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Abstract

Low and middle income countries experienced rapid demographic changes and increased life expectancy during the 1930s-1960s, mainly because of public health interventions and medical innovations. Increasingly larger groups of survivors of poor early life conditions continued to live in poor socioeconomic conditions which continued to produce a stunted population. Older adults from these cohorts may now exhibit sharper SES health inequalities due to being less socially mobile as a result of early life conditions. Drawing from a subset of the harmonized cross national RELATE data (n=160,661), we examined the degree to which this conjecture has merit by comparing SES health disparities according to adult height for measured obesity, self-reported diabetes, and measured hypertension in older adults from low and middle income countries born in the 1930s through the mid-1940s and living in urban areas. We benchmarked results using data from the US and England. A positive education gradient appeared for obesity in taller individuals but there was no significant gradient for shorter individuals; sharper positive gradients appeared for diabetes for shorter individuals; and no significant association appeared for hypertension for individuals of any height. In contrast, the US and England showed significant negative gradients for education across all health outcomes. The results show the overall importance of early life conditions in adult health, particularly for obesity, across all developing countries, in contrast with US and England. However, the results do not produce convincing evidence of the conjecture regarding sharper SES inequalities in the cohorts born during the 1930s-1940s. Nevertheless, because obesity is a strong predictor of diabetes and hypertension, the results may forecast what is to come for the health of cohorts born in the later period of the 1930s-1960s.

INTRODUCTION

One of the more intriguing questions for demographers is the degree to which the rapid demographic changes of the 1930s-1960s influence elderly health status in the developing world. Infant and child mortality during this period decreased, with large-scale improvements in public health measures and medical technology (Preston, 1976), leading to dramatically increased life expectancy. At the same time, there were few parallel improvements in standard of living, resulting in continued exposure to poor diet and nutrition leading to poor childhood health. Poor childhood health may have ultimately limited chances for upward social mobility for many resulting in sharper socioeconomic (SES) disparities in health at older ages (Palloni, Pinto-Aguirre, & Pelaez, 2002). The purpose of this paper is to examine the degree to which this conjecture has merit for adult obesity, diabetes, and hypertension—conditions which are known to originate in early life (Barker, 1998).

The historical demographic conditions of the 1930s-1960s produced a unique cohort increasingly comprised of individuals who were most at risk of having been affected by harsh early childhood experiences and less affected by mortality-driven selection than preceding cohort. However, country differences in the timing of these changes created cohorts with differential mortality experiences which may now be leading to different health patterns later in life reflecting survivorship of poor early life conditions (Palloni & Souza, 2013; Palloni, Pinto-Aguirre, & Pelaez, 2002). Thus, a comparison of SES health disparities across different mortality regimes at birth should provide insight into the merit of the conjecture regarding sharper SES disparities. There should be sharper SES disparities in health among older adults born in countries that were experiencing rapid changes in mortality primarily due to public health interventions and medical technology as compared with their counterparts in countries not yet experiencing these changes.

Poor environmental circumstances in early life, such as poor nutrition, infectious diseases, and adverse socioeconomic conditions can have lasting effects at older ages

(60+ years) (Elo & Preston, 1992; WHO, 2006). However, early life theories regarding the importance of poor nutrition *in utero* leading to an increased risk of adult obesity, diabetes, and hypertension (Barker, 1998) may be most relevant because the historical circumstances of the 1930s-1960s may have produced a greater manifestation of Barker-type mechanisms in cohorts increasingly characterized by their survival of poor early life conditions but continued exposure to poor diet and nutrition. Having been exposed to harsh nutrition environments in early life followed by exposure to a richer nutritional environment in later life may compound the effects of poor early life conditions (Osmond and Barker, 2000; Bateson et al., 2004). Developing countries around the world have experienced not only demographic changes but also economic and nutritional changes such as the increasing consumption of foods high in saturated fats which increases the risk of disease (Popkin, 2006). If the conjecture regarding the unique cohorts of the 1930s-1960s has merit, then we must consider that the forecasted large increase in diabetes, obesity, and hypertension in the developing world (Murray & López, 1996) may well have its origins in the past and that health patterns in the developing world will be different than what has been observed in the developed world. The explanation that the macro-level events of the 1930s-1960s could be contributing to differential health patterns in the developing world remains relevant.

The dramatic improvements in life expectancy of the 1930s-1960s could potentially lead to sharper health inequalities due to SES among the unique cohorts of the 1930s-1960s that were increasingly characterized by survivorship of early life conditions (Table 1). These cohorts may have more difficulty in achieving a better SES throughout their lifetime due to poor health beginning in early life. Strong economic growth has not always translated into increased social mobility and economic benefits for the entire population in the developing world (López-Alonso, 2007) and thus even in countries where the benefits of economic growth were more widely distributed, many in the unique cohorts may be less socially mobile and less able to benefit because of their start in early life. Therefore, we might expect to observe a steeper negative SES gradient in health in these populations.

Table 1: Mortality Regimes at Birth and Expected Health Patterns in Older Adults

Country Type A	→	Country Type E
	Nature of Mortality Decline At Birth	
Early graded	Mortality decline	Late, rapid
Higher fraction	Improvements in SES	Lower fraction
Smaller fraction	Public health interventions	Higher fraction
	Expected Health Patterns In Older Adults	
Less	Poor health	Greater
Weaker	Early life conditions	Stronger
Weaker	SES differentials	Stronger
Lower	Expected mortality risk	Higher

Source: Adapted from McEniry, 2014.

Notes: Country type A are developed countries (e.g. England, Netherlands, US) and country type E are low income countries (e.g. China, Ghana, India, Indonesia). In between these extremes are predominantly middle income countries (types B-D: Costa Rica, Mexico, South Africa) characterized by differences in the timing, pace, and reason for mortality decline during the 1930s-1960s.

However, patterns of the SES gradient in health in the developing world may not always appear as expected in the developed world. The SES gradient reflects stages in developing economies and other conditions particular to the developing world (Monteiro et al. 2004). In developing economies, the SES gradient in health has shown to be either positive or negative according to a particular health condition (Rosero-Bixby & Dow, 2009). Given the mismatch between early life and later life environmental conditions described in the Barker hypothesis (1998), it may be the case that some survivors took advantage of economic growth in their countries during adulthood and achieved a certain level of social mobility but this social mobility has resulted in negative consequences in terms of their health. In this scenario, we might expect to see the more vulnerable portion of the population exhibit sharper positive SES gradients in health.

There are circumstances which might mitigate the impact of poor early life conditions. Adult SES has important effects on adult health status (Smith, 2005), and changes in economic conditions later in life can impact health either negatively or positively (van den Berg, Doblhammer, & Christensen, 2009). Social factors can modify the effects of poor early life conditions (Almond & Currie 2010; Wilkinson & Marmot, 2003). Educational and economic opportunity during adulthood can lessen the impact of earlier environmental disadvantages (Davey Smith et al. 1998; Elo, Martikainen, & Myrskylä, 2010). Interpreting the SES gradient in health in developing economies which are undergoing large changes in economy and nutrition may be more complex than in the developed world where clear negative patterns have consistently appeared.

The conjecture regarding the 1930s-1960s may be particularly relevant for the cohorts born in the now-middle income countries. Those born at the beginning of the 1930s-1960s period are now experiencing a higher prevalence of chronic conditions such as obesity and diabetes (Palloni et al. 2005). In contrast, older adults born during the beginning period in the now-low income countries experienced a harsher mortality regime in early life and for the most part have not shown the same higher levels of these conditions—as predicted by the conjecture (Table 1). Thus, a comparison of the SES gradients in obesity, diabetes, and hypertension between low and middle income countries is relevant.

In this paper we examine SES disparities in older adult health across mortality regimes from low and middle income countries using measured obesity, measured hypertension, self-reported diabetes, and diabetes based on biomarkers when possible. Using height as a reflection of early life conditions and recently compiled cross national data of older adult health, we compare SES disparities in health for those older adults born in middle income countries which experienced mid to late rapid mortality decline during the 1930s-1940s (mostly countries from Latin America) to those older adults born in low income countries which experienced a much later mortality decline during the 1950s-1960s (countries from Asia and Africa). We use the developed world as a benchmark. If our conjecture has merit, we expect to observe sharper SES disparities for diabetes, obesity, and hypertension among the more vulnerable older adult population, or shorter individuals reflecting exposure to poor early life nutritional and infectious disease environments, in selected middle income countries as compared to their counterparts in low income countries. However, given that all of these countries are undergoing transitions and development, it may be that the direction of the gradient does not follow the expected gradient found in the developed world—namely, a negative gradient between health and SES and a weaker effect of early life conditions on health.

DATA AND METHODS

Data

We use a subset of data from the recently compiled Research on Early Life and Aging Trends and Effects (RELATE) which contains harmonized cross sectional and panel data from major surveys of over 160,000 older adults or households in 20 countries in Latin America, Asia, Africa, the US, England, and the Netherlands (RELATE, 2013). All studies followed a random sampling and are representative of the older adult population either nationally or in major country provinces. All studies obtained high response rates. The RELATE data were harmonized where possible to make cross national comparisons across surveys possible; more detailed information about the surveys can be found elsewhere (McEniry, Moen, & McDermott, 2013). For this paper, we select the following studies from RELATE: CHARLS (China Health and Retirement Longitudinal Study), CHNS (China Health and Nutrition Study), CRELES (Costa Rican Elderly Health Study), ELSA (English Longitudinal Study of Ageing), HRS (Health and Retirement Study), IFLS (Indonesian Family Life Survey), and SAGE (Study on Global Ageing and Adult Health).

Measures

We used the *number of years of education* and classification of educational categories (no school, primary, secondary, and secondary and above) for the developing countries. For the developed world we used at least 12 years of education (high school), two years beyond high school, and anything greater than 2 years beyond high school. *Household income per capita* in units of PPP (purchasing power parity) is available in most studies and for this study we used quintiles of income.

We used *height* as the primary focus of early life conditions in model estimation because it is available in most surveys of older adults and reflects net nutritional status. We use both continuous height, quartiles of height, and height combined with obesity status. *Rural/urban birthplace*, a broad measure of early life nutritional and infectious disease environment, is also available in most studies and we incorporate it into model estimation. Where available, we used *parental SES* to describe the sample obtained across countries.

We examined three adult health outcomes that are known to originate in early life (Barker, 1998): obesity, diabetes, and hypertension. We defined *obesity* as a BMI >=30 using measured height and weight. For diabetes we used mainly self-reports regarding a medical diagnosis of diabetes because not all countries have publicly available biomarkers for diabetes. However, where possible we compared results with diabetes using a measure of *diabetes risk* based on glycated hemoglobin, HbA1c, modified for diabetes medication use (respondent identifies if taking medicine for diabetes including insulin). The latter measure is available in surveys where HbA1c is measured (e.g. HRS, ELSA, CHARLS, CRELES, CHNS). We follow the Yan et al. (2012) definition of three categories of diabetes risk: Not at risk (HbA1c<5.7%); at risk-impaired glucose control (HbA1c between 5.7 and 6.5%); and high risk (HbA1c>6.5%or taking diabetes medication). Although glycated hemoglobin is not regularly used in medical screenings to identify diabetes, it is highly correlated with fasting plasma glucose and a level higher than 6.5 percent indicates a need for diabetes treatment (Goldman et al. 2003). For surveys where blood pressure is measured, we defined *measured hypertension* as systolic BP≥140 mmHg, diastolic BP≥90 mmHG, or taking medication to control hypertension.

Age and *gender* are key control variables. Variables reflecting *smoking* and current residence are available in most countries. We also used a harmonized variable to gauge the *use of health services* within the last 12 months of the survey. We created dichotomous variables to reflect current residence: 1 (rural), 0 (urban).

Analyses

We selected older adults who were born in the late 1920s-the early 1940s in the developing and developed world and who are currently residing in urban areas in the developing world. In some middle income countries, older adults 60+ in the developing world born in the first part of the 1930s-1960s period are experiencing a higher prevalence of obesity, diabetes, and hypertension (Palloni and Souza, 2013) and thus may provide insight into the question posed in this study. We only selected studies which contained measured obesity, self-reported diabetes, and measured hypertension. We use data from CHARLS and CHNS as a benchmark to show prevalence of diabetes using biomarkers but did not incorporate these countries into model estimation as they did not have all variables needed for comparable models. As a preliminary step in the analysis, we imputed the data to account for missing values using recognized imputation methods (Raghunathan, Reiter, and Rubin 2003).

Analysis

We first compared overall prevalence for each health outcome and prevalence according to Q1 of height versus Q2-Q4 of height using the US and England as benchmarks. We then estimated individual country models to examine the direction and magnitude of education and income gradients in each developing country controlling for age, gender, height, birthplace, smoking, and the use of health services.

We used pooled models for all countries and then only for SAGE countries to examine country interactions with education and early life conditions both for all respondents and then models estimated for respondents in the Q1 of height and Q2-Q4 of height and (in the case of diabetes and hypertension) for stunted obese and all other respondents. We also estimated separate pooled models for the US and England. Because we want to eliminate the possible effect of different sample designs and questionnaires, we use the SAGE countries to show results in this paper. Before pooling the data, we checked individual models for differences in direction of coefficients on basic model variables. Although models were estimated for both income and education, because income did not show many significant results (perhaps a better measure using consumption is needed), we present the results for education only. To reduce the amount of information shown in this paper, we show only results for the education gradient using Q1 and Q2-Q4 of height and only make reference to results with models for stunted obese respondents.

RESULTS

Characteristics of Sample

The sample shows a population of older adults born in the later 1920s through the early 1940s (Table 2). Most are female with the exception of countries such as Ghana and India. This population of older adults has, on average, achieved a primary level of education. Although most adults in these countries were exposed to poor early life conditions during the 1930s-1940s, there are differences in terms of rural/urban birthplace in that the studies with the higher percentage of older adults born in rural areas are mostly in the low income countries. Across all countries there is a high percent of adults whose father had no education (58-87%), and, for the most part, the average heights across all countries reflect a stunted population. In relation to height and education, it is clear that those with less education are also shorter (Figure 1).

Differences across countries are more pronounced for adult health conditions and current residence. There is a higher prevalence of obesity and diabetes and shorter obese individuals in the middle income countries. The prevalence of obesity among those in the Q1 of height was very small in most countries (1-4%) except in Mexico and South Africa where the percent was 9% and 17% respectively. There is a higher percent of adults living in rural areas in the low income countries. Among those living in urban areas, there are large differences in the composition of the population in terms of birthplace. Costa Rica and Indonesia have the highest percent of urban residents who were born in rural areas (64% and 69% respectively) as compared with other countries (7-19%).

Education Gradient for Obesity

Prevalence of obesity is particularly high in the middle income countries (Figure 1). While we observe that in the US and England there are very clear negative gradients, in the developing world different patterns emerge. In most cases, the gradient either increases with higher education (mostly in middle income countries) or is flat (mostly in low income countries). The one exception is in China where shorter respondents manifest a negative gradient. There are clear differences in prevalence of obesity according to shorter (Q1 of height) and taller individuals (Q2-Q4 of height). Shorter adults are experiencing a higher prevalence of obesity, particularly in the middle income countries of Costa Rica and South Africa (over 60% among those with secondary or higher level of education) and in the low income country of Ghana. There are also differences between the Q1 and Q2-Q4 of height in the pattern of inequality. In Q1 (India), the gradient is flat whereas for taller individuals the gradient is increasing with higher education. In Q1 (China), the gradient is negative but for taller individuals the gradient is flat.

Table 2: Sample characteristics for cross national data on aging populations born during the late 1920s-early 1940s in selected countries

Variables/Countries	Middle Income Countries				Low Income Countries		
	Costa Rica	South Africa	Mexico	China	Ghana	India	Indonesia
Age	68 (5.3)	69 (6.0)	72 (5.7)	70 (5.4)	70 (5.5)	69 (5.1)	62 (5.0)
Female (%)	52	62	50	53	49	48	55
Childhood							
Born rural (%)	72	43	32	54	61	72	84
Father no education (%)	-	58	58	74	87	68	67
Years school	5.2 (4.1)	4.9 (4.7)	4.1 (4.2)	4.7 (4.7)	3.3 (5.0)	3.2 (4.4)	3.4 (3.9)
Height (avg)							
Female	150.7	154.4	148.8	152.5	156.6	148.4	147.3
Male	164.4	159.1	163.7	163.0	164.8	162.5	158.6
Adulthood							
Obese (%)	25	48	26	6	8	2	2
Q1 height + obese (%)	4	17	9	2	3	1	<1
Diabetes (%)	22	11	20	9	4	7	4
Hypertension (%)	72	82	75	69	60	38	63
Visited doctor (%)	93	69	42	60	68	88	9
Rural residence (%)	38	38	26	45	60	70	62
Percent urban, born rural (%)	64	10	7	19	15	17	69
Never smoked (%)	58	69	57	67	74	43	51
Smoked but not now (%)	32	10	23	9	15	6	6
Current smoker (%)	11	22	20	25	11	51	43

Source: RELATE 2013, imputed, weighted, low and middle income countries where both measured blood pressure and variables on childhood conditions were available; harmonized variables where applicable; older adults born during the late 1930s through early 1940s.

Notes: The table above is based on a total sample of 16,837 respondents. Sample sizes for individual countries were: Costa Rica (1,654), South Africa (1,476), Mexico-SAGE (1,169), China-SAGE (5,363), Ghana (1,946), India (2,723), and Indonesia (2,506). All numbers are either percentages (where indicated) or averages with standard deviations in parentheses. Age is at the time of the surveys. Percent urban, born rural shows the percent of those respondents now living in urban areas who were born in rural areas. To compare China in the graph we use CHARLS which includes respondents born between 1928-1945 with a mean age of 72, 49% female, average education of 3.8 years of schooling, 89% born rural, 76% currently in rural residence, 20% of those respondents born rural who are now living in urban areas, female height 149.5 cm and male height 161.4 cm, 42% in the lowest height quartile, 4% obese, 10% diabetes, and 61% hypertension.

Estimated country-specific models for obesity mirrored the results shown in Figure 1 in that overall there was either a positive gradient for education or no significance, although differences exist (results not shown). Estimated pooled models showed a very strong likelihood of being obese in the middle income countries of Mexico and South Africa (OR 15.88, 95% CI 9.95, 25.33; OR 24.78, 95% CI 15.82, 38.80) (results come from Table 3, Panel A, Model 1 but are not shown in table). Models also showed a very strong positive education gradient. Having secondary or higher education increased the likelihood of being obese by about 56% in comparison with those with no schooling (Table 3, Panel A, Model 1). There were no significant interactions between height and education across all models suggesting that the coefficients for education are similar across countries. However, separate models for Q1 and Q2-Q4 of height show differences in the gradient. The education gradient for those shorter respondents was not significant but for those taller respondents it was significant and sharper than the overall Model 1 (OR 1.72, 95% CI 1.35-2.20; Table 3, Panel A, Models 3). Pooled models for the US and England showed a very clear negative gradient. The odds of obesity were reduced by almost 40% for those with a higher education (Table 3, Panel B, Model 1) and these effects were consistent for taller individuals (Table 3, Panel B, Model 3). It is notable that the effects for height for the US and England is weaker than it is in the developing countries (OR 1.16, 95% CI 1.02-1.31 US and England versus OR 1.60, 95% CI 1.36-1.88 for low and middle income countries—results not shown in table). Results are similar when estimating pooled models for all seven countries.

Education Gradient for Diabetes

Patterns of prevalence of diabetes with Q1 and Q2-Q4 of height and benchmarked with the US and England showed similar results in that the middle income country of Costa Rica shows a higher prevalence of diabetes, a clear negative gradient appears for the US and England, and mostly positive gradients appear in developing countries (Figure 2). Although we do not yet have diabetes based on biomarkers from China-SAGE, data from CHARLS and CHNS suggests a positive gradient for taller individuals in China but a potentially mixed gradient for shorter individuals (Figure 2). Costa Rica shows a positive gradient for shorter individuals and a negative gradient for taller individuals.

Table 3. Education Gradient for Obesity (Pooled)

Panel A: SAGE Countries, Urban Residents

Variables	Model 1 (All)		Model 2 (Q1 height)		Model 3 (Q2-4 height)	
No school	1.00		1.00		1.00	
Primary	1.39	[1.13, 1.71]	1.30	[0.93, 1.83]	1.46	[1.12, 1.89]
Secondary	1.56	[1.28, 1.90]	1.29	[0.91, 1.81]	1.72	[1.35, 2.20]
N	6,206		1,660		4,546	

Panel B: England and US

Variables	Model 1 (All)		Model 2 (Q1 height)		Model 3 (Q2-4 height)	
HS	1.00		1.00		1.00	
LE two years beyond HS	0.72	[0.62, 0.85]	0.73	[0.48, 1.10]	0.73	[0.61, 0.86]
GT two years beyond HS	0.64	[0.56, 0.72]	0.47	[0.33, 0.65]	0.67	[0.59, 0.77]
N	8,165		1,510		6,655	

Source: RELATE 2013, imputed, weighted, low and middle income countries where both measured blood pressure and variables on childhood conditions were available; harmonized variables where applicable; older adults born during the late 1930s through early 1940s.

Notes: Notes: The table above is based on a sample of 6,206 respondents for low and middle income countries and 8,165 respondents for England and the US. Sample sizes for individual countries: South Africa-SAGE (972), Mexico-SAGE (850), China-SAGE (2,946), Ghana-SAGE (767), India (671), England (2,940), and US (5,225). The table shows results from logistic models that controlled for age, gender, type of birthplace (rural/urban), health use, and recent smoking behaviors for urban residents. For England-ELSA and US-HRS, models do not have variables of current residence (urban/rural) and health use. Age is at the time of the surveys. Obesity is defined as BMI≥30. Q1 is the lowest quartile of height.

Figure 1: Obesity across low, middle and high income countries by education: Cohort of the late 1920s – early 1940s

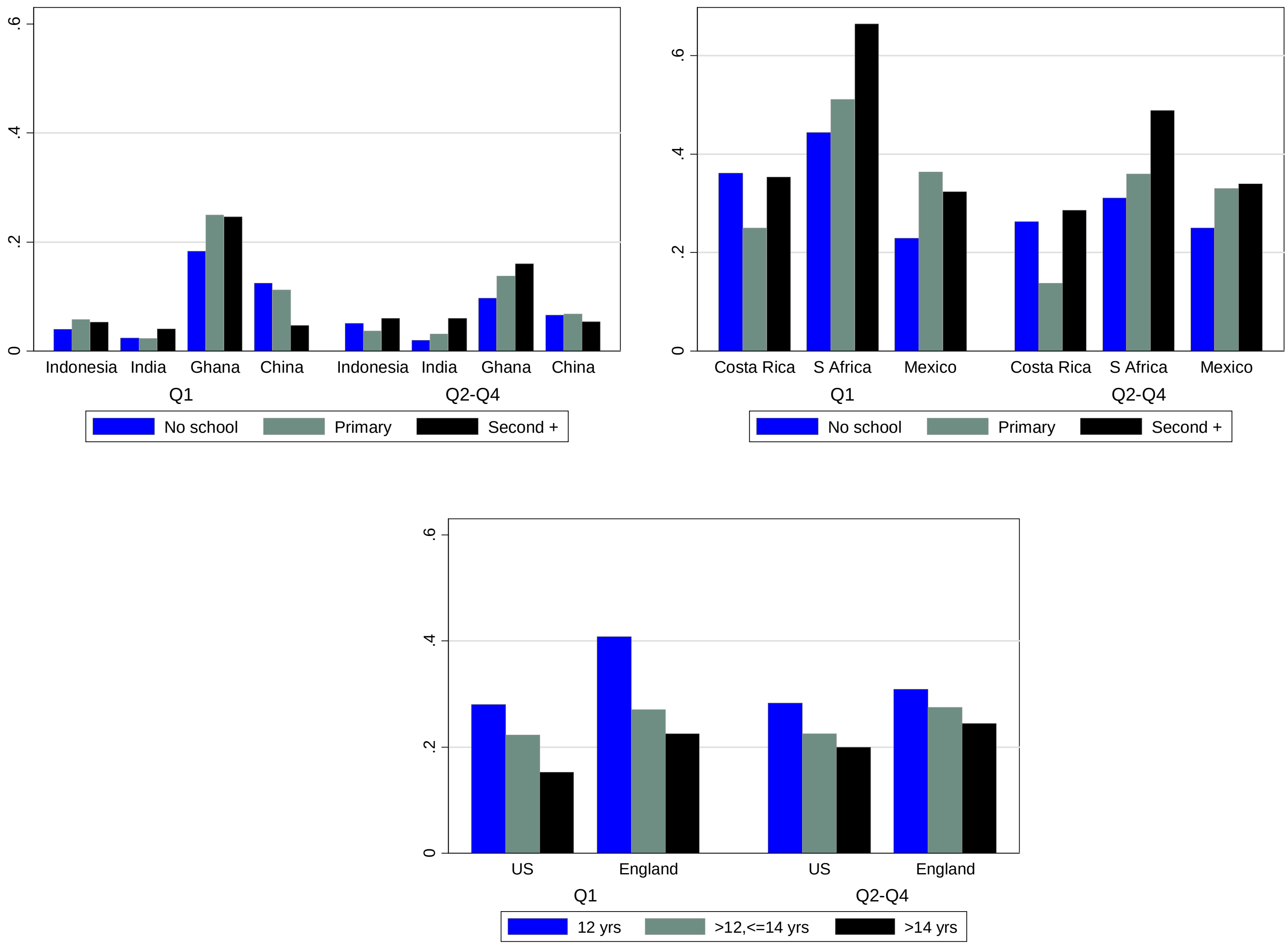
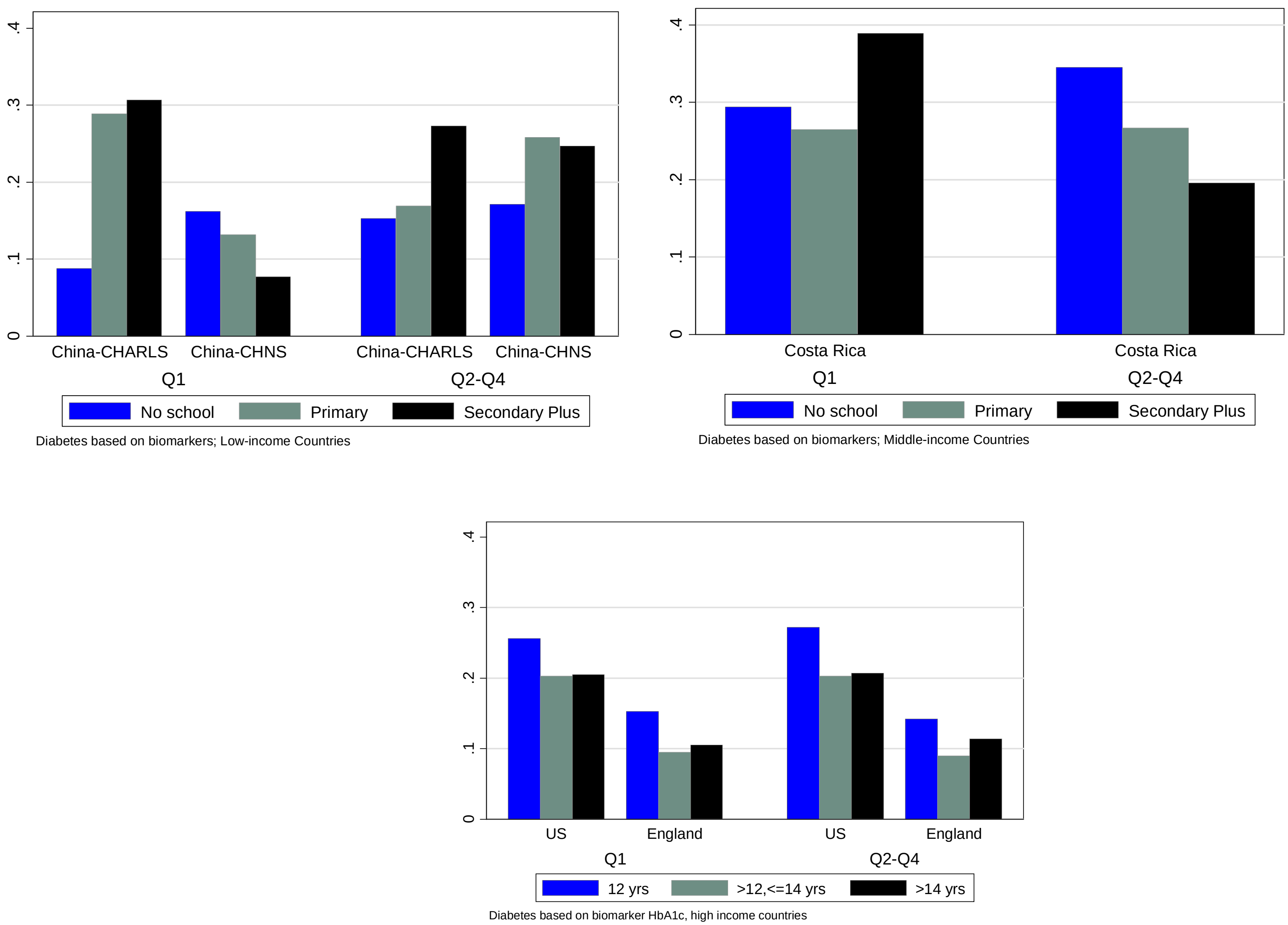


Figure 2: Height and diabetes across low, middle and high income countries by education: Cohort of the late 1920s – early 1940s



Estimated pooled models using Q1 of height versus Q2-Q4 of height showed that overall there was a strong positive gradient for diabetes (Table 4, Panel A, Model 1): the odds of diabetes were increased by about 47% for those with secondary or secondary plus education relative to those with no education (OR 1.47, 95% CI 1.21-1.78). Taller adults were more likely to report diabetes (OR 0.81, 95% CI 0.68-0.96—results not shown in table). Separate models for Q1 and Q2-Q4 showed a similar pattern although the gradient was sharper for the Q1 of height adults (OR 1.94, 95% CI 1.34-2.80 shorter; OR 1.35, 95% CI 1.08-1.70 taller; Table 4, Panel A, Models 2-3). The US and England showed an overall strong negative gradient (Table 4, Panel B, Model 1). Higher education reduces the likelihood of diabetes by about 35% (OR 0.65, 95% CI 0.55-0.77). Similar results are obtained for shorter and taller individuals (Table 4, Panel B, Models 2-3). It is notable that the effects for height in the US and England are not significant (Table 4, Panel B, Model 1: OR 0.91, 95% CI 0.77-1.09—results not shown in table). Results are similar when estimating pooled models for all seven countries.

Predicted probabilities comparing shorter and taller respondents for Models 2 and 3 in Table 4 for the developing world and US and England show a sharper education gradient for shorter rather than taller adults for the developing world (Figure 3) although the differences are not statistically significant. The US and England show an expected negative gradient.

For stunted obese models (results not shown because we wanted to reduce the amount of information presented in this paper and results are similar to the comparison between Q1 and Q2-Q4), a comparison of the prevalence of diabetes between the shorter obese individuals and other respondents in Mexico, South Africa, the US, and England shows similar contrasting gradients. Shorter, obese adults in South Africa showed an increasing prevalence of diabetes as education increased whereas their counterparts in Mexico showed a decreasing prevalence of diabetes as education increased. Benchmarking with US and England using biomarkers for diabetes shows a clear negative gradient across all groups, although the shorter obese individuals show a much higher prevalence of diabetes than do the other adults. Estimated models for all developing countries showed no significant education gradient for the shorter obese adults, but a significant positive gradient for all other adults: having secondary education or higher increased the odds of reporting diabetes by about 24% (OR 1.24, 95% CI 1.24-1.85).

Figure 3: Predicted probabilities for diabetes by years of education and by quartile of height

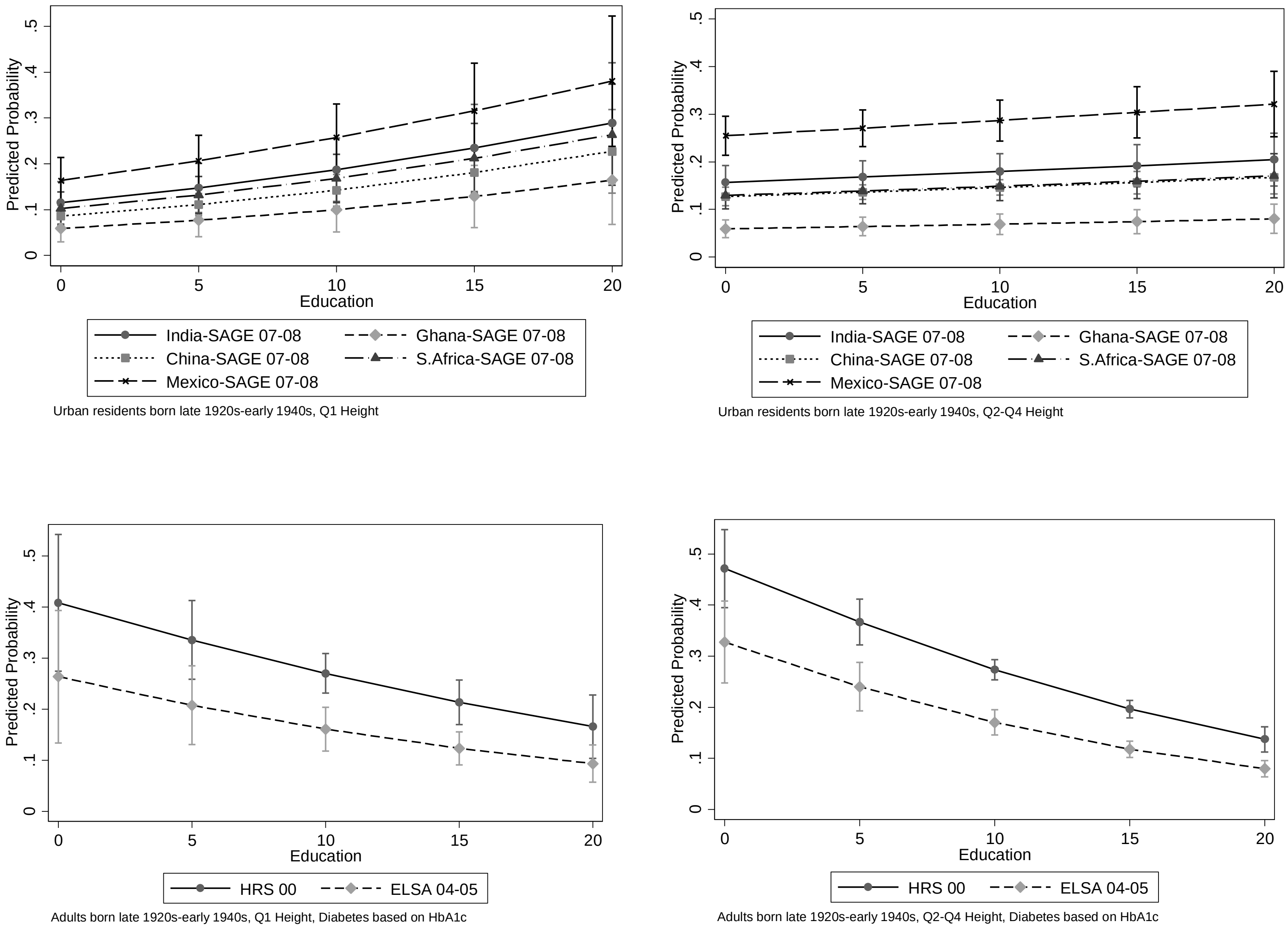


Table 4. Education Gradient for Diabetes (Pooled)

Panel A: Low Height for SAGE Countries, Urban Residents (using self-reported diabetes)

Variables	Model 1 (All)		Model 2 (Q1 height)		Model 3 (Q2-4 height)	
No school	1.00		1.00		1.00	
Primary	1.08	[0.88, 1.33]	1.03	[0.70, 1.52]	1.09	[0.85, 1.39]
Secondary	1.47	[1.21, 1.78]	1.94	[1.34, 2.80]	1.35	[1.08, 1.70]
N	6,206		1,660		4,546	

Panel B: Low Height for England and US (using biomarkers)

Variables	Model 1 (All)		Model 2 (Q1 height)		Model 3 (Q2-4 height)	
HS	1.00		1.00		1.00	
LE two years past HS	0.71	[0.58, 0.86]	0.68	[0.38, 1.21]	0.71	[0.57, 0.88]
GT two years past HS	0.70	[0.59, 0.82]	0.63	[0.41, 0.96]	0.71	[0.59, 0.84]
N	6,078		1,078		5,000	

Source: RELATE 2013, imputed, weighted, low and middle income countries where both measured blood pressure and variables on childhood conditions were available; harmonized variables where applicable; older adults born during the late 1930s through early 1940s.

Notes: The table above is based on a sample of 6,206 respondents for low and middle income countries and 6,078 respondents for England and the US. Sample sizes for individual countries: South Africa-SAGE (972), Mexico-SAGE (850), China-SAGE (2,946), Ghana-SAGE (767), India (671), England (2,076), and US (4,002). The table shows results from logistic models that controlled for age, gender, type of birthplace (rural/urban), health use, and recent smoking behaviors for urban residents. For England-ELSA and US-HRS, models do not have variables of current residence (urban/rural) and health use. Age is at the time of the surveys. Q1 is the lowest quartile of height. Diabetes is self-reported for Panel A but based on the biomarker HbA1c in Panel B.

Education Gradient for Hypertension

Using Q1 of height versus Q2-Q4 of height shows an expected pattern—the US and England show a clear negative gradient whereas the remaining countries do not (Figure 4). However, estimated models show no significant associations between education and hypertension (Table 5, Panel A, Models 1-3) although overall taller individuals are more at risk of hypertension (OR 0.84, 95% CI 0.74-0.96—results not shown in table). In contrast, the US and England show a significant education gradient but no significant effects for height (Table 5, Panel B, Models 1-3). Results were similar when pooling all seven countries. For stunted obese models (results not shown here), similar results were obtained in that no significant associations appear between the education gradient and hypertension across all groups for the developing countries in contrast to the significant associations for education showing in the US and England.

Figure 4: Height and hypertension across low, middle and high income countries by education: Cohort of the late 1920s – early 1940s

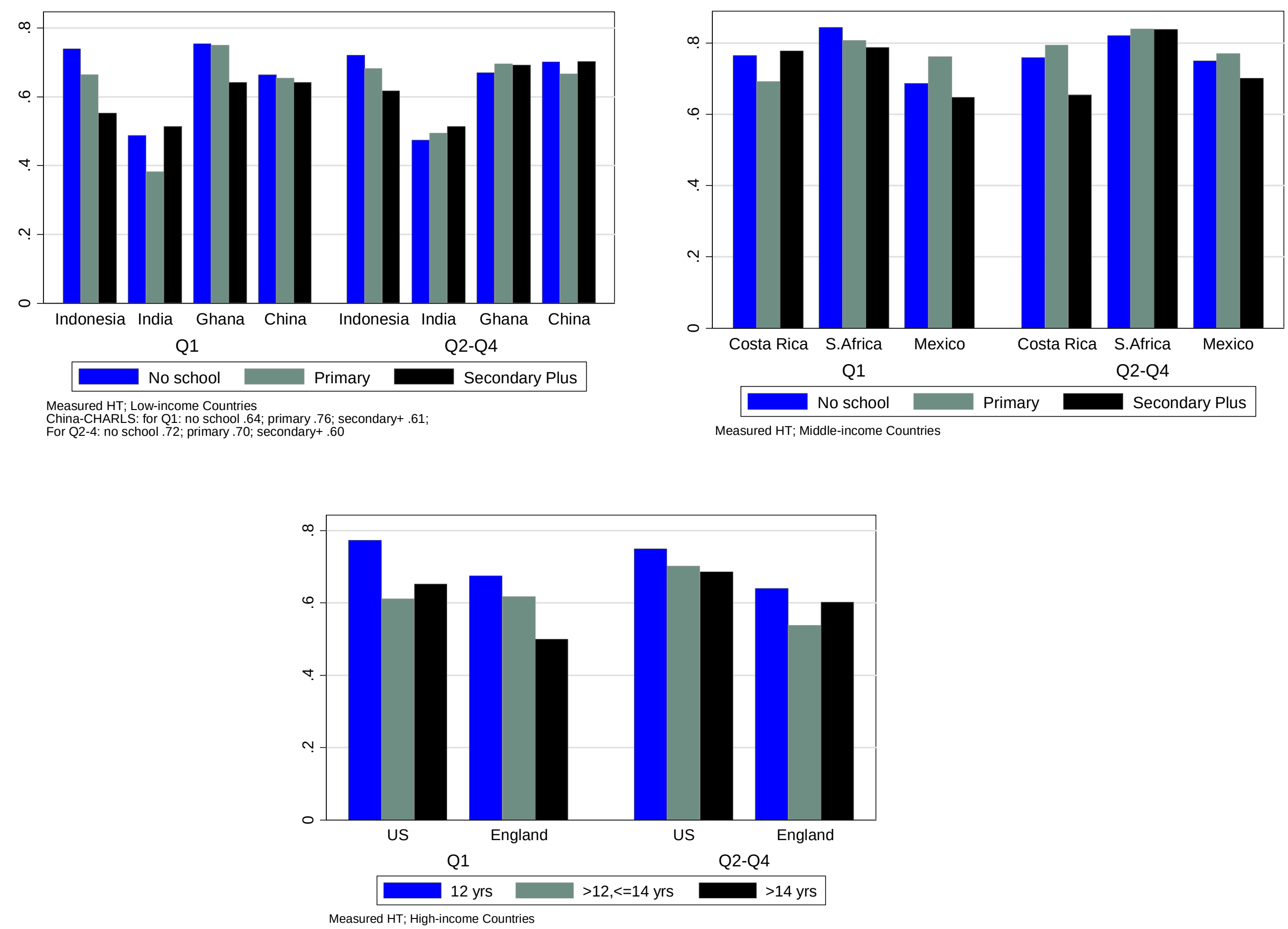


Table 5. Education Gradient for Hypertension (Pooled)

Panel A: Low Height for SAGE Countries, Urban Residents

Variables	Model 1 (All)		Model 2 (Q1 height)		Model 3 (Q2-4 height)	
No school	1.00		1.00		1.00	
Primary	1.06	[0.91, 1.24]	1.07	[0.81, 1.41]	1.07	[0.88, 1.29]
Secondary	1.12	[0.96, 1.30]	0.94	[0.71, 1.24]	1.18	[0.99, 1.41]
N	6,206		1,660		4,546	

Panel B: Low Height for England and US

Variables	Model 1 (All)		Model 2 (Q1 height)		Model 3 (Q2-4 height)	
HS	1.00		1.00		1.00	
LE two years beyond HS	0.73	[0.63, 0.84]	0.53	[0.36, 0.77]	0.77	[0.66, 0.91]
GT two years beyond HS	0.72	[0.64, 0.80]	0.53	[0.40, 0.70]	0.76	[0.67, 0.86]
N	8,165		1,510		6,655	

Source: RELATE 2013, imputed, weighted, low and middle income countries where both measured blood pressure and variables on childhood conditions were available; harmonized variables where applicable; older adults born during the late 1930s through early 1940s.

Notes: The table above is based on a sample of 6,206 respondents for low and middle income countries and 8,165 respondents for England and the US. Sample sizes for individual countries: South Africa-SAGE (972), Mexico-SAGE (850), China-SAGE (2,946), Ghana-SAGE (767), India (671), England (2,940), and US (5,225). The table shows results from logistic models that controlled for age, gender, type of birthplace (rural/urban), and recent smoking behaviors for urban residents. Age is at the time of the surveys. Diabetes is self-reported. Hypertension is defined to be systolic ≥140 mmHg or diastolic≥90 mmHg or taking medication to control hypertension.

DISCUSSION

We used cross national data on older adults born in the late 1920s through early 1940s to examine the merit of a conjecture regarding the degree to which the historical and demographic changes of the 1930s-1960s are having long-term negative consequences on older adult health for those born during this period—particularly for health conditions that are known to originate in early life. Using short height as a reflection of poor early life conditions, we found an early life connection with adult obesity in low and middle income countries in urban areas: (1) shorter adults are at greater risk of being obese than taller adults; but (2) no significant education gradient for shorter adults but a significant positive gradient for taller adults. For adult diabetes, we found that overall taller adults are more likely to report diabetes but a comparison between shorter and taller adults shows a sharper education gradient for shorter adults than it does for taller adults living in urban areas. There were no significant associations between education and hypertension in pooled models in the developing world using all adults and broken down according to shorter versus taller adults. Although we found evidence for the importance of early life conditions on adult obesity, we found insufficient evidence to suggest that there were significant differences between countries in terms of the education gradient. In contrast, the US and England showed consistently significant negative gradients in health with weaker effects for height on health.

Developing countries experienced dramatic increases in life expectancy among infants and children primarily due to public health intervention but not in parallel with economic development resulting in increased survivorship but continued poor diet and nutrition. If early life conditions are important to older adult health, they should help explain the increasing prevalence of adult disease known to originate in early life such as obesity, diabetes, and hypertension. Given our selection of countries, this means we expected to observe sharper differentials in the selected middle income countries as compared with the selected low income countries.

A few observations are important to note. First, although we continue to not find strong evidence regarding the merit of the conjecture of the long-term consequences of the historical and demographic changes of the 1930s-1960s (e.g. McEniry, 2013), the findings do not negate the importance of the conjecture. It may be too early to observe the results in countries because most of the mortality decline occurred after the mid-1940s (Preston, 1976). Large countries such as Mexico and South Africa were beginning to experience mortality decline in the 1930s-1940s in urban areas but other smaller countries such as Costa Rica and Puerto Rico were experiencing much more widespread improvements in life expectancy during this period (Clark, 1930; Rosero-Bixby, 1990). Another indication of the importance of timing of historical changes is suggested by the small prevalence of short obese adults in this study (Table 2), but other recent studies of children in the developing world show an increasing prevalence of short obese adults, placing individuals at a much higher risk of adult disease (Adair 2013). Thus, the results for obesity may foreshadow what is to come for cohorts born after the mid-1940s as they reach older ages.

However, we did find evidence to suggest that the conjecture may be suitable for some but not all developing countries. The expectation that increasing survivorship of poor early life conditions would result in less social mobility because of childhood health leading to sharper SES inequalities (assuming a negative SES gradient) does not appear to be the case in the data examined for diabetes. Increasing education increased the likelihood of diabetes for shorter individuals and these findings show an opposite pattern to the expected negative gradient that appears very clearly in countries such as the US and England. On the other hand, the education gradient for diabetes for shorter individuals suggests (albeit weakly because the gradient is steeper but not significantly different from taller individuals) the merit of hypotheses put forward regarding the mismatch between poor early life conditions and later a more nutritionally enriched environment (Osmond and Barker, 2000; Bateson et al., 2004). Thus, the gradient may be sharper due to early life conditions but in the opposite expected direction of the developed world. Because we know that the gradient can be positive in some settings (Rosero-Bixby & Dow, 2009; Monteiro et al., 2004), a modification of the conjecture may be warranted to more fully examine the consequences of social mobility when it does occur in the cohorts increasing characterized by survivorship of early life conditions.

The insignificance of the education gradient for shorter individuals for obesity and for diabetes may reflect that being short has negative consequences no matter the education attained. Indeed, recent evidence suggests the overall negative impact of being short on adult health independent of the level of SES (Nelson et al. 2015). The insignificance of the education gradient for hypertension across all groups is puzzling. Although measures such as low birth weight have shown strong associations (Barker 1998, Johnson and Schoeni 2011; Lawlor and Davey Smith 2005; McGovern 2012), height may not be a direct pathway from early life to adult hypertension (Popkin, Horton & Kim 2001). It may also be the case that in the developing world, diet and exercise are important in terms of hypertension. Questions on diet are more limited in surveys of older adults and this may help explain the results for hypertension.

The results for diabetes in the developing world are based on self-reports. While under some conditions self-reports perform well as compared with biomarkers (Banks et al. 2006; Brenes 2008; Goldman et al. 2003), underestimation of conditions such as diabetes is probably higher in low and middle income countries where access to quality health care may be problematic for some older adults even living in urban areas. Comparing the results using biomarkers for diabetes for Costa Rica (CRELES) and China (CHARLS, CHNS) provides some insight in the short term but more biomarkers are needed in the long term to more fully interpret the results for diabetes in the SAGE countries.

Benchmarking with the England and the US is helpful even though the determinants of health may not be the same as in the developing world. Similarly, not all variables were available for the estimated models for England and the US (e.g. rural/urban birthplace, current residence, and visits to a medical doctor).

The overall insignificant results for income are not as surprising on second glance as it may very well be the case that reported consumption is a better indicator of SES levels than reported income. However, most surveys of older adults do not collect information on consumption with some exception (e.g. IFLS, CHARLS, and MHAS).

There are several limitations to the study. First, given our broad measure of height, we cannot identify specific mechanisms of early life nor can we distinguish the impact of nutrition versus infectious disease. As mentioned earlier, diet is an important piece of adult lifestyle but we have limited questions on diet in surveys of older adults. Having measures of social mobility is also important but we have limited information on social mobility in surveys of older adults. Finally, pooling of countries assumes that there is similarity in sample design and questionnaires. Although we reported results for SAGE because of similar sample design and questionnaire, the assumption for pooling cannot be readily verified. We focused on urban areas in this paper because the prevalence of obesity, diabetes, and hypertension is higher in urban as compared to rural areas, but future effort will benefit from also examining patterns in rural areas and examining how the different composition of urban residents in terms of birthplace could also be contributing to different patterns of adult health.

In spite of the limitations, surveys of older adults are one of the better choices that we have to examine the determinants of older adult health. We do not yet fully understand the determinants of older adult health and their relative importance in the developing world. We do know that, under some conditions, adult diabetes, obesity, and hypertension can originate in early life. Although the measures are limited, in some cases the patterns presented in this paper indicate that data from surveys of older adults do provide insight into older adult health. In that light, continued research on the topic of early life conditions using surveys of older adults remains important.

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