The Long Arm of Childhood: A study of life course trajectories of cognitive function in six low and middle-income countries

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Abstract

Attaining healthy ageing is a crucial public policy goal across the globe. Better cognitive function in old age is a protective factor for health and overall wellbeing. In this study, we examine the impact of life course socioeconomic status, height on cognitive function in later life. Cross-country analysis was conducted using the WHO's Study on global AGEing and adult health (SAGE) data for six countries. Regression models were estimated to predict the association. Further, Relative Index of Inequality (RII) was used to assess the inequality in cognition across subgroups. Results showed considerable variations in cognitive abilities across countries. Cognitive function showed a strong association with education and wealth quintile and further showed robust association with parental education and employment. Taller individuals scored well in cognitive tests; this association was significant independent of socioeconomic status and grip strength. RII in cognitive ability is evident across life course SES characteristics and height.

Background

Globally, rising share of the older population and ageing associated physical and cognitive decline are a significant cause of concern for policymakers and the growing older population. Along with the change in physical strength such as grip strength and walking speed, the decline in cognitive ability is a marker of ageing and a significant contributor to overall health and vitality. In emerging literature, cognitive function is recognized as a key indicator under the domain of cognitive wellbeing; one of the five functional domains of Intrinsic Capacity as part of the WHO framework of health ageing metrics (de Carvalho et al., 2017). WHO defines Intrinsic Capacity (IC) as "the measure of all the physical and mental capacities that an individual can draw on at any point in time" (WHO 2015). Lower cognitive ability is linked with higher risk of all-cause of mortality (Gottfredson and Deary, 2004; Batty, Deary and Zaninotto, 2016). On the other hand, better cognitive ability is linked with better physical and

mental health outcomes (Jokela et al., 2010; Shimada et al., 2016; Ahmed, Kesavayuth and Zikos, 2018) and avoiding risky health behaviours (Batty et al., 2007).

The cognitive ability of an individual is determined by several factors over a period of time starting from childhood. The role of early life circumstances plays important role in determining the cognitive ability of the individual through several pathways. The early life factors affect the health of the individual at different times; an individual who experiences adverse childhood conditions have poor socioeconomic status and poor health throughout life (Conroy, Sandel, and Zuckerman, 2010; Johnson and Schoen, 2011; McEniry, 2013). The fatal hypothesis proposed by Barker (1995) is one of the landmark theory in suggesting the early life contribution on health. Also, Birth weight as one of the nutritional indicators that has an impact on child growth and health; children born with low weight tend to have poor cognitive ability and poor educational achievement in life cycle (Richards et al., 2001; Richards et al., 2002) and poor health in later years (Johnson and Schoeni, 2011).

Further, another independent measure of childhood nutrition and health is adult height. The height of the individual is determined by both genetics and net nutrition in early childhood. At the individual level, stature/height is used as a proxy measure of childhood environment and health in the life cycle, this hypothesis is supported by several studies (Bozzoli et al., 2009). Many possible factors are responsible for variation in height across countries and population are genetics, socioeconomic status, maternal height and health, childhood nutritional status and childhood diseases environment (Fogel and Costa, 1997; Silventoinen, 2003; Subramanian, Ozaltin and Finlay, 2011; 8 Perkins et al., 2011). Genetic factors contribute to around 80 percent in height attainment, the other factors such as childhood nutrition and disease environment contribute about 20 percent of variations in height (Silventoinen, 2003). Being tall, reflect in many ways on the individual outcome, on average taller people have a more economic advantage than short people; tall people earn more than their counterparts (Case, Paxson, 2006), mainly income height hypothesis operate through cognitive abilities (Case and Paxson, 2008) also, taller older adults have a higher cognitive function than the counterparts (Guven and Lee, 2011). Height is also associated with happiness and overall quality of life (Deaton and Arora, 2009; Sohn, 2016). Further, height is associated with better and longevity (Fujiwara et al., 2013; McGovern, 2014; Peck and Vågerö, 1989; Silventoinen, Lahelma and Rahkonen, 1999; Ihira et al., 2018)

Studies show that the effect of early life circumstances on health and wellbeing is larger in low and middle-income countries as childhood shocks are larger. Yet, very little evidence has been available in developing countries to understand the role of life course socioeconomic status and height in later life cognition. In this study, we examine the role of early life circumstances (childhood socioeconomic status, nutrition and health as measured as height) adult socioeconomic status (schooling, employment and wealth quintile) on cognitive function in six low and middle-income countries.

Methods

Data

WHO Study on global AGEing and adult health (SAGE)

We used data from the WHO's SAGE survey. SAGE is a nationally representative household health survey conducted in six low and middle income countries: China, Ghana, India, Mexico, the Russian Federation and South Africa during 2007-10. SAGE data was collected by the World Health Organisation with support from national and international organisations. The aim of the SAGE was to fulfil the data gaps and understand the health and wellbeing of the growing ageing population in six low and middle income countries. SAGE measures are comparable with other studies from high-income countries such as the Health and Retirement Study (HRS), the Survey of Health, Ageing and Retirement in Europe (SHARE). SAGE collected data on self-reported as well as biomarkers on different domains of health, wellbeing and anthropometric indicators. This analysis was carried out on the 30155 sample of older adults aged 50 years and above for the six countries. More detailed information on sampling, methodology and data are provided in Kowal et al. (2012).

Cognitive functioning

To understand the composite effect of cognition we made a cognitive index combining four variables: verbal fluency, verbal recall, digit span forward and digit span backward.

Different cognition tests and procedure used in the survey are;

Verbal recall: Interviewer read out a list of 10 commonly used words to the respondents and asked them to repeat again in some time.

Digit span (forward and backward): Participants were read a series of digits and asked to immediately repeat them back. In the backward test, the person must repeat

the numbers in reverse order. These tests measure concentration, attention, and immediate memory.

Verbal fluency: Participants were asked to produce as many animal names as possible in one-minute time span. This test assessed retrieval of information from semantic memory.

The composite index was derived using Principal Components Analysis (PCA), a mathematical tool which helps in creating a composite index using uncorrelated components, where each component captures the largest possible variation in the original variables. Selected raw scores for cognitive tasks were bundled into three domains (digit span, memory and executive functioning) to yield compound cognitive scores. This was done to condense the number of cognitive variables while refining the robustness of the underlying cognitive construct. We followed two steps to make a cognitive index:

Step 1: All four variables were in different scales. So first, we standardized these variables. A standardized variable (sometimes called a z-score or a standard score) is a variable that has been rescaled to have a mean of zero and a standard deviation of one. Each case's value on the standardized variable designates its difference from the mean of the primary variable in some standard deviations (of the original variable).

Step 2: PCA is a multivariate statistical technique used for extracting from a set of variables those few orthogonal linear combinations that capture the common information most successfully. Further, this index comprises both values, positive and negative. So we converted this index into a 0–100 scale which facilitates easier interpretation of the data. Higher scores indicate better cognitive abilities.

Measures of life course socioeconomic status

Parental education

SAGE measures the level of parental education separately for mother and father. The answers were captured in seven categories from no formal education to post-graduation. For the purpose of analysis, we have categorized the parental education into four categories: 1) no formal education, 2) less than primary, 3) primary and secondary school and 4) high school and above.

Parental employment

Parental employment was categorised into four categories 1.Not employed, 2.Self-employed/informal sector, 3. Private sector, 4. Public sector.

Measures of socioeconomic status.

In this study years of schooling and wealth quintile have been included as the markers of socioeconomic status. Schooling (years) was categorized as '0-5 years', '5–9 years', '10+ years'.

A composite wealth index was generated based on household ownership of assets. Principal component analysis was used to create the composite index and categorized as first (lowest), second, third, fourth and fifth (highest) with cut-off points of 20% quintile each.

Own employment

Employment status of the study participants was categorised into four categories 1.Not employed, 2.Self-employed/informal sector, 3. Private sector, 4. Public sector.

Height

Height has been used as a proxy measure of childhood health and nutrition. In the SAGE survey, height was measured in centimeters using a stadiometer by trained investigators. In the analysis, sex and country-specific height quintile was generated to examine the association between height and quality of life.

Multi-morbidity

Multi-morbidity is defined as the presence of one or more chronic condition at the time of data collection. In this analysis, we have included eight chronic health conditions, namely: arthritis, stroke, angina pectoris, diabetes mellitus, asthma, hypertension, chronic lung disease and visual acuity. Among these, for arthritis, angina pectoris, asthma, lung disease, SAGE survey provides two types of measures: First, self-reports of the diagnosis of individual diseases and second is the symptom based assessment or direct health examination of abovementioned diseases. The specific question asked in SAGE for self-reports is: "Have you ever been diagnosed with/told that you have disease name? Thus, we have considered an individual as suffering from these diseases if he/she is found positive in the symptom based assessment. For, stroke and diabetes mellitus we have relied on the self-reports of diagnosis and for hypertension and visual acuity, we have used measured outcomes of blood pressure monitor and vision test. Further, we generated a multi-morbidity variable by combining 8 diseases.

Grip strength measurement

In SAGE survey, handgrip strength was assessed in both the hands using a Smedley Hand Dynamometer (Scandidact Aps, Denmark). In total, four measurements were taken in sitting position. In the analysis, we have considered the best of four measurements.

Confounders

The covariates included are age (50-59, 60-69 and 70+), place of residence (urban/rural), marital status (currently married/otherwise).

Table 1 Descriptive statistics of the Study Population in Six Countries, WHO-SAGE Wave 1

Characteristics	India (n=6,283)	China (n=12,084)	Ghana (n=3,977)	Mexico (n=1,933)	Russia (n=2,954)	South Africa (n= 2,924)
Mean age	61.3	62.3	63.9	62.4	63.1	61.7
% Female	48.9	50.2	46.9	53.0	60.1	55.2
% Urban	28.3	45.5	41.2	79.6	71.6	65.0
% Currently married	77.4	85.5	60.0	72.6	59.4	54.8
10+ years schooling	16.5	15.0	29.8	10.5	75.7	21.6
Highest wealth quintile	24.0	20.4	21.4	26.7	26.9	21.3
Mean height	156.9	159.2	162.0	156.6	164.5	158.5
Mean grip strength	23.4	28.2	29.2	26.1	32.8	32.6
Mean cognition	38.2	50.9	44.0	43.6	53.2	45.0
% 3+ chronic diseases	19.1	15.6	12.2	18.3	35.1	21.9
Total sample %	20.8	40.1	13.2	6.4	9.8	9.7

Statistical Analysis

First, cross-country variations in cognitive ability were assessed. We used four different models to understand the cross-country variations in cognitive ability. Further, we assessed the association of life course socioeconomic status and height (quintile) and cognitive ability using multivariate linear regression methods. The association between height and cognition was assessed using four different models to better understand the effect of height on cognitive ability.

Relative Index of Inequality (RII)

To better understand the inequality in cognitive ability by selected life course SES characteristics and height. We used the Relative Index of Inequality (RII). We obtained the relative index of inequality by dividing the mean outcome (i.e., the relative difference between the top and bottom of the life course SES characteristics and height quintile). This technique

takes account of the population distribution across SEP categories, enabling comparison across outcomes.

Table 2 Cross-national differences in cognitive function for men and women, WHO-SAGE Wave 1

	Model 1: Age adjusted	Model 2: Age + marital status and residence adjusted	Model 3: Age + marital status and residence +SES adjusted	Model 4: Age + marital status and residence +SES +height, grip strength and multi-morbidity adjusted
Men				
	β [95% CI]	β [95% CI]	β [95% CI]	β [95% CI]
India®				
China	11.7***(11.2,12.2)	10.7***(10.2, 11.2)	11.4***(11.02,11.92)	11.4***(10.9,11.85)
Ghana	5.44***(4.83,6.05)	4.91***(4.32,5.51)	4.72***(4.16,5.27)	4.58***(4.03,5.14)
Mexico	2.69***(1.83,3.55)	0.78*(-.07,1.64)	3.21***(2.40,4.02)	3.23***(2.42,4.05)
Russia	10.2(9.44, 10.9)	8.32***(7.54,9.09)	5.48***(4.73,6.22)	6.03***(5.28,6.78)
South Africa	4.84***(4.12, 5.56)	3.24***(2.52, 3.97)	4.24***(3.50,4.97)	4.21***(3.49,4.94)
Adjusted R^2	0.2126	0.2503	0.362	0.3767
Sample size	13845	13845	13362	13202
Women				
India®				
China	15.46***(14.98, 15.9)	13.7***(13.3,14.2)	13.16***(12.71,13.6)	13.2***(12.8,13.7)
Ghana	7.26***(6.62, 7.90)	6.95***(6.32, 7.58)	6.01***(5.42,6.59)	5.79***(5.2,6.37)
Mexico	8.32***(7.57,9.06)	5.95***(5.21,6.68)	6.40***(5.70,7.10)	6.47***(5.77,7.17)
Russia	17.06***(16.4,17.7)	14.63***(13.9,15.2)	9.25***(8.57,9.93)	9.77***(9.08,10.4)
South Africa	8.26***(7.60,8.92)	6.67***(6.02, 7.33)	5.21***(4.57,5.86)	5.33***(4.69,5.97)
Adjusted R^2	0.2977	0.3435	0.44	0.4553
Sample size	15630	15630	15234	15027

Results

Study participants

Table 1 shows descriptive statistics of the study population. Of the total sample of 30155 older adults in all six countries, China has proportionately a higher sample size of 40 percent. The mean age of older adults in Ghana was higher (63.9 years) and was lower in India (61.3 years). In Mexico, Russia and South Africa, the share of older women participants are much higher than older men. The distribution of sample by place of residence showed more than half of sample from urban areas in Mexico, Russia and South Africa. The mean grip strength was higher in Russia, whereas older adults in India had lower grip strength and cognition score. The prevalence of 3+ chronic diseases was higher in Russia.

Cross-country variation in cognitive ability is notable **(table 2).** Older men and women in India had lower cognitive ability than the counterparts in other countries.

Results further showed that childhood characteristics such as parental education were significantly associated with late-life cognition **(Table 3)**. Own education and household economic status are emerged as a strong predictor of cognitive ability across countries. Further, height is strongly associated with cognition independent of socioeconomic status and grip strength.

Taller individuals performed well in cognitive tests than the shorter counterparts **(table 4).** The results are consistent across different models in China, Ghana and Mexico. In India, the inclusion of grip strength modifies the results significantly, suggesting the role of physical strength in determining cognitive ability.

Results from the Relative Index of Inequality suggest significant inequality in cognitive ability across different measures of socioeconomic status (**Table 5**). Own education is an important factor in determining inequality in cognitive ability across six countries. Further, the level of inequality is higher in relation to wealth quintile and parental education. Further, inequality in cognitive ability related to height is notable across countries except Mexico.

Conclusion

Based on the preliminary analysis. The results suggest that childhood circumstances play important role in determining later-life cognition independent of adult socioeconomic status, demographic, and measures of multi-morbidity and grip strength. In particular, own education and parental education played significant role in determining later-life cognition. Height plays important role in determining cognitive ability, suggesting the role of childhood net nutrition and health. The results also suggest that considerable inequality in cognitive function across the life course SES measures and height. In specific, own education, economic status, parental education and height determined inequality in cognitive ability.

The SAGE wave 2 data is expected to available soon in the public domain. The result based on SAGE wave 2 data (Longitudinal) will be updated.

Table 3. Life course factors affecting cognitive ability in six LMICs, WHO-SAGE

Characteristics	India	China	Ghana	Mexico	Russia	South Africa
	β [95% CI]	β [95% CI]	β [95% CI]	β [95% CI]	β [95% CI]	β [95% CI]
Own education						
0-5 years ®						
6-9 years	4.57***(3.88,5.26)	3.73***(3.25,4.21)	3.93***(2.80,5.06)	4.18***(3.06, 5.29)	1.88*(-.07,3.84)	4.74***(3.51,5.98)
10+	7.26***(6.49,8.02)	6.06***(5.38,6.74)	7.29***(6.47,8.10)	6.84***(5.03,8.66)	6.17***(4.23,8.10)	7.83***(6.13,9.54)
Own employment						
Not employed ®						
self/informal	0.72**(.09,1.35)	0.45(-0.25,1.16)	-1.69(-4.43,1.03)	1.25**(.12,2.38)	0.45(-5.04, 5.95)	5.07***(3.42, 6.71]
Private	0.83 (-.16,1.83)	3.53***(2.64,4.43)	-1.05(-4.18,2.07)	0.67(-.77,2.11)	3.09(-2.09,8.28)	4.47***(2.90,6.03)
Public	1.57***(.59, 2.55)	3.50***(2.71,4.28)	0.75(-2.13, 3.64)	0.56(-1.26,2.39)	2.85(-2.16,7.87)	4.33***(2.38, 6.28)
Wealth Quintile						
Lowest ®						
2	1.17***(.45,1.89)	1.34***(.74,1.93)	0.58(-0.36,1.54)	1.84**(.43,3.24)	0.76 (-.65,2.19)	-1.34*(-2.82,.14)
3	1.88***(1.16,2.61)	2.1***(1.48,2.71)	0.33 (-0.62,1.29)	2.14***(.64,3.64)	2.50***(1.08,3.92)	0.01(-1.51,1.54)
4	2.91***(2.19,3.64)	4.08***(3.46,4.71)	2.32***(1.33,3.31)	3.40***(1.93,4.86)	2.76***(1.32,4.19)	1.46*(-.13,3.07)
Highest	4.05***(3.29,4.81)	5.47***(4.80,6.14)	3.15***(2.06,4.24)	5.86***(4.33,7.40)	3.49***(2.05,4.93)	3.43***(1.64,5.22)
Mothers education						
No schooling®						
Less than primary	1.16**(.21,2.12)	1.12**(.26,1.99)	1.26(-.63,3.16)	-.93(-2.21,.34)	-1.41*(-2.99,.16)	1.05(-.55,2.66)
Completed primary and secondary	1.78***(.59,2.97)	-.02(-1.02, .97)	2.35*(-.40,5.11)	[-0.02(-1.98,1.93)	0.22(-1.24,1.68)	2.99***(1.14,4.84)
High school and above	4.34***(1.73,6.96)	0.84(-.91, 2.61)	-0.84(-3.88, 2.18)	1.33(-3.02,5.69)	2.28**(.50,4.06)	6.05***(2.37, 9.73)
Fathers education						
No schooling®						
Less than primary	1.46***(.81,2.11)	1.51***(.90,2.12)	0.45(-1.12, 2.03)	2.16***(.97,3.35)	1.15(-.71,3.01)	0.42(-1.14,1.99)
Completed primary and secondary	1.72***(1.01,2.43)	1.46***(.78, 2.14)	0.56(-1.04,2.17)	2.37***(.59,4.15)	1.28(-.52,3.08)	1.05(-.60,2.72)
High school and above	2.97***(1.72,4.21)	4.35***(3.19,5.51)	1.37*(-.15,2.91)	2.76*(-.20,5.74)	3.26***(1.24,5.28)	-0.31(-3.38,2.76)
Mothers employment						

Not employed ®						
Self/informal	0.59**(.08,1.10)	0.19(-.58,.97)	-3.04***(-4.63,-1.44)	-0.29(-1.38,.78)	-0.42(-4.13,3.28)	-3.06***(-4.36,-1.75)
Private	-0.35(-1.92, 1.20)	1.05(-.60, 2.71)	-6.21***(-10.5, -1.85)	0.37(-2.42,3.16)	2.83(-2.25,7.92)	-0.89(-2.32,.54)
Public	-3.73***(-6.90,-.55)	1.11**(.25,1.97)	-0.10(-3.70,3.49)	0.36(-4.95,5.67)	0.76(-.53,2.06)	-1.53(-4.40,1.33)
Fathers employment						
Not employed ®						
Self/informal	2.82***(1.61,4.03)	0.14(-.65,.95)	3.60***(1.58, 5.62)	-0.14(-1.24,.95)	-3.85*(-8.03,.32)	0.37(-1.28,2.03)
Private	2.99***(1.51,4.48)	-.30(-1.59,.98)	5.86***(2.69,9.04)	0.72(-.91,2.36)	-8.95***(-13.9,-3.98)	1.60**(.03,3.17)
Public	3.48***(2.01,4.95)	0.28(-.49,1.06)	4.62***(2.24,7.00)	0.66(-1.25,2.59)	-4.87***(-7.9,-1.78)	[-.84(-2.87,1.19)
Height quintile						
Q1 (Shortest)®						
Q2	0.23(-.44,.91)	1.22***(.62,1.82)	0.19(-.73,1.13)	1.00(-.45,2.46)	-1.27*(-2.58,.03)	-.13(-1.66,1.38)
Q3	0.59*(-.07, 1.26)	1.72***(1.11, 2.32)	1.09**(.14, 2.04)	2.17***(.69,3.65)	-2.17***(-3.54, -.79)	2.03**(.47,3.60)
Q4	0.65*(-.02, 1.33)	1.87***(1.24,2.50)	1.28***(.34, 2.23)	1.44*(-.07,2.97)	-0.54(-1.89,.80)	1.08 (-.49,2.65)
Q5 (Tallest)	1.14***(.45,1.83)	2.37***(1.71,3.03)	0.974**(.008, 1.94)	2.00**(.45, 3.55)	-0.83(-2.22,.55)	1.90**(.30,3.49)
Adjusted R2	0.3835	0.3237	0.3514	0.301	0.322	0.3428
Sample size	5673	10913	3556	1352	2264	1669

The results are adjusted for age, sex, marital status and place of residence, chronic diseases and grip strength

CI: Confidence Interval

*p< 0.05 ** p< 0.01 *** p< 0.001

Table 4 Multivariable regression models of height and cognitive function, adjusting sociodemographic and health variables in six low and middle-income countries

	HQ 2 (Ref=HQ1)	HQ 3 (Ref=HQ1)	HQ 4 (Ref=HQ1)	HQ 5 (Ref=HQ1)		
	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]	Adj R^2	n
India						
Model 1	1.09***(.36,1.83)	1.84***(1.12,2.56)	2.46***(1.72, 3.20)	3.61***(2.88,4.34)	0.2055	6057
Model 2	0.71**(.04,1.37)	1.20***(.54,1.86)	1.46***(.79,2.14)	2.13***(1.46,2.81)	0.3534	6005
Model 3	0.69**(.02,1.36)	1.18***(.53, 1.84)	1.44***(.77,2.12)	2.09***(1.42,2.76)	0.3538	6005
Model 4	0.35(-.30, 1.01)	0.74**(.08,1.39)	0.87**(.19,1.54)	1.24***(.56,1.92)	0.3677	6005
China						
Model 1	1.68***(1.06,2.29)	2.73***(2.13, 3.34)	3.44***(2.81, 4.08)	4.69***(4.03,5.34)	0.2104	11938
Model 2	1.01***(.43,1.60)	1.62***(1.04, 2.20)	1.87***(1.26,2.48)	2.63***(1.99, 3.26)	0.3021	11747
Model 3	0.97***(.39,1.56)	1.58***(1.00, 2.16)	1.82***(1.21, 2.42)	2.52***(1.89,3.15)	0.3082	11747
Model 4	0.92***(.34,1.51)	1.52***(.94,2.10)	1.75***(1.14,2.36)	2.44***(1.80,3.08)	0.3083	11747
Ghana						
Model 1	0.65(-.35, 1.67)	1.91***(.88,2.93)	2.72***(1.70,3.74)	2.35***(1.32,3.38)	0.1822	3772
Model 2	0.41(-.53,1.35)	1.51***(.56, 2.47)	2.14***(1.19,3.09)	1.88***(.92, 2.85)	0.3004	3711
Model 3	0.44(-.49,1.38)	1.51***(.56,2.46)	2.03***(1.08,2.97)	1.84***(.89,2.80)	0.3106	3711
Model 4	0.21(-.70,1.13)	1.17**(.23,2.10)	1.34***(.41, 2.28)	0.97**(.02,1.92)	0.3353	3711
Mexico						
Model 1	2.88***(1.52,4.25)	4.12***(2.75,5.50)	4.41***(3.03, 5.80)	5.57***(4.18,6.97)	0.1596	1839
Model 2	1.96***(.70,3.22)	2.81***(1.53,4.09)	2.61***(1.32,3.90)	3.16***(1.84,4.48)	0.2669	1768
Model 3	1.95***(.69,3.21)	2.81***(1.53,4.09)	2.61***(1.31,3.90)	3.16***(1.84, 4.48)	0.2661	1768
Model 4	1.80***(.54,3.06)	2.62***(1.33,3.90)	2.19***(.89,3.50)	2.76***(1.43,4.09)	0.2703	1768
Russia						
Model 1	0.52(-.75,1.80)	0.18(-1.16,1.52)	1.49**(.164, 2.81)	2.19***(.84,3.53)	0.1978	2691
Model 2	0.09(-1.14,1.34)	-0.39(-1.70, .90)	0.92(-.36,2.21)	1.43**(.11, 2.74)	0.258	2648
Model 3	-0.01(-1.25,1.22)	-0.60(-1.90, .69)	0.68(-.60,1.96)	0.99(-.32,2.30)	0.2679	2648
Model 4	-0.69(-1.91,.52)	-1.55**(-2.83, -.26)	-0.17(-1.44,1.09)	-0.07(-1.38,1.22)	0.2988	2648
South Africa						
Model 1	0.38(-.92,1.70)	2.04***(.69,3.40)	2.65***(1.30,4.00)	3.21***(1.82,4.59)	0.1105	2786
Model 2	0.50(-.83, 1.84)	1.82***(.46,3.18)	1.78**(.40,3.16)	2.73***(1.35, 4.12)	0.2445	2350
Model 3	0.45(-.88, 1.79)	1.82***(.47,3.18)	1.59**(.22,2.97)	2.61***(1.22, 3.99)	0.2497	2350
Model 4	0.11(-1.19, 1.41)	1.71**(.38, 3.03)	1.09(-.25,2.43)	1.88***(.51,3.25)	0.2875	2350
Pooled						
Model 1	1.29***(.91, 1.67)	2.35***(1.98,2.73)	3.15***(2.76,3.54)	4.11***(3.71,4.50)	0.3201	29083
Model 2	0.82***(.46,1.17)	1.48***(1.12,1.83)	1.87***(1.50,2.23)	2.49***(2.11,2.86)	0.4164	28229
Model 3	0.78***(.42,1.13)	1.42***(1.07,1.78)	1.77***(1.41,2.14)	2.35***(1.98,2.73)	0.4205	28229
Model 4	0.55***(.19, .90)	1.13***(.77,1.49)	1.36***(.99,1.72)	1.78***(1.41,2.16)	0.4264	28229

Model 1: adjusted for age, sex, residence and marital status

Model 2: adjusted for model 1+ schooling and wealth quintile

Model 3: adjusted for model 2+ multimorbidity

Model 4: adjusted for model 3+ grip strength

HQ=Height Quintile , CI: Confidence Interval *p< 0.05 ** p< 0.01 *** p< 0.001

Table 5. Relative index of inequality in cognitive ability by life course trajectories, WHO-SAGE

Adjusted for demographic factors						
Characteristics	**India**	**China**	**Ghana**	**Mexico**	**Russia**	**South Africa**
	β [95% CI]	β [95% CI]	β [95% CI]	β [95% CI]	β [95% CI]	β [95% CI]
Own education	12.8***(11.6, 14.0)	9.17***(8.26, 10.0)	13.5***(11.9, 15.0)	11.0***(8.70, 13.44)	10.9***(8.35, 13.4)	14.4***(11.3, 17.5)
Own employment	1.46***(0.54, 2.38)	4.62***(3.66, 5.59)	3.76***(1.88, 5.63)	0.84(-0.97, 2.67)	0.37(-2.29, 3.04)	3.92***(1.81, 6.02)
Wealth quintile	5.45***(4.57, 6.33)	6.95***(6.21, 7.69)	4.06***(2.80, 5.32)	6.75***(4.98, 8.51)	5.12***(3.43, 6.80)	4.48***(2.38, 6.57)
Mother's education	3.42***(1.76, 5.07)	2.47***(1.01, 3.92)	3.30**(0.25, 6.36)	-1.12(-4.14, 1.89)	4.47***(2.00, 6.94)	7.42***(3.46, 11.3)
Father's education	3.45***(2.25, 4.65)	4.25***(3.14, 5.36)	1.89*(-0.24, 4.03)	5.61***(2.53, 8.70)	4.4***(1.81, 6.98)	1.41(-2.69, 5.51)
Mother's employment	1.01**(0.06, 1.97)	0.53(-0.36, 1.42)	-4.76***(-7.34, -2.19)	-0.22(-2.24, 1.79)	1.29(-1.31, 3.89)	-2.51**(-4.96, -.07)
Father's employment	1.71***(0.52, 2.90)	-0.11(-1.07, 0.84)	3.17***(0.93, 5.40)	0.75(-1.19, 2.69)	-3.41(-7.7 ,0.87)	1.01(-1.71, 3.74)
Height quintile	2.48***(1.71, 3.26)	2.92***(2.19, 3.64)	2.84***(1.72, 3.96)	2.96***(1.22, 4.71)	1.05(-0.54, 2.65)	4.04***(2.14, 5.94)
Adjusted for demographic factors + chronic diseases and grip strength						
Own education	12.4***(11.2,13.6)	8.96***(8.06, 9.87)	13.6***(12.1,15.1)	11.2***(8.85,13.5)	9.94***(7.44,12.4)	14.2***(11.1,17.2)
Own employment	1.17**(.26,2.09)	4.76***(3.80, 5.72)	3.63***(1.81,5.46)	0.94(-.88,2.77)	1.15(-1.45,3.75)	3.57***(1.51, 5.64)
Wealth quintile	5.06***(4.19,5.93)	6.92***(6.18,7.66)	4.03***(2.80,5.26)	6.7***(4.94, 8.46)	4.37***(2.72,6.03)	4.41***(2.36,6.47)
Mother's education	3.62***(1.98,5.25)	2.3***(.85, 3.74)	3.11**(.14,6.09)	-1.23(-4.25, 1.78)	4.48***(2.08,6.89)	6.74***(2.86,10.6)
Father's education	3.58***(2.39,4.77)	4.06***(2.95,5.16)	1.64(-.44,3.74)	5.7***(2.62, 8.79)	4.33***(1.81,6.85)	2.3(-1.71,6.32)
Mother's employment	0.99**(.05, 1.94)	0.65 (-.23,1.55)	-4.05***(-6.56, -1.53)	-0.35(-2.37,1.65)	1.35(-1.18,3.88)	-2.85**(-5.24,-.45)
Father's employment	1.95***(.78,3.13)	0.09 (-.86,1.05)	3.78***(1.60, 5.97)	0.77(-1.16,2.72)	-3.06(-7.25, 1.11)	1.1(-1.57,3.78)
Height quintile	1.45***(.66, 2.23)	2.74***(2.01,3.47)	1.65***(.54,2.76)	2.40***(.63,4.17)	-0.56(-2.15,1.02)	3.4***(1.52,5.29)

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