Poland and India were associated with higher odds for ADL limitations. Tendencies for the richer to have reduced odds for ADL limitations was observed in most countries with the exception of India which showed a U-shaped relationship (ie, the rich and the poor were less likely to have ADL disability). When data from all countries were pooled, the OR of the risk for ADL disability of obesity compared to normal weight was significantly higher in high-income countries compared to low-income and middle- income countries (table 3).

The association between BMI and ADL limitations adjusting for chronic diseases is illustrated in table 4. Stoke and arthritis were significantly associated with ADL disability in seven and six countries, respectively. Angina, diabetes and hypertension were associated with ADL disability in three countries. After the inclusion of chronic diseases in the model, most ORs were attenuated and the association between class II+ obesity and ADL limitation observed in Poland and South Africa became non-significant.

The results of the sensitivity analysis when including the BMI<18.5 kg/m^2 category in the analysis are shown in online supplementary appendix tables A2a, A2b and A2c. In the analysis of the association of BMI, demographic and lifestyle factors with limitations of ADL in India (see online supplementary table A2a), the association between BMI 30.0–34.9 kg/m^2 (obesity class I) and ADL disability, which was only of borderline significance in the analysis without BMI<18.5 kg/m^2, became significant (OR 2.14 (95% CI 1.22 to 3.77)). Furthermore, the previously observed U-shaped association between wealth and ADL limitation in India was no longer observed. There were no other major differences in the other analyses (see online supplementary table A2b and A2c). The results of the analysis which used a different definition of ADL disability (ie, included moderate category) were similar to those of the original analysis (see online supplementary tables A3a, A3b and A3c).

DISCUSSION

Our study shows that the association between obesity and ADL disability may differ by context. A significant association between obesity class II+ and ADL disability was observed in Poland, Finland, Spain and South Africa. Results from pooled data demonstrated that the risk for ADL disability among those with obesity is higher compared to individuals with normal weight in high-income compared to low-income and middle-income countries. The strength of the study is the large sample size and the use of nationally-representative datasets obtained by

Table 2 Association of BMI, demographic and lifestyle factors with limitations in activities of daily living

		COURAGE survey			SAGE survey					
Characteristics	**Categories**	**Finland**	**Poland**	**Spain**	**China**	**Ghana**	**India**	**Mexico**	**Russia**	**South Africa**
BMI (kg/m^2)	18.5–24.9 (normal weight)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	25.0–29.9 (overweight)	1.24	1.10	0.80	1.05	1.07	1.05	2.57*	1.15	0.61
		(0.51–3.03)	(0.76–1.60)	(0.51–1.27)	(0.67–1.66)	(0.70–1.65)	(0.69–1.61)	(1.17–5.64)	(0.71–1.85)	(0.31–1.23)
	30.0–34.9 (obesity class I)	1.67	1.91**	1.20	0.52	1.56	1.96	1.45	1.59	1.07
		(0.50–5.57)	(1.25–2.92)	(0.76–1.89)	(0.23–1.19)	(0.82–2.97)	(0.99–3.87)	(0.66–3.17)	(0.95–2.65)	(0.40–2.84)
	≥35.0 (obesity class II+)	4.64**	2.77***	2.42***	0.84	1.64	1.58	2.35	1.78	2.19*
		(1.76–12.21)	(1.71–4.47)	(1.50–3.90)	(0.10–7.30)	(0.88–3.05)	(0.57–4.42)	(0.48–11.64)	(0.66–4.80)	(1.11–4.32)
Age (years)	50–54	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	55–59	1.55	1.39	1.37	1.23	1.07	1.99**	0.44	2.17	1.06
		(0.30–7.85)	(0.82–2.34)	(0.58–3.25)	(0.39–3.91)	(0.49–2.31)	(1.22–3.24)	(0.11–1.78)	(0.78–6.01)	(0.43–2.64)
	60–64	0.95	1.27	1.73	2.58	1.56	2.41**	0.85	4.04**	0.94
		(0.21–4.24)	(0.74–2.20)	(0.83–3.59)	(0.84–7.98)	(0.85–2.84)	(1.35–4.33)	(0.24–3.00)	(1.45–11.22)	(0.39–2.26)
	65–69	0.64	1.89	1.46	4.41**	1.94*	2.44***	0.48	6.55***	3.16*
		(0.14–2.87)	(0.98–3.66)	(0.66–3.21)	(1.51–12.86)	(1.10–3.45)	(1.48–4.02)	(0.13–1.70)	(2.53–16.97)	(1.22–8.17)
	70–74	1.22	2.52**	1.72	3.75*	2.05*	3.68***	0.78	15.45***	5.26***
		(0.25–6.01)	(1.42–4.47)	(0.78–3.79)	(1.23–11.37)	(1.11–3.78)	(2.23–6.08)	(0.20–3.06)	(5.37–44.45)	(2.06–13.44)
	≥75	1.92	3.84***	3.80***	9.74***	4.77***	5.33***	1.68	35.20***	3.59**
		(0.36–10.24)	(2.30–6.40)	(1.83–7.88)	(3.53–26.88)	(2.85–7.99)	(3.35–8.48)	(0.50–5.59)	(13.36–92.70)	(1.44–8.95)
Sex	Female	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Male	1.38	0.69	0.53**	1.04	0.95	0.66	2.37	0.82	0.67
		(0.65–2.95)	(0.47–1.00)	(0.34–0.81)	(0.68–1.60)	(0.60–1.51)	(0.42–1.03)	(0.87–6.41)	(0.30–2.27)	(0.32–1.39)
Education	≥Tertiary	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Secondary	0.79	1.48	1.44	1.16	2.21	1.99	0.42	0.85	5.06
		(0.35–1.76)	(0.86–2.53)	(0.57–3.66)	(0.45–2.95)	(0.68–7.22)	(0.79–4.99)	(0.09–2.02)	(0.44–1.64)	(0.58–43.84)
	≤Primary	1.54	1.96*	3.25**	1.23	1.76	2.83*	1.93	1.06	7.40
		(0.69–3.42)	(1.10–3.50)	(1.42–7.45)	(0.51–2.98)	(0.54–5.72)	(1.14–7.04)	(0.53–6.97)	(0.48–2.34)	(0.94–57.96)
Marital status	Married/cohabiting	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Not married	1.00	0.92	0.95	1.00	1.76*	1.30	0.89	0.80	1.09
		(0.48–2.07)	(0.66–1.28)	(0.70–1.29)	(0.71–1.42)	(1.11–2.78)	(0.95–1.78)	(0.42–1.89)	(0.39–1.62)	(0.57–2.08)
Wealth	Poorest	6.09**	1.26	1.41	1.22	0.73	0.51**	5.30***	0.99	3.97***
		(1.60–23.23)	(0.82–1.93)	(0.81–2.42)	(0.68–2.21)	(0.43–1.24)	(0.30–0.84)	(2.06–13.66)	(0.49–1.99)	(1.79–8.79)
	Poorer	3.18	1.01	1.29	1.33	0.84	0.53*	4.24*	0.90	3.45**
		(0.75–13.57)	(0.64–1.58)	(0.81–2.07)	(0.58–3.04)	(0.50–1.43)	(0.31–0.91)	(1.29–13.98)	(0.34–2.40)	(1.52–7.85)
	Middle	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Richer	1.59	0.59*	0.84	0.71	0.60	0.52*	2.10	0.54	1.60
		(0.30–8.50)	(0.35–1.00)	(0.45–1.58)	(0.43–1.16)	(0.34–1.04)	(0.31–0.87)	(0.68–6.50)	(0.24–1.23)	(0.73–3.52)

Continued

Table 2 Continued

Characteristics	Categories	COURAGE survey			SAGE survey					
		Finland	Poland	Spain	China	Ghana	India	Mexico	Russia	South Africa
	Richest	0.44	0.67	0.79	0.20***	0.77	0.43***	1.02	0.56	1.80
		(0.04–4.53)	(0.35–1.27)	(0.40–1.57)	(0.11–0.39)	(0.45–1.35)	(0.26–0.71)	(0.33–3.16)	(0.27–1.13)	(0.82–3.95)
Smoking	Never smoked	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Smoker	0.46	0.96	1.34	0.86	0.69	0.80	0.33*	1.06	1.12
		(0.12–1.74)	(0.63–1.48)	(0.76–2.35)	(0.51–1.44)	(0.35–1.34)	(0.55–1.16)	(0.12–0.90)	(0.52–2.15)	(0.62–2.03)
	Quit	0.82	0.92	1.18	1.62	1.54	1.95	0.48	1.13	2.49*
		(0.42–1.62)	(0.61–1.39)	(0.76–1.83)	(0.80–3.26)	(0.92–2.56)	(0.73–5.19)	(0.15–1.60)	(0.44–2.88)	(1.07–5.82)

Data are adjusted OR (95% CIs). Country-wise regression models are adjusted for all covariates in the table.
*p<0.05, **p<0.01, ***p<0.001.
BMI, body mass index; COURAGE, Collaborative Research on Ageing in Europe; SAGE, WHO Study on global AGEing and adult health.

Table 3 OR for the body mass index and country income level interaction

BMI-country income level interaction	OR (95% CI)*	p Value	BMI-country income level interaction	OR (95% CI)*	p Value
BMI 18.5–24.9 kg/m^2 (reference)	1.00		BMI 18.5–24.9 kg/m^2 (reference)	1.00	
BMI 25.0–29.9 kg/m^2 × country income level	1.14 (0.78 to 1.65)	0.500	BMI 25.0–29.9 kg/m^2 × country income level	1.14 (0.78 to 1.65)	0.506
BMI ≥30.0 kg/m^2 × country income level	1.55 (1.06 to 2.28)	0.025	BMI 30.0–34.9 kg/m^2 × country income level	1.52 (0.99 to 2.34)	0.056
			BMI ≥35.0 kg/m^2 × country income level	1.77 (1.00 to 3.11)	0.048

Estimates are based on pooled analysis of all nine countries.
Country income level was a dichotomous variable with low-income or middle-income countries (China, Ghana, India, Mexico, Russia, South Africa) coded as 0 and high-income countries (Finland, Poland, Spain) coded as 1. All countries classified as low-income or middle-income countries were from the WHO Study on global AGEing and adult health (SAGE) survey and countries classified as high-income countries were from the Collaborative Research on Ageing in Europe (COURAGE) survey.
*The OR indicate the change in the OR associated with being in that BMI category for high-income countries relative to low-income or middle-income countries adjusting for age, sex, education, marital status, wealth and smoking.
BMI, body mass index.

Table 4 Association between BMI and limitations in activities of daily living adjusting for chronic conditions

	COURAGE survey			SAGE survey					
Characteristics	**Finland**	**Poland**	**Spain**	**China**	**Ghana**	**India**	**Mexico**	**Russia**	**South Africa**
BMI (kg/m^2)									
18.5–24.9 (normal weight)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25.0–29.9 (overweight)	1.08	0.85	0.72	0.92	0.97	0.95	2.46*	1.03	0.53
	(0.44–2.62)	(0.56–1.28)	(0.45–1.16)	(0.57–1.50)	(0.62–1.52)	(0.61–1.48)	(1.08–5.60)	(0.65–1.62)	(0.25–1.11)
30.0–34.9 (obesity class I+)	1.31	1.18	1.01	0.43	1.37	1.75	1.27	1.22	0.85
	(0.32–5.34)	(0.73–1.91)	(0.60–1.68)	(0.18–1.02)	(0.73–2.55)	(0.89–3.43)	(0.58–2.75)	(0.70–2.12)	(0.32–2.30)
≥35.0 (obesity class II)	3.29*	1.54	1.75*	0.81	1.41	1.84	2.33	1.17	1.64
	(1.12–9.69)	(0.87–2.74)	(1.03–2.98)	(0.09–7.67)	(0.74–2.71)	(0.69–4.91)	(0.45–12.05)	(0.55–2.46)	(0.81–3.31)
Chronic conditions									
Angina	2.96**	2.50***	1.84*	0.89	0.96	1.94	0.38	1.01	1.22
	(1.47–5.94)	(1.61–3.89)	(1.08–3.12)	(0.53–1.49)	(0.50–1.85)	(0.87–4.36)	(0.05–2.94)	(0.60–1.72)	(0.44–3.35)
Arthritis	1.64	3.18***	2.78***	1.18	1.53	2.31***	2.45*	2.72**	2.82***
	(0.80–3.34)	(2.29–4.42)	(1.93–4.02)	(0.82–1.70)	(0.87–2.72)	(1.68–3.18)	(1.21–4.96)	(1.48–5.00)	(1.58–5.01)
Diabetes	1.70	1.34	1.78*	1.97*	1.71	0.74	1.74	3.06**	1.38
	(0.89–3.27)	(0.93–1.95)	(1.12–2.81)	(1.09–3.57)	(0.92–3.17)	(0.45–1.22)	(0.87–3.46)	(1.53–6.12)	(0.68–2.77)
Hypertension	1.04	1.56*	1.27	1.28	1.57*	1.68**	1.32	1.20	1.35
	(0.54–2.00)	(1.10–2.23)	(0.89–1.83)	(0.90–1.80)	(1.02–2.40)	(1.21–2.34)	(0.75–2.30)	(0.74–1.94)	(0.74–2.45)
Stroke	4.38**	2.62**	1.07	7.17***	3.13**	3.18**	4.47**	3.03**	2.23
	(1.62–11.79)	(1.29–5.31)	(0.50–2.30)	(4.13–12.42)	(1.55–6.31)	(1.46–6.94)	(1.51–13.21)	(1.39–6.62)	(0.92–5.40)

Data are adjusted OR (95% CIs). Country-wise regression models are adjusted for all covariates in the table in addition to age, sex, education, marital status, wealth, and smoking status.
*p<0.05, **p<0.01, ***p<0.001.
BMI, body mass index; COURAGE, Collaborative Research on Ageing in Europe; SAGE, WHO Study on global AGEing and adult health.

standardised questionnaires and measured BMI across a variety of settings with different medical resources and in different stages of the demographic, epidemiological and nutritional transition. To the best of our knowledge, this is the first multicontinent study to examine the association between BMI and disability.

Several limitations deserve mentioning before discussing the results. BMI was based on measurement but other variables such as ADL were based on self-report and may have been subject to reporting bias. Self-report of ADL, for example, is dependent on the personal perception of disability, and this may vary across cultures and countries. Thus, future studies are warranted to assess whether our results may be replicated using objective measures of strength or performance. The reason for the low prevalence of ADL disability in China is unclear but a recent study using the SAGE data set which assessed the correspondence between self-reported and measured mobility difficulty found that the degree of correspondence of China was relatively low compared to other countries, where those with measured mobility difficulty were less likely to report mobility difficulty.[21] Thus, reporting bias may have been a problem but the clear dose-dependent association between age and ADL disability observed in China demonstrates the robustness of this variable. Also, although self-report of diseases have been shown to demonstrate good agreement with medical records in developed countries,[22] in settings with limited access to medical facilities or screening for diseases, patients may be less aware of their illness or may only have them detected when they are more severe. This may mean that the mediating effect of chronic diseases on the association between BMI and ADL disability may not have been estimated accurately in some settings. Next, information on BMI was missing from 3.1% (India) to 11.9% (Mexico) of the participants. We did not attempt to impute BMI as we had no information about whether these data were missing at random.[23] Those with ADL limitations were more likely to have missing BMI, and this was probably because they were unable to stand by a stadiometer or on a balance. The exclusion of those with limited cognitive function and the institutionalised may also have resulted in the exclusion of those with severe ADL impairment resulting in a potential underestimation of the association between obesity and ADL limitations. In addition, in our study, high-income countries only consisted of European countries. Thus, our findings may not be generalisable to more ethnically and culturally diverse high-income settings such as the USA. Finally, because this was a cross-sectional study, causality cannot be inferred. For example, obesity might have been the result of disability rather than the preceding factor for disability. All these limitations should be taken into account when interpreting the data.

The significantly higher odds for ADL disability among the overweight and/or obese individuals compared to those with normal weight observed in our study accords with the results of a recent meta-analysis including developed country studies and one Latin American study which reported pooled ORs to be 1.04 (95% CI 1.00 to 1.08), 1.16 (95% CI 1.11 to 1.21) and 1.76 (95% CI 1.28 to 2.41) for overweight, class I and class II+ obesity respectively for cross-sectional studies, and which demonstrated a similar slightly stronger dose-dependent associations for longitudinal studies.[18] The significant association observed in South Africa may have been attributable to the exceptionally high proportion of class III obesity (11.6%) as when we excluded individuals with class III obesity from the analysis presented in table 2, the OR for obesity class II compared to normal weight remained significant for the three high-income countries but the OR for South Africa became insignificant. However, additional analysis by dividing the obesity class II+ category into class II and III obesity for South Africa yielded ORs of 1.95 (95% CI 0.85 to 4.46; p=0.114) and 2.45 (95% CI 1.07 to 5.59; p=0.033) for class II and III obesity respectively, demonstrating that obesity class III is associated with higher odds for ADL limitations in this setting. The strong association between obesity class II+ and ADL limitations observed in the three high-income countries compared to other countries might be related to factors such as longer exposure to obesity, and reduction in CVD-related mortality observed in developed countries.[13]

The reason for the particularly weak association observed in China is unclear but the analysis of the China Health and Nutrition Survey revealed a significant positive association between obesity and disability among older adults in 1997 but a non-significant or weaker association in 2006, suggesting that people with obesity have become healthier in more recent years in China.[24] These results contradict the results from one US study, which found a stronger association in more recent cohorts,[11] and this highlights the potential complex interplay of factors that may act to weaken (eg, better primary prevention of obesity-related chronic conditions) or strengthen (eg, reduction in CVD mortality and longer years lived with disability) the association between obesity and disability. These factors may compensate in different ways depending on the level of prevention efforts and availability of medical resources of a setting. We also speculated that the results for China may have been influenced by the fact that conventional BMI categories as the one used in this study may not be a good predictor for future CVD events particularly in Asia,[25] but the use of lower cut-off points such as BMI 18.5–22.9, 23.0–27.4, ≥27.5 kg/m^2 did not alter the association between BMI and disability.

The attenuation of the association between obesity and disability after the inclusion of chronic conditions in the model suggest that this association is mediated by chronic conditions to a certain extent but the fact that some countries still showed a significant association after adjustment may indicate that obesity is a risk factor for disability independent of chronic conditions.

In conclusion, obesity class II+ was associated with higher risks for disability especially in high-income countries. This may be related to factors such as the decline in CVD mortality and the resulting longer life lived with disability in this setting. Our results suggest that primary prevention of obesity may have an important role to prevent disability among older adults especially in countries where the CVD mortality risk has declined. However, confirmation of our results are necessary using data from more culturally and ethnically diverse high-income settings. In addition, studies using better predictors of CVD risk such as percent body fat rather than BMI may be necessary especially in Asian countries. An understanding of the contribution of factors such as longer exposure to obesity or decrease of CVD mortality on disability is also necessary. If the paradoxical consequence of lower CVD mortality is indeed more disability, measures to extend disability-free years would be a priority. If this paradox is more pronounced in developed country settings due to better availability of medical care, developing countries may have to envision this possible future adversity as a consequence of socioeconomic development.

Author affiliations
[1]Research and Development Unit, Parc Sanitari Sant Joan de Déu, Fundació Sant Joan de Déu, Sant Boi de Llobregat, Barcelona, Spain
[2]Instituto de Salud Carlos III, Centro de Investigación Biomédica en Red de Salud Mental, CIBERSAM, Madrid, Spain
[3]Pharmacy Department, Hospital de la Santa Creu i Sant Pau, Institut d'Investigacions Biomédiques Sant Pau (IIB Sant Pau), Sant Antoni Maria Claret 167, 08025 Barcelona, Universitat Autónoma de Barcelona, Bellaterra 08193 (Cerdanyola del Vallés), Spain
[4]Department of Psychiatry, Universidad Autónoma de Madrid, Madrid, Spain
[5]Department of Psychiatry, Hospital Universitario de La Princesa, Instituto de Investigación Sanitaria Princesa (IP), Madrid, Spain
[6]Department of Health Statistics and Information Systems, World Health Organization, Geneva, Switzerland
[7]Department of Neurology, Public Health and Disability Unit, Neurological Institute Carlo Besta IRCCS Foundation, Milan, Italy
[8]National Institute for Health and Welfare, Helsinki, Finland
[9]Department of Epidemiology, Jagiellonian University Medical College, Krakow, Poland

Contributors AK conceived the study idea, analysed and interpreted the data and wrote the main body of the text. MVM and NG assisted in the data analysis and commented for intellectual content. BO, JLA-M, SC, ML, PS, AG, JMH organised and undertook the survey and contributed to drafting the manuscript. All authors were involved in writing the paper and had final approval of the manuscript.

Funding AK's work was supported by the Miguel Servet contract financed by the CP13/00150 project, integrated into the National R+D+I and funded by the ISCIII—General Branch Evaluation and Promotion of Health Research—and the European Regional Development Fund (ERDF-FEDER). BO's work was supported by the Sara Borrell postdoctoral programme (reference no. CD12/00429) from Instituto de Salud Carlos III (Spain). WHO's Study on global AGEing and adult health is supported by the USA National Institute on Aging's Division of Behavioral and Social Research through Interagency Agreements (OGHA 04034785; YA1323-08-CN-0020; Y1-AG-1005-01) and through research grants (R01-AG034479 and R21-AG034263) and the WHO's Department of Health Statistics and Information Systems. The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007–2013) under grant agreement number 223071 (COURAGE in Europe), from the Instituto de Salud Carlos III-FIS research grants number PS09/00295 and PS09/01845 and from the Spanish Ministry of Science and Innovation ACI-Promociona (ACI2009-1010). The study was also supported by the Centro de Investigación Biomédica en Red de Salud Mental (CIBERSAM), Instituto de Salud Carlos III.

Competing interests None.

Ethics approval WHO ethical review committee and local research review boards.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement SAGE data is available on the WHO's webpage (http://www.who.int/healthinfo/sage/en/). Data from the COURAGE will be available soon under a similar system.

REFERENCES

1. Swinburn BA, Sacks G, Hall KD, *et al*. The global obesity pandemic: shaped by global drivers and local environments. *Lancet* 2011;378:804–14.
2. Kelly T, Yang W, Chen CS, *et al*. Global burden of obesity in 2005 and projections to 2030. *Int J Obes (Lond)* 2008;32:1431–7.
3. World Health Organization. *Obesity: preventing and managing the global epidemic*. Report of a WHO consultation. World Health Organization technical report series 2000;894.
4. Manini T. Development of physical disability in older adults. *Curr Aging Sci* 2011;4:184–91.
5. World Health Organization. World Report on Disability, 2011.
6. Anderson WL, Wiener JM, Khatutsky G, *et al*. Obesity and people with disabilities: the implications for health care expenditures. *Obesity (Silver Spring)* 2013;21:E798–804.
7. Gregg EW, Cheng YJ, Cadwell BL, *et al*. Secular trends in cardiovascular disease risk factors according to body mass index in US adults. *JAMA* 2005;293:1868–74.
8. Mehta NK, Chang VW. Secular declines in the association between obesity and mortality in the United States. *Popul Dev Rev* 2011;37:435–51.
9. Gerber Y, Jacobsen SJ, Frye RL, *et al*. Secular trends in deaths from cardiovascular diseases: a 25-year community study. *Circulation* 2006;113:2285–92.
10. Alley DE, Chang VW, Doshi J. The shape of things to come: obesity, aging, and disability. *LDI Issue Brief* 2008;13:1–4.
11. Alley DE, Chang VW. The changing relationship of obesity and disability, 1988–2004. *JAMA* 2007;298:2020–7.
12. Reuser M, Bonneux LG, Willekens FJ. Smoking kills, obesity disables: a multistate approach of the US Health and Retirement Survey. *Obesity (Silver Spring)* 2009;17:783–9.
13. Institute of Medicine (US) Committee on Preventing the Global Epidemic of Cardiovascular Disease: meeting the challenges in developing countries. Epidemiology of cardiovascular disease. In: Fuster V, Kelly BB, eds. *Promoting cardiovascular health in the developing world: a critical challenge to achieve global health*. Washington, DC: National Academies Press (US), 2012:49–124.
14. Brunani A, Capodaglio P, Leonardi M, *et al*. The obesity-related disability. In: Capodaglio P, Faintuch J, Liuzzi A, eds. *Disabling obesity from determinants to health care models*. Berlin Heidelberg: Springer Verlag, 2013:55–76.
15. Kowal P, Chatterji S, Naidoo N, *et al*. Data resource profile: the World Health Organization Study on global AGEing and adult health (SAGE). *Int J Epidemiol* 2012;41:1639–49.
16. Leonardi M, Chatterji S, Koskinen S, *et al*. Determinants of health and disability in ageing population: the COURAGE in Europe project (Collaborative Research on Ageing in Europe). *Clin Psychol Psychother* 2014;21:193–8.
17. Salvador-Carulla L, Gasca VI. Defining disability, functioning, autonomy and dependency in person-centered medicine and integrated care. *Int J Integr Care* 2010;10(Suppl):e025.
18. Backholer K, Wong E, Freak-Poli R, *et al*. Increasing body weight and risk of limitations in activities of daily living: a systematic review and meta-analysis. *Obes Rev* 2012;13:456–68.

19. Al Snih S, Graham JE, Kuo YF, *et al*. Obesity and disability: relation among older adults living in Latin America and the Caribbean. *Am J Epidemiol* 2010;171:1282–8.
20. Katz S, Ford AB, Moskowitz RW, *et al*. Studies of illness in the aged. The index of ADL: a standardized measure of biological and psychosocial function. *JAMA* 1963;185:914–19.
21. Capistrant BD, Glymour MM, Berkman LF. Assessing mobility difficulties for cross-national comparisons: results from the world health organization study on global ageing and adult health. *J Am Geriatr Soc* 2014;62:329–35.
22. Kriegsman DM, Penninx BW, van Eijk JT, *et al*. Self-reports and general practitioner information on the presence of chronic diseases in community dwelling elderly. A study on the accuracy of patients' self-reports and on determinants of inaccuracy. *J Clin Epidemiol* 1996;49:1407–17.
23. Little RJA, Rubin DB. *Statistical analysis with missing data*. New York: Wiley, 1987.
24. Chou KL. The changing relationship between obesity and disability in middle and older adults: 1997 and 2006 China health and nutrition surveys. *J Am Geriatr Soc* 2012;60:2364–5.
25. WHO expert consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* 2004;363:157–63.

Table A1 Frequency distribution of variables of activities of daily living by BMI (body mass index)

(1) In the last 30 days, how much difficulty did you have in bathing/washing your whole body?											
		China					**Finland**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	6,986	460	125	40	23	403	15	7	2	2
	%	91.51	6.03	1.64	0.52	0.3	93.94	3.5	1.63	0.47	0.47
25.0-29.9	n	3,178	172	51	18	7	502	35	11	2	5
	%	92.76	5.02	1.49	0.53	0.2	90.45	6.31	1.98	0.36	0.9
30.0-34.9	n	496	34	10	4	0	230	19	6	3	2
	%	91.18	6.25	1.84	0.74	0	88.46	7.31	2.31	1.15	0.77
≥35.0	n	129	6	3	0	0	92	6	4	2	3
	%	93.48	4.35	2.17	0	0	85.98	5.61	3.74	1.87	2.8
		Ghana					**India**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	1,912	282	111	29	9	2,696	344	94	52	17
	%	81.6	12.04	4.74	1.24	0.38	84.17	10.74	2.93	1.62	0.53
25.0-29.9	n	668	75	38	6	0	610	72	21	13	5
	%	84.88	9.53	4.83	0.76	0	84.6	9.99	2.91	1.8	0.69
30.0-34.9	n	200	27	14	8	1	105	21	5	3	1
	%	80	10.8	5.6	3.2	0.4	77.78	15.56	3.7	2.22	0.74
≥35.0	n	121	12	7	2	0	42	4	2	5	1
	%	85.21	8.45	4.93	1.41	0	77.78	7.41	3.7	9.26	1.85
		Mexico					**Poland**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	400	52	32	13	6	599	75	45	26	5
	%	79.52	10.34	6.36	2.58	1.19	79.87	10	6	3.47	0.67
25.0-29.9	n	659	94	41	13	4	810	97	84	39	8
	%	81.26	11.59	5.06	1.6	0.49	78.03	9.34	8.09	3.76	0.77
30.0-34.9	n	369	52	29	3	2	453	92	56	40	6
	%	81.1	11.43	6.37	0.66	0.44	70.02	14.22	8.66	6.18	0.93
≥35.0	n	144	25	9	9	2	195	33	37	21	7
	%	76.19	13.23	4.76	4.76	1.06	66.55	11.26	12.63	7.17	2.39
		Russia					**South Africa**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	586	124	25	22	5	793	78	32	14	4
	%	76.9	16.27	3.28	2.89	0.66	86.1	8.47	3.47	1.52	0.43
25.0-29.9	n	1,089	215	44	32	12	908	55	27	8	2
	%	78.23	15.45	3.16	2.3	0.86	90.8	5.5	2.7	0.8	0.2
30.0-34.9	n	532	146	26	19	15	672	49	28	6	0
	%	72.09	19.78	3.52	2.57	2.03	89.01	6.49	3.71	0.79	0
≥35.0	n	236	100	28	18	6	639	58	34	8	3
	%	60.82	25.77	7.22	4.64	1.55	86.12	7.82	4.58	1.08	0.4
		Spain									
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme					
18.5-24.9	n	687	33	22	16	3					
	%	90.28	4.34	2.89	2.1	0.39					
25.0-29.9	n	1,331	89	51	20	10					
	%	88.67	5.93	3.4	1.33	0.67					
30.0-34.9	n	691	55	41	18	13					
	%	84.47	6.72	5.01	2.2	1.59					
≥35.0	n	212	38	24	12	11					
	%	71.38	12.79	8.08	4.04	3.7					

(2) In the last 30 days, how much difficulty did you have in getting dressed?											
		China					**Finland**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	7,225	311	68	27	10	402	19	7	0	1
	%	94.56	4.07	0.89	0.35	0.13	93.71	4.43	1.63	0	0.23
25.0-29.9	n	3,248	131	33	9	5	513	25	12	4	1
	%	94.8	3.82	0.96	0.26	0.15	92.43	4.5	2.16	0.72	0.18
30.0-34.9	n	513	23	5	2	0	236	15	7	2	0
	%	94.48	4.24	0.92	0.37	0	90.77	5.77	2.69	0.77	0
≥35.0	n	132	5	2	0	0	88	15	2	1	1
	%	94.96	3.6	1.44	0	0	82.24	14.02	1.87	0.93	0.93
		Ghana					**India**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	1,916	258	146	18	6	2,763	288	99	42	11
	%	81.74	11.01	6.23	0.77	0.26	86.26	8.99	3.09	1.31	0.34
25.0-29.9	n	658	73	49	6	1	633	56	22	7	3
	%	83.61	9.28	6.23	0.76	0.13	87.79	7.77	3.05	0.97	0.42
30.0-34.9	n	205	26	11	6	1	110	16	8	1	0
	%	82.33	10.44	4.42	2.41	0.4	81.48	11.85	5.93	0.74	0
≥35.0	n	125	10	6	1	0	43	4	3	4	0
	%	88.03	7.04	4.23	0.7	0	79.63	7.41	5.56	7.41	0
		Mexico					**Poland**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	392	64	30	11	7	600	74	51	23	2
	%	77.78	12.7	5.95	2.18	1.39	80	9.87	6.8	3.07	0.27
25.0-29.9	n	607	122	62	16	4	802	101	91	37	7
	%	74.85	15.04	7.64	1.97	0.49	77.26	9.73	8.77	3.56	0.67
30.0-34.9	n	340	65	33	14	2	451	83	75	35	3
	%	74.89	14.32	7.27	3.08	0.44	69.71	12.83	11.59	5.41	0.46
≥35.0	n	124	34	21	7	3	188	46	32	22	5
	%	65.61	17.99	11.11	3.7	1.59	64.16	15.7	10.92	7.51	1.71
		Russia					**South Africa**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	644	99	14	7	4	812	63	36	8	1
	%	83.85	12.89	1.82	0.91	0.52	88.26	6.85	3.91	0.87	0.11
25.0-29.9	n	1,184	155	32	23	4	918	49	28	5	1
	%	84.69	11.09	2.29	1.65	0.29	91.71	4.9	2.8	0.5	0.1
30.0-34.9	n	591	121	11	12	5	683	39	29	5	0
	%	79.86	16.35	1.49	1.62	0.68	90.34	5.16	3.84	0.66	0
≥35.0	n	275	92	13	6	2	648	53	31	10	0
	%	70.88	23.71	3.35	1.55	0.52	87.33	7.14	4.18	1.35	0
		Spain									
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme					
18.5-24.9	n	688	36	23	11	3					
	%	90.41	4.73	3.02	1.45	0.39					
25.0-29.9	n	1,312	91	64	26	8					
	%	87.41	6.06	4.26	1.73	0.53					
30.0-34.9	n	660	70	51	24	13					
	%	80.68	8.56	6.23	2.93	1.59					
≥35.0	n	214	31	36	8	8					
	%	72.05	10.44	12.12	2.69	2.69					

(3) In the last 30 days, how much difficulty did you have with moving around inside your home (such as walking across a room)?

		China					Finland				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	7,250	296	61	26	9	397	17	12	1	1
	%	94.87	3.87	0.8	0.34	0.12	92.76	3.97	2.8	0.23	0.23
25.0-29.9	n	3,257	123	29	13	0	510	30	11	4	0
	%	95.18	3.59	0.85	0.38	0	91.89	5.41	1.98	0.72	0
30.0-34.9	n	506	31	4	3	0	228	18	7	6	1
	%	93.01	5.7	0.74	0.55	0	87.69	6.92	2.69	2.31	0.38
≥35.0	n	130	5	3	0	0	78	19	9	0	1
	%	94.2	3.62	2.17	0	0	72.9	17.76	8.41	0	0.93
		Ghana					**India**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	1,873	298	127	30	16	2,438	497	184	62	24
	%	79.91	12.71	5.42	1.28	0.68	76.07	15.51	5.74	1.93	0.75
25.0-29.9	n	629	88	53	10	5	531	135	32	17	6
	%	80.13	11.21	6.75	1.27	0.64	73.65	18.72	4.44	2.36	0.83
30.0-34.9	n	195	29	17	7	3	92	26	13	3	0
	%	77.69	11.55	6.77	2.79	1.2	68.66	19.4	9.7	2.24	0
≥35.0	n	110	17	8	7	0	36	9	5	3	1
	%	77.46	11.97	5.63	4.93	0	66.67	16.67	9.26	5.56	1.85
		Mexico					**Poland**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	354	80	52	13	6	586	74	68	21	1
	%	70.1	15.84	10.3	2.57	1.19	78.13	9.87	9.07	2.8	0.13
25.0-29.9	n	585	134	64	26	1	775	124	97	39	3
	%	72.22	16.54	7.9	3.21	0.12	74.66	11.95	9.34	3.76	0.29
30.0-34.9	n	320	82	39	12	2	452	86	85	22	2
	%	70.33	18.02	8.57	2.64	0.44	69.86	13.29	13.14	3.4	0.31
≥35.0	n	117	39	21	7	5	185	38	44	24	2
	%	61.9	20.63	11.11	3.7	2.65	63.14	12.97	15.02	8.19	0.68
		Russia					**South Africa**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	649	91	15	8	3	765	87	48	18	3
	%	84.73	11.88	1.96	1.04	0.39	83.06	9.45	5.21	1.95	0.33
25.0-29.9	n	1,222	131	20	19	8	850	78	58	10	4
	%	87.29	9.36	1.43	1.36	0.57	85	7.8	5.8	1	0.4
30.0-34.9	n	619	91	12	10	3	629	68	49	8	2
	%	84.22	12.38	1.63	1.36	0.41	83.2	8.99	6.48	1.06	0.26
≥35.0	n	282	77	16	10	3	553	96	76	14	2
	%	72.68	19.85	4.12	2.58	0.77	74.63	12.96	10.26	1.89	0.27
		Spain									
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme					
18.5-24.9	n	670	55	19	14	2					
	%	88.16	7.24	2.5	1.84	0.26					
25.0-29.9	n	1,289	114	69	22	4					
	%	86.05	7.61	4.61	1.47	0.27					
30.0-34.9	n	652	86	57	20	2					
	%	79.8	10.53	6.98	2.45	0.24					
≥35.0	n	200	36	39	14	4					
	%	68.26	12.29	13.31	4.78	1.37					

(4) In the last 30 days, how much difficulty did you have with eating (including cutting up your food)?											
		China					**Finland**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	7,003	421	169	34	8	418	6	4	0	1
	%	91.72	5.51	2.21	0.45	0.1	97.44	1.4	0.93	0	0.23
25.0-29.9	n	3,195	165	50	13	1	538	12	3	2	0
	%	93.31	4.82	1.46	0.38	0.03	96.94	2.16	0.54	0.36	0
30.0-34.9	n	501	32	9	2	0	251	7	1	1	0
	%	92.1	5.88	1.65	0.37	0	96.54	2.69	0.38	0.38	0
≥35.0	n	135	3	1	0	0	97	5	2	3	0
	%	97.12	2.16	0.72	0	0	90.65	4.67	1.87	2.8	0
		Ghana					**India**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	2,015	215	97	16	3	2,539	362	175	85	15
	%	85.89	9.16	4.13	0.68	0.13	79.94	11.4	5.51	2.68	0.47
25.0-29.9	n	676	65	40	6	0	594	66	30	19	7
	%	85.9	8.26	5.08	0.76	0	82.96	9.22	4.19	2.65	0.98
30.0-34.9	n	214	24	10	3	0	107	21	2	3	0
	%	85.26	9.56	3.98	1.2	0	80.45	15.79	1.5	2.26	0
≥35.0	n	130	6	5	1	0	39	6	2	4	1
	%	91.55	4.23	3.52	0.7	0	75	11.54	3.85	7.69	1.92
		Mexico					**Poland**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	412	53	32	5	3	637	59	40	11	3
	%	81.58	10.5	6.34	0.99	0.59	84.93	7.87	5.33	1.47	0.4
25.0-29.9	n	660	96	37	14	4	881	83	56	16	2
	%	81.38	11.84	4.56	1.73	0.49	84.87	8	5.39	1.54	0.19
30.0-34.9	n	372	51	23	9	0	525	75	32	11	4
	%	81.76	11.21	5.05	1.98	0	81.14	11.59	4.95	1.7	0.62
≥35.0	n	147	26	11	4	1	232	35	17	7	2
	%	77.78	13.76	5.82	2.12	0.53	79.18	11.95	5.8	2.39	0.68
		Russia					**South Africa**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	678	66	9	6	3	822	62	28	6	0
	%	88.98	8.66	1.18	0.79	0.39	89.54	6.75	3.05	0.65	0
25.0-29.9	n	1,244	126	9	11	3	908	66	21	5	0
	%	89.3	9.05	0.65	0.79	0.22	90.8	6.6	2.1	0.5	0
30.0-34.9	n	651	66	11	6	0	686	35	24	8	0
	%	88.69	8.99	1.5	0.82	0	91.1	4.65	3.19	1.06	0
≥35.0	n	331	46	6	0	2	656	51	26	8	0
	%	85.97	11.95	1.56	0	0.52	88.53	6.88	3.51	1.08	0
		Spain									
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme					
18.5-24.9	n	730	19	11	1	0					
	%	95.93	2.5	1.45	0.13	0					
25.0-29.9	n	1,417	54	18	7	5					
	%	94.4	3.6	1.2	0.47	0.33					
30.0-34.9	n	767	25	18	4	4					
	%	93.77	3.06	2.2	0.49	0.49					
≥35.0	n	264	22	6	4	1					
	%	88.89	7.41	2.02	1.35	0.34					

(5) In the last 30 days, how much difficulty did you have with getting up from lying down?											
		China					**Finland**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	7,026	458	115	31	14	370	40	12	5	2
	%	91.92	5.99	1.5	0.41	0.18	86.25	9.32	2.8	1.17	0.47
25.0-29.9	n	3,177	183	51	14	2	463	61	19	11	1
	%	92.7	5.34	1.49	0.41	0.06	83.42	10.99	3.42	1.98	0.18
30.0-34.9	n	493	34	12	3	1	198	36	18	7	1
	%	90.79	6.26	2.21	0.55	0.18	76.15	13.85	6.92	2.69	0.38
≥35.0	n	129	6	3	1	0	64	28	9	5	1
	%	92.81	4.32	2.16	0.72	0	59.81	26.17	8.41	4.67	0.93
		Ghana					**India**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	1,507	491	278	65	4	1,958	812	315	113	6
	%	64.26	20.94	11.86	2.77	0.17	61.11	25.34	9.83	3.53	0.19
25.0-29.9	n	511	167	83	24	3	446	173	69	26	7
	%	64.85	21.19	10.53	3.05	0.38	61.86	23.99	9.57	3.61	0.97
30.0-34.9	n	158	47	33	10	0	63	45	17	9	1
	%	63.71	18.95	13.31	4.03	0	46.67	33.33	12.59	6.67	0.74
≥35.0	n	93	25	16	7	1	28	17	5	2	2
	%	65.49	17.61	11.27	4.93	0.7	51.85	31.48	9.26	3.7	3.7
		Mexico					**Poland**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	360	69	59	16	1	472	125	90	55	8
	%	71.29	13.66	11.68	3.17	0.2	62.93	16.67	12	7.33	1.07
25.0-29.9	n	570	138	74	28	1	552	194	176	99	17
	%	70.28	17.02	9.12	3.45	0.12	53.18	18.69	16.96	9.54	1.64
30.0-34.9	n	306	83	51	14	1	290	123	124	99	11
	%	67.25	18.24	11.21	3.08	0.22	44.82	19.01	19.17	15.3	1.7
≥35.0	n	107	44	29	8	1	99	58	66	60	10
	%	56.61	23.28	15.34	4.23	0.53	33.79	19.8	22.53	20.48	3.41
		Russia					**South Africa**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	471	195	60	25	12	651	150	87	31	1
	%	61.73	25.56	7.86	3.28	1.57	70.76	16.3	9.46	3.37	0.11
25.0-29.9	n	842	412	79	56	11	736	133	88	41	3
	%	60.14	29.43	5.64	4	0.79	73.53	13.29	8.79	4.1	0.3
30.0-34.9	n	384	255	58	34	6	536	114	84	20	2
	%	52.1	34.6	7.87	4.61	0.81	70.9	15.08	11.11	2.65	0.26
≥35.0	n	152	141	43	43	8	483	129	81	44	5
	%	39.28	36.43	11.11	11.11	2.07	65.09	17.39	10.92	5.93	0.67
		Spain									
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme					
18.5-24.9	n	583	74	71	30	3					
	%	76.61	9.72	9.33	3.94	0.39					
25.0-29.9	n	1,056	214	144	78	9					
	%	70.35	14.26	9.59	5.2	0.6					
30.0-34.9	n	490	135	122	66	5					
	%	59.9	16.5	14.91	8.07	0.61					
≥35.0	n	135	57	59	40	6					
	%	45.45	19.19	19.87	13.47	2.02					

(6) In the last 30 days, how much difficulty did you have with getting to and using the toilet?											
		China					**Finland**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	7,139	358	92	36	12	421	5	2	0	1
	%	93.48	4.69	1.2	0.47	0.16	98.14	1.17	0.47	0	0.23
25.0-29.9	n	3,217	145	47	13	3	536	16	1	2	0
	%	93.93	4.23	1.37	0.38	0.09	96.58	2.88	0.18	0.36	0
30.0-34.9	n	496	31	12	2	1	249	9	1	1	0
	%	91.51	5.72	2.21	0.37	0.18	95.77	3.46	0.38	0.38	0
≥35.0	n	129	5	3	1	0	100	5	1	0	1
	%	93.48	3.62	2.17	0.72	0	93.46	4.67	0.93	0	0.93
		Ghana					**India**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	1,697	412	184	45	8	2,402	500	185	92	21
	%	72.34	17.56	7.84	1.92	0.34	75.06	15.62	5.78	2.88	0.66
25.0-29.9	n	588	122	58	15	5	544	106	36	27	8
	%	74.62	15.48	7.36	1.9	0.63	75.45	14.7	4.99	3.74	1.11
30.0-34.9	n	183	43	18	6	0	95	20	11	8	1
	%	73.2	17.2	7.2	2.4	0	70.37	14.81	8.15	5.93	0.74
≥35.0	n	111	19	7	3	2	35	11	4	1	3
	%	78.17	13.38	4.93	2.11	1.41	64.81	20.37	7.41	1.85	5.56
		Mexico					**Poland**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	412	58	28	5	2	636	65	36	11	2
	%	81.58	11.49	5.54	0.99	0.4	84.8	8.67	4.8	1.47	0.27
25.0-29.9	n	666	94	43	7	2	872	85	56	20	5
	%	82.02	11.58	5.3	0.86	0.25	84.01	8.19	5.39	1.93	0.48
30.0-34.9	n	374	52	21	5	2	515	70	47	13	2
	%	82.38	11.45	4.63	1.1	0.44	79.6	10.82	7.26	2.01	0.31
≥35.0	n	146	25	14	3	0	221	30	31	8	3
	%	77.66	13.3	7.45	1.6	0	75.43	10.24	10.58	2.73	1.02
		Russia					**South Africa**				
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme	None	Mild	Moderate	Severe	Extreme
18.5-24.9	n	668	72	10	11	1	796	60	42	18	2
	%	87.66	9.45	1.31	1.44	0.13	86.71	6.54	4.58	1.96	0.22
25.0-29.9	n	1,218	138	22	14	5	900	56	30	13	1
	%	87.19	9.88	1.57	1	0.36	90	5.6	3	1.3	0.1
30.0-34.9	n	628	86	8	8	4	665	36	37	10	0
	%	85.56	11.72	1.09	1.09	0.54	88.9	4.81	4.95	1.34	0
≥35.0	n	293	70	14	9	3	611	74	42	11	2
	%	75.32	17.99	3.6	2.31	0.77	82.57	10	5.68	1.49	0.27
		Spain									
BMI (kg/m^2)		None	Mild	Moderate	Severe	Extreme					
18.5-24.9	n	711	31	14	5	0					
	%	93.43	4.07	1.84	0.66	0					
25.0-29.9	n	1,383	72	34	10	2					
	%	92.14	4.8	2.27	0.67	0.13					
30.0-34.9	n	736	47	24	8	3					
	%	89.98	5.75	2.93	0.98	0.37					
≥35.0	n	245	27	20	4	1					
	%	82.49	9.09	6.73	1.35	0.34					

ANALYSIS INCLUDING BMI<18.5 KG/M^2

Table A2a Association of BMI, demographic and lifestyle factors with limitations in activities of daily living (India)

Characteristics	Categories	India
BMI (kg/m^2)	<18.5 (underweight)	1.13
		(0.89-1.44)
	18.5-24.9 (normal weight)	1.00
	25.0-29.9 (overweight)	1.20
		(0.85-1.69)
	30.0-34.9 (obesity class I)	2.14**
		(1.22-3.77)
	≥35.0 (obesity class II+)	1.24
		(0.54-2.89)
Age (years)	50-54	1.00
	55-59	1.42**
		(1.10-1.84)
	60-64	1.89***
		(1.37-2.62)
	65-69	2.78***
		(1.94-3.97)
	70-74	3.14***
		(2.37-4.16)
	≥75	3.83***
		(2.77-5.31)
Sex	Female	1.00
	Male	0.64***
		(0.53-0.79)
Education	≥Tertiary	1.00
	Secondary	2.08**
		(1.23-3.50)
	≤Primary	3.24***
		(1.91-5.48)
Marital status	Married/cohabiting	1.00
	Not married	1.15
		(0.94-1.39)
Wealth	Poorest	0.98
		(0.69-1.39)
	Poorer	0.89
		(0.68-1.16)
	Middle	1.00
	Richer	0.89
		(0.67-1.18)
	Richest	0.71*
		(0.52-0.95)
Smoking	Never smoked	1.00
	Smoker	0.99
		(0.82-1.19)
	Quit	1.50
		(0.96-2.36)

Data are adjusted OR (95% confidence intervals). Model is adjusted for all covariates in the table.
Abbreviations: BMI Body Mass Index.
* p<0.05, ** p<0.01, *** p<0.001

Table A2b Odds ratio for the body mass index and country income level interaction

BMI-country income level interaction	OR (95%CI)*	P-value	BMI-country income level interaction	OR (95%CI)*	P-value
BMI <18.5 kg/m^2 X country income level	1.04 (0.43-2.51)	0.939	BMI <18.5 kg/m^2 X country income level	1.04 (0.43-2.51)	0.938
BMI 18.5-24.9 kg/m^2 (reference)	1.00		BMI 18.5-24.9 kg/m^2 (reference)	1.00	
BMI 25.0-29.9 kg/m^2 X country income level	1.15 (0.8-1.67)	0.453	BMI 25.0-29.9 kg/m^2 X country income level	1.15 (0.79-1.67)	0.457
BMI ≥30.0 kg/m^2 X country income level	1.57 (1.07-2.31)	0.021	BMI 30.0-34.9 kg/m^2 X country income level	1.55 (1.01-2.39)	0.043
			BMI ≥35.0 kg/m^2 X country income level	1.78 (1.01-3.14)	0.046

Abbreviations: BMI Body Mass Index; OR Odds ratio; CI Confidence intervals.

Estimates are based on pooled analysis of all 9 countries.

Country income level was a dichotomous variable with low- or middle-income countries (China, Ghana, India, Mexico, Russia, South Africa) coded as 0 and high-income countries (Finland, Poland, Spain) coded as 1. All countries classified as low- or middle-income countries were from the WHO Study on global AGEing and adult health (SAGE) survey and countries classified as high-income countries were from the Collaborative Research on Ageing in Europe (COURAGE) survey.

*The OR indicate the change in the OR associated with being in that BMI category for high-income countries relative to low- or middle-income countries adjusting for age, sex, education, marital status, wealth, and smoking.

Table A2c Association between BMI and limitations in activities of daily living adjusting for chronic conditions (India)

Characteristics	India
BMI (kg/m^2)	
<18.5 (underweight)	1.07
	(0.82-1.40)
18.5-24.9 (normal weight)	1.00
25.0-29.9 (overweight)	0.95
	(0.61-1.47)
30.0-34.9 (obesity class I)	1.67
	(0.87-3.20)
≥35.0 (obesity class II)	1.70
	(0.64-4.53)
Chronic conditions	
Angina	1.93**
	(1.19-3.12)
Arthritis	1.84***
	(1.41-2.39)
Diabetes	0.93
	(0.61-1.42)
Hypertension	1.66**
	(1.22-2.26)
Stroke	2.99**
	(1.55-5.76)

Abbreviations: BMI Body Mass Index.
Data are adjusted OR (95% confidence intervals). Model is adjusted for all covariates in the table in addition to age, sex, education, marital status, wealth, and smoking status.
* p<0.05, ** p<0.01, *** p<0.001

ANALYSIS BASED ON DEFINITION OF LIMITATIONS IN ACTIVITIES OF DAILY LIVING WHICH INCLUDED MODERATE LEVEL OF LIMITATION

Table A3a Association of BMI, demographic and lifestyle factors with limitations in activities of daily living[#]

		COURAGE survey			SAGE survey					
Characteristics	Categories	Finland	Poland	Spain	China	Ghana	India	Mexico	Russia	S. Africa
BMI (kg/m^2)	18.5-24.9 (normal weight)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	25.0-29.9 (overweight)	1.25	1.31	0.96	1.03	1.07	1.24	1.85	0.91	0.69
		(0.66-2.37)	(0.98-1.75)	(0.69-1.33)	(0.83-1.29)	(0.83-1.39)	(0.89-1.71)	(0.97-3.53)	(0.59-1.39)	(0.47-1.00)
	30.0-34.9 (obesity class I)	1.47	1.63**	1.24	1.02	1.14	2.33**	1.60	1.40	1.15
		(0.72-3.01)	(1.15-2.30)	(0.87-1.77)	(0.69-1.51)	(0.73-1.77)	(1.33-4.09)	(0.83-3.07)	(0.92-2.12)	(0.72-1.85)
	≥35.0 (obesity class II+)	4.15***	2.38***	2.54***	1.67	1.29	1.27	2.48	1.76	1.63*
		(2.19-7.88)	(1.58-3.58)	(1.79-3.61)	(0.54-5.18)	(0.84-1.97)	(0.56-2.91)	(0.76-8.07)	(0.80-3.86)	(1.02-2.61)
Age (years)	50-54	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	55-59	2.12	1.61*	1.53	1.50	1.28	1.44*	1.34	2.22	1.39
		(0.81-5.54)	(1.12-2.32)	(0.87-2.69)	(0.88-2.55)	(0.96-1.72)	(1.04-1.99)	(0.40-4.43)	(0.97-5.11)	(0.83-2.31)
	60-64	1.12	1.93**	1.67*	1.53	1.48*	1.83**	1.16	5.71***	1.61
		(0.38-3.28)	(1.31-2.85)	(1.01-2.77)	(0.92-2.52)	(1.07-2.06)	(1.20-2.77)	(0.37-3.64)	(2.19-14.87)	(0.95-2.73)
	65-69	0.72	2.54***	1.92*	2.36**	2.07***	2.74***	1.30	8.44***	2.16**
		(0.23-2.24)	(1.60-4.02)	(1.00-3.67)	(1.37-4.07)	(1.46-2.94)	(1.78-4.22)	(0.42-4.00)	(3.62-19.69)	(1.31-3.58)
	70-74	1.88	3.83***	2.77**	2.67***	2.46***	2.44***	1.79	12.23***	2.31**
		(0.60-5.92)	(2.41-6.08)	(1.50-5.10)	(1.54-4.62)	(1.72-3.52)	(1.65-3.63)	(0.51-6.31)	(5.21-28.69)	(1.28-4.16)
	≥75	2.77	5.02***	4.54***	6.48***	3.96***	3.98***	4.28*	32.13***	4.19***
		(0.94-8.14)	(3.46-7.29)	(2.65-7.77)	(3.78-11.11)	(2.80-5.60)	(2.73-5.78)	(1.26-14.55)	(13.96-73.97)	(2.55-6.88)
Sex	Female	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Male	1.00	0.78	0.49***	0.97	0.86	0.70*	1.12	0.60	0.98
		(0.61-1.62)	(0.60-1.02)	(0.36-0.67)	(0.79-1.19)	(0.67-1.12)	(0.53-0.94)	(0.47-2.68)	(0.29-1.24)	(0.68-1.40)
Education	≥Tertiary	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Secondary	1.37	1.24	2.33*	1.69	1.04	2.50**	0.32	1.53	1.81
		(0.87-2.14)	(0.85-1.82)	(1.05-5.20)	(0.93-3.09)	(0.60-1.79)	(1.39-4.49)	(0.07-1.39)	(0.87-2.69)	(0.73-4.49)
	≤Primary	2.00**	2.02***	3.35***	2.55**	1.14	3.82***	0.72	2.16*	2.28
		(1.20-3.32)	(1.35-3.03)	(1.69-6.64)	(1.42-4.60)	(0.64-2.04)	(2.13-6.84)	(0.21-2.48)	(1.11-4.20)	(0.97-5.37)
Marital status	Married/cohabiting	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Not married	0.69	0.91	0.91	1.04	1.12	1.18	0.80	1.02	1.41
		(0.38-1.27)	(0.70-1.17)	(0.73-1.13)	(0.82-1.31)	(0.87-1.43)	(0.92-1.52)	(0.48-1.33)	(0.59-1.78)	(0.96-2.07)
Wealth	Poorest	3.29**	1.84***	1.76*	1.35	0.50***	0.91	3.57***	1.26	2.04**
		(1.50-7.24)	(1.29-2.62)	(1.13-2.73)	(0.99-1.85)	(0.35-0.69)	(0.60-1.38)	(1.85-6.89)	(0.64-2.47)	(1.26-3.31)
	Poorer	1.80	1.16	1.60**	1.19	0.64**	0.76	2.60	1.18	1.96**

		(0.83-3.91)	(0.81-1.66)	(1.13-2.27)	(0.92-1.54)	(0.46-0.88)	(0.51-1.12)	(0.96-7.06)	(0.66-2.11)	(1.27-3.04)
	Middle	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Richer	0.98	0.83	0.92	0.70*	0.65**	0.74	1.57	0.60	1.54
		(0.46-2.12)	(0.57-1.21)	(0.61-1.39)	(0.51-0.95)	(0.47-0.89)	(0.53-1.03)	(0.79-3.13)	(0.35-1.03)	(0.96-2.49)
	Richest	0.41	0.89	1.07	0.42***	0.58**	0.55**	1.40	0.64	1.26
		(0.15-1.12)	(0.54-1.48)	(0.59-1.95)	(0.30-0.60)	(0.41-0.84)	(0.38-0.79)	(0.59-3.32)	(0.32-1.28)	(0.76-2.09)
Smoking	Never smoked	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Smoker	1.32	1.01	1.08	1.05	0.99	0.94	0.80	1.14	1.04
		(0.60-2.91)	(0.72-1.42)	(0.69-1.67)	(0.81-1.36)	(0.71-1.40)	(0.74-1.20)	(0.32-2.02)	(0.64-2.04)	(0.75-1.46)
	Quit	1.25	1.07	1.08	1.32	1.11	1.44	1.06	1.83	1.14
		(0.79-1.96)	(0.78-1.46)	(0.72-1.62)	(0.87-1.99)	(0.81-1.51)	(0.77-2.72)	(0.42-2.66)	(0.84-3.98)	(0.67-1.94)

Data are adjusted OR (95% confidence intervals). Country-wise regression models are adjusted for all covariates in the table.
Abbreviations: COURAGE Collaborative Research on Ageing in Europe; SAGE WHO Study on global AGEing and adult health; S. Africa South Africa; BMI Body Mass Index.
[#] ADL disability was assessed by six standard basic ADL questions on difficulties in the last 30 days with washing whole body, getting dressed, moving inside home, eating (including cutting food), getting up from lying down, and getting to and using the toilet. The answer options to these six questions were none, mild, moderate, severe, and extreme/cannot do. ADL disability was a dichotomous variable where those who answered moderate, severe or extreme/cannot do to any of the six questions were considered to have limitations in ADL.
* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table A3b Odds ratio for the body mass index and country income level interaction

BMI-country income level interaction	OR (95%CI)*	P-value	BMI-country income level interaction	OR (95%CI)*	P-value
BMI 18.5-24.9 kg/m^2 (reference)	1.00		BMI 18.5-24.9 kg/m^2 (reference)	1.00	
BMI 25.0-29.9 kg/m^2 X country income level	1.38 (1.05-1.80)	0.020	BMI 25.0-29.9 kg/m^2 X country income level	1.37 (1.05-1.80)	0.020
BMI $\geq$30.0 kg/m^2 X country income level	1.42 (1.05-1.92)	0.024	BMI 30.0-34.9 kg/m^2 X country income level	1.40 (1.00-1.96)	0.051
			BMI $\geq$35.0 kg/m^2 X country income level	1.61 (1.02-2.54)	0.043

Abbreviations: BMI Body Mass Index; OR Odds ratio; CI Confidence intervals.

Estimates are based on pooled analysis of all 9 countries.

Country income level was a dichotomous variable with low- or middle-income countries (China, Ghana, India, Mexico, Russia, South Africa) coded as 0 and high-income countries (Finland, Poland, Spain) coded as 1. All countries classified as low- or middle-income countries were from the WHO Study on global AGEing and adult health (SAGE) survey and countries classified as high-income countries were from the Collaborative Research on Ageing in Europe (COURAGE) survey.

*The OR indicate the change in the OR associated with being in that BMI category for high-income countries relative to low- or middle-income countries adjusting for age, sex, education, marital status, wealth, and smoking.

Table A3c Association between BMI and limitations in activities of daily living adjusting for chronic conditions[#]

	COURAGE survey			SAGE survey					
Characteristics	Finland	Poland	Spain	China	Ghana	India	Mexico	Russia	S. Africa
BMI (kg/m^2)									
18.5-24.9 (normal weight)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25.0-29.9 (overweight)	1.14	1.13	0.82	0.97	1.01	1.13	1.96*	0.86	0.62*
	(0.59-2.17)	(0.83-1.53)	(0.59-1.14)	(0.77-1.22)	(0.78-1.32)	(0.82-1.55)	(1.05-3.66)	(0.57-1.30)	(0.42-0.92)
30.0-34.9 (obesity class I)	1.12	1.20	0.98	0.93	1.05	2.17**	1.64	1.21	0.89
	(0.51-2.48)	(0.83-1.73)	(0.67-1.45)	(0.60-1.44)	(0.67-1.64)	(1.21-3.87)	(0.94-2.88)	(0.77-1.90)	(0.55-1.42)
≥35.0 (obesity class II)	2.94**	1.65*	1.70*	1.60	1.15	1.40	2.74	1.47	1.16
	(1.44-6.00)	(1.04-2.61)	(1.13-2.54)	(0.49-5.25)	(0.74-1.78)	(0.64-3.06)	(0.86-8.66)	(0.76-2.84)	(0.72-1.88)
Chronic conditions									
Angina	1.35	1.89**	1.98**	1.30	1.19	1.74*	2.70	1.07	2.22**
	(0.83-2.18)	(1.28-2.80)	(1.18-3.31)	(0.96-1.77)	(0.71-1.98)	(1.01-3.02)	(0.35-20.96)	(0.68-1.68)	(1.30-3.80)
Arthritis	2.96***	2.56***	3.57***	1.53***	1.52*	2.18***	2.09*	2.35***	3.11***
	(1.88-4.68)	(1.94-3.36)	(2.83-4.52)	(1.23-1.91)	(1.05-2.19)	(1.62-2.93)	(1.04-4.21)	(1.58-3.49)	(2.14-4.52)
Diabetes	1.67	1.34	1.54*	1.22	1.53	1.09	1.18	1.77	0.99
	(0.99-2.81)	(0.94-1.90)	(1.09-2.17)	(0.88-1.69)	(0.99-2.36)	(0.74-1.60)	(0.71-1.99)	(0.96-3.25)	(0.63-1.55)
Hypertension	1.10	1.15	1.51**	0.96	1.35*	1.22	0.84	0.98	1.58*
	(0.72-1.68)	(0.87-1.50)	(1.11-2.05)	(0.75-1.21)	(1.04-1.73)	(0.93-1.61)	(0.53-1.33)	(0.66-1.48)	(1.10-2.28)
Stroke	2.00	2.10*	2.42*	4.85***	2.15**	2.53**	1.60	1.88*	2.93**
	(0.85-4.74)	(1.16-3.80)	(1.21-4.84)	(3.46-6.79)	(1.25-3.68)	(1.28-5.01)	(0.58-4.40)	(1.13-3.14)	(1.45-5.93)

Abbreviations: COURAGE Collaborative Research on Ageing in Europe; SAGE WHO Study on global AGEing and adult health; S. Africa South Africa; BMI Body Mass Index.

[#] ADL disability was assessed by six standard basic ADL questions on difficulties in the last 30 days with washing whole body, getting dressed, moving inside home, eating (including cutting food), getting up from lying down, and getting to and using the toilet. The answer options to these six questions were none, mild, moderate, severe, and extreme/cannot do. ADL disability was a dichotomous variable where those who answered moderate, severe or extreme/cannot do to any of the six questions were considered to have limitations in ADL. Data are adjusted OR (95% confidence intervals). Country-wise regression models are adjusted for all covariates in the table in addition to age, sex, education, marital status, wealth, and smoking status.

* $p<0.05$, ** $p<0.01$, *** $p<0.001$