Early Life Conditions, Adult Disability and Mortality among Aging Populations in Developing Countries

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Abstract

Adverse early-life conditions may have strong effects on levels and severity of older adult chronic conditions such as heart disease and diabetes which in turn impact disability and mortality. These effects may be particularly apparent in mortality regimes which produced a larger pool of survivors of poor early life conditions. Data from 16 countries across Latin America and the Caribbean, Asia and Africa are used to examine early life conditions, disease and disability, with data from the US, UK, and Netherlands as benchmarks. Estimates of the effects of early life conditions on heart disease and diabetes were generated, followed by estimates of effects on disability and mortality, controlling for chronic conditions. In some cases, older adults born in mortality regimes which produced a larger pool of survivors of early-life conditions are at higher odds of experiencing heart disease and diabetes, as well as being at increased risk of being disabled and dying. That is, we find that (1) there are strong positive effects of poor early life conditions (poor nutrition, infectious diseases and socioeconomic status) on adult chronic conditions (heart disease and diabetes) among older adults born in mortality regimes which during the late 1920s and early 1940s most probably produced a larger number of survivors of poor early childhood conditions and who are now experiencing a higher prevalence of heart disease and diabetes; whereas (2) there are weaker positive effects of these conditions among older adults born in harsher mortality regimes and who now show much lower prevalence of chronic conditions. Thus, although not overwhelming, there is some evidence to suggest that the conjecture has merit.

Introduction

The dramatic improvement in life expectancy during the 20th century (1930s-1960s) in low and middle income countries was primarily due to reductions in infant and child mortality as a result of massive public health interventions and medical technology but largely in the absence of improvements in standard of living. Did these circumstances also produce a larger pool of survivors of poor early life conditions (poor nutrition, infectious diseases and poor socioeconomic conditions) that is more susceptible to their effects later in life? As a result, are older adults from these "special" cohorts now, on average, in poorer health? Or, have other factors helped mediate the effects of these poor early life conditions?

The aim of this paper is to examine these questions in regards to adult chronic conditions (heart disease and diabetes), disability and mortality across mortality regimes of the early 20th century in low and middle income countries. The argument for the conjecture is based on a debate begun over thirty years ago when Preston (1976) examined the degree to which mortality decline in the 20th century in low and middle income countries was due to public health interventions and medical technology or to improvements in standard of living. However, with only a few exceptions (Omran, 1971; Palloni et al., 2007), there has been relatively little discussion or study regarding the long term impact of these historical circumstances, especially as they relate to early life conditions and their influence on older adult health. The conjecture has not yet been fully tested, most probably because until recently there was no available compiled cross national data on older adult health in low and middle income countries. This paper contributes to the understanding of the conjecture by examining chronic conditions (heart disease and diabetes), disability and mortality across countries and mortality regimes of the 20th century using recently compiled comprehensive cross national data.

The value of this type of comparison is that the pace (graded/rapid), timing (earlier/later) and reason for mortality decline (improvements in standard of living/public health interventions and medical technology) were sufficiently diverse across countries in the early 20th century as to now provide possible insight into the differential effects of poor early life conditions on older adult health. The significant mortality decline of the developed world in the late 19th and early 20th century is a benchmark to compare across different regimes of the developing world. By the late 1920s-early 1940s these countries had overall a higher GDP per capita than the developing world and on average poor nutrition and infectious diseases were not predominant causes of illness or death. In the developing world the pattern was one of declining mortality but often in the context of stagnant improvements in standard of living. There were differences across countries. Older adults born in countries such as Argentina and Uruguay were at higher levels of GDP per capita during the early 20th century, had a better public health infrastructure and had lower levels of infant and child mortality. During the 1930s-1960s, they also experienced dramatic improvements in infant and child mortality but the cumulative change in mortality over time during the 1930s-1960s was much higher in countries that experienced a later mortality decline. Countries most likely to have experienced a larger and more rapid increase in the pool of survivors of early life conditions at the beginning of the period of dramatic mortality decline (1930s-1960s) were countries such as Chile, Costa Rica, Puerto Rico, Taiwan and possibly South Africa. In the late 1920s, these countries began implementing larger scale public health interventions and improving medical technology and these efforts brought about consistent reductions in infant and child mortality. Other countries such as Mexico, Brazil and Barbados began similar larger scale public health initiatives slightly later in the 1940s. Older adults born prior to the 1950s in countries such as Bangladesh, India, Indonesia and China experienced a much more severe mortality regime as infant and child mortality was very high (e.g. Banister, 1987).

The conjecture has important ramifications on at least two fronts. First, it may provide better insight into the determinants of health of older adults born during the 1930s-1960s in low and middle income countries. We know that aging populations are increasing (Kinsella & He, 2009) and that the present growth rate of individuals 60 years and older can be directly tied back to the mortality decline of the 1930s-1960s (Palloni et al., 2007). We also know that there will be a heavier burden of disease due to adult heart disease and diabetes in these settings (Murray & Lopez, 1996), and that these chronic conditions partially originate in early life exposures such as poor nutrition and infectious diseases (Barker, 1998). A better understanding of the determinants of older health of the cohorts of the 1930s-1960s will help improve policy interventions for older adults born during the 1930s-1960s who will be impacting health care systems for at least the next 20-30 years. Second, poor nutrition and infectious diseases continue to prevail in many low and middle income countries (Murray et al., 1996). Understanding the long range impact of historical strategies to improve survival at the beginning of life may help to better formulate effective public health policies for the future aging population in low and middle income countries.

Early life conditions

Evidence of the importance of early life conditions for older adult health has accumulated for a long time in the developed world. A number of pathways and mechanisms are possible beginning with poor nutrition and infectious diseases *in utero* or early infancy (Barker, 1998; Finch & Crimmins, 2004; Catalano & Bruckner, 2006). Socioeconomic status (SES) and childhood health can also be important determinants of adult health (Lundberg, 1991; Hertzman, 1994; Wadsworth et al., 2002; Wadsworth & Kuh, 1997; Davey Smith & Lynch, 2004; Elo & Preston, 1992; Bengtsson & Mineau, 2009; Delaney, McGovern & Smith, 2009). Evidence is now accumulating from low and middle income countries regarding how these mechanisms affect adult health (Victora et al., 2008; Moore et al., 1999; Palloni et al., 2005; Kohler & Soldo, 2005; Brenes, 2008; Monteverde, Norhonha & Palloni, 2009; McEniry & Palloni, 2010; Zhang, Gu & Hayward, 2010; Campbell & Lee, 2009; Xu et al. 2009).

Possible pathways to adult disability and mortality are shown in Figure 1. Several different mechanisms operating either *in utero* (Barker, 1998; Catalano & Bruckner, 2006; Finch & Crimmins, 2004) or during childhood (Elo & Preston, 1992; Delaney, McGovern & Smith, 2009) may lead to later adult heart disease and diabetes. Having an adult chronic condition such as heart disease or diabetes may then lead to higher risk of being disabled, and having both conditions is associated with adult mortality (Kuh & Ben-Shlomo, 2004). Thus, one possible pathway (but not the only pathway) to adult disability begins in early life when individuals are exposed to adverse early life conditions (poor nutrition and/or infectious diseases), continues when these exposed individuals manifest a higher risk of adult heart disease and diabetes, continues when they show a higher risk of being disabled and ultimately ends when they also are at higher risk of dying. Evidence for at least part of this pathway has been shown for older adults in the Latin American and Caribbean region for some chronic conditions (Monteverde, Norhonha & Palloni, 2009) and in China (Xu et al., 2009).

[Insert Figure 1 about here]

The question this paper addresses is the degree to which this pattern which originates in early life is particularly salient among those mortality regimes which produced cohorts with larger pools of survivors of poor early life conditions and which are now experiencing a higher prevalence of adult heart disease and diabetes. If the conjecture regarding differential health patterns in mortality regimes in low and middle income countries has merit and if the survey data on older adults from low and middle income countries adequately capture health and other variables of interest, we expect to observe two major regularities. **First**, there should be strong positive effects of poor early life conditions (poor nutrition, infectious diseases and socioeconomic status) on adult chronic conditions (heart disease and diabetes) which then show strong associations with adult functionality and mortality among older adults born in mortality regimes which during the late 1920s and early 1940s most probably produced a larger number of survivors of poor early childhood conditions as a result of massive public health interventions and medical technology largely in the absence of improvements in standard of living. Older adults born in these mortality regimes are now experiencing a high prevalence of heart disease and diabetes. **Second**, there should be weaker positive effects of poor early life conditions on adult chronic conditions although their effects may be manifested more directly on adult functionality and mortality among older adults born in mortality regimes which during the late 1920s and early 1940s were still experiencing very harsh environmental conditions with little or no mortality decline. In these settings there is still a relatively low prevalence of reported adult heart disease and diabetes.

Methods

Data

The data come from a newly compiled cross national data set of low, middle and high income countries. They are drawn from comprehensive national representative surveys of older adults or household surveys. From Latin America there are the Mexican Health and Aging Study (**MHAS**, first wave, n=13,463), Puerto Rican Elderly: Health Conditions (**PREHCO**, first wave, n=4,291), Study of Aging Survey on Health and Well Being of Elders (**SABE**, n=10,597) and Costa Rican Study of Longevity and Healthy Aging (**CRELES**, first wave, n=2,827). From Asia there are the China Health and Nutrition Study (**CHNS**, n=6,452), Chinese Longitudinal Healthy Longevity Survey (**CLHLS**, n=16,064), WHO Study on Global Ageing and Adult Health Study in China (**WHO-SAGE,** n=12,284), Indonesia Family Life Survey (**IFLS**, wave 2000, n=13,260), the

Bangladesh Matlab Health and Socio-Economic Survey (**MHSS**, n= 3,721), WHO Study on Global Ageing and Adult Health Study in India (**WHO-SAGE**, first wave, n=6,559) and Social Environment and Biomarkers of Aging Study (**SEBAS**, n=1,023). From Africa there are the WHO Study on Global Ageing and Adult Health Survey in Ghana (**WHO-SAGE**, n=4,302) and South Africa (**WHO-SAGE**, first wave, n=3,830). From the developed world there are the Health and Retirement Study (**HRS**, wave 2000, n=12,527), Wisconsin Longitudinal Study (**WLS**, wave 2004, n=10,317), English Longitudinal Study of Ageing (**ELSA**, second wave, n=8,780) and Survey of Health, Ageing and Retirement-Netherlands (**SHARE-Netherlands**, first wave, n= 2,979).

Measures

Mortality regimes.—In previous work, a reasonable classification of 19 very diverse countries was developed reflecting the speed of mortality decline, timing of the onset of mortality decline, the degree to which mortality decline was due to exposure to public health interventions and medical technology, and the degree to which mortality decline was due to improvements in standard of living (McEniry, 2009). The resulting classification of 19 countries is: (A) very early mortality decline (e.g. Netherlands, UK, US); (B) early, graded mortality decline (e.g. Argentina, Uruguay); (C) early, less graded mortality decline (e.g. Chile, Costa Rica, Puerto Rico, South Africa, Taiwan); (D) late, rapid mortality decline (e.g. Barbados, Mexico, Brazil); and (E) little or no mortality decline prior to 1950 (e.g. Bangladesh, China, Indonesia, India, Ghana).

Early life conditions.—Early life conditions are ascertained through survey questions regarding birthplace (rural versus urban), parental education or occupation, childhood health, adult height and season of birth. Most countries have questions regarding birthplace, measured adult height (and in some cases knee height) and season of birth whereas not all countries have parental education or occupation. Rural/urban birthplace is used as a proxy for early life SES because of its strong association with parental SES in these data and height is a measure of net nutritional status (Fogel, 2004). For the Latin American and Caribbean countries, respondents were asked to rate their childhood health using a five-point scale ("Would you say that your health as a child was excellent, very good, good, fair or poor?") and to rate their childhood SES based on a three-point scale ("In general, would you say that the economic conditions in the home in which you were raised were good, fair or poor?"). We use these responses to create dichotomous variables for (1) poor childhood health where 1 indicated that the respondent rated his or her health during childhood as poor or fair and 0 indicated better, and (2) poor SES during childhood where 1 indicated if a respondent defined his or her childhood SES as poor and 0 indicated good or fair. We use gender-specific quartiles of height (knee height) as a proxy for early nutritional status and stunting in the case of knee height (Eveleth & Tanner, 1976). Season of birth is also a potential useful indicator of early life *in utero*/early infancy exposures to poor nutrition and infectious diseases (Doblhammer, 2004) and we use quarter of birth and harvest/lean season with appropriately defined dummy variables in the case of Puerto Rico.

Adult SES.— Levels of education are defined according to the number of years of education and using the United Nations' standards for low to middle income countries: no schooling; primary (1-6 years of education); and secondary and above (7 years and above). Three levels of education are defined because, for the most part, many countries had a very small number of respondents with greater than 12 years of education. In the case of the US, UK and Netherlands, we also use three levels according to what has been suggested by others (Banks et al., 2006): low (0-12 years of education); middle (13-15 years); and high (16 and above years).

Adult health.—Disability is defined according to difficulty with activities of daily living (ADLs) (Katz & Akpom, 1976). ADLs reflect impairments associated with underlying conditions that induce physiological limitations and deterioration and provide a useful benchmark to calibrate demand for care, assistance, and support. ADLs are good probes of physical functioning, particularly lower body functionality (Smith, Branch & Scherr, 1990), and reflect impairment created by chronic conditions as well as cognitive and affective functioning (Stump, Clark, Johnson & Wolinsky, 1977; Wray, Herzog & Park, 1996; Wray & Lynch, 1998). We use dressing, toileting, bathing and transferring and define the proportion of elderly with at least one ADL using a harmonized measure of ADLs. We harmonized ADLs according to Pluijm et al. (2005) by selecting items in common across most countries (dressing, bathing, toileting and transferring). In the case of countries which do not have a particular item (Costa Rica—difficulty in dressing, Indonesia—toileting and transferring, and China-CHNS—transferring), we constructed items using physical performance measures following guidelines developed by Pluijm et al. (2005). Country-specific Cronbach alpha and the Kuder-Richardson coefficient of reliability (Kuder & Richardson, 1937) were used to test the internal consistency and the reliability of the items. We defined a dichotomous variable for reporting at least one ADL (1=at least one difficulty, 0=none) and then assess the construct validity by examining the country-specific relationship between disability and age group. Results from harmonizing the ADLs show very good country-specific reliability and validity of the harmonized ADL measure. In all countries, (1) internal consistency was very high (kr20 ranged from 0.66-0.93); (2) age was significantly associated with reporting at least one ADL (Figure 2); and (3) there were significant associations between poor self-reported health and disability. In most countries there were significant associations between disability and adult heart disease, diabetes and obesity.

Adult chronic conditions were defined by dichotomous variables using self-reported heart disease and self-reported diabetes from the PREHCO study. These variables ask the respondent if a doctor has ever diagnosed them with heart disease or diabetes. In some cases (e.g. SAGE), there are questions asked of the respondent which capture symptoms for heart disease and these were used to construct an alternative measure of heart disease. Other countries such as Costa Rica had biomarkers for diabetes which were also used to construct an alternative measure of diabetes. Mortality data was available in some countries and we used poor self-reported health as a proxy for mortality given its strong association with mortality.

Adult conditions.—These conditions included obesity (a dichotomous variable indicating if BMI>=30) and adult behavior (smoking). Smoking is defined according to non-smokers (never smoked), former smokers and current smokers.

Analysis

We first examined the association between rural/urban birthplace and other early life conditions because birthplace is a variable present across most countries and we are using it in this paper as one of the primary variables reflecting poor early life conditions. We also examined associations between rural/urban birthplace and disability and adult chronic conditions, poor self-reported health and obesity. Following the conceptual framework (Figure 1), we then used a three step process for model estimation for each country. In the first step, the effects of poor early life conditions (rural/urban birthplace, adult height, childhood health and childhood SES) are estimated on adult heart disease and diabetes, controlling for age, gender, respondent's educational level and smoking. In the second step, the effects of poor early life conditions are estimated on adult disability with the same variables but also controlling for either adult heart disease or diabetes. In the third step, the effects are estimated on adult mortality and poor self-reported health, controlling also for reporting at least one difficulty with functionality. Overall models to examine the effects of poor childhood conditions on adult disability, poor self-reported health and mortality controlling only for age, gender, education and smoking are also estimated. Because not all types of childhood conditions are measured in every country, we estimated the above models for three groups of cases: (1) all countries using birthplace (rural/urban) and adult height; (2) Latin American and Caribbean countries using childhood health questions and a question rating childhood SES; and (3) Puerto Rico using season of birth in addition to childhood health, childhood SES and height. Because of smaller sample sizes for SABE cities, we also estimated models using pooled SABE data using appropriately defined country dummies. Because height is an imprecise measure of *in utero*/early infancy exposures, we also examined the possibility of a different pathway to older adult low height originating in early life as reflected in mother's education and affecting adult low height and SES with the implications for SES health disparities. Finally, we conducted several sensitivity analyses comparing results for those who have/have not visited a medical doctor in the last year; for alternative measures of heart disease and diabetes using symptom and biomarker data; and for scenarios assuming a higher prevalence of heart disease and diabetes.

Results

Sample characteristics and associations

Sample characteristics are presented in Table 1 for low and middle income countries and show that most respondents are women with some exceptions[1]; average age was similar with the exception of Bangladesh and SAGE countries which surveyed respondents earlier (1996) or later (2007-08); educational levels are low in most countries; a high percent of older adults were born in rural areas especially in the later regimes; a majority of respondents had visited a doctor within the last year and a higher prevalence of adult heart disease and diabetes tended to appear in the earlier regimes whereas there was a higher percentage of adults who had difficulty with at least one ADL in the later mortality regimes. In a comparison across countries by gender, age shows (1) increasing prevalence of heart disease in some countries, (2) higher prevalence of diabetes than in the

[1] Taiwan has more men than women due to selective migration from mainland China during WWII.

developed world in some cases, and (3) high prevalence of difficulties with functionality in some low income countries (Figures 2-4).

[Insert Table 1 and Figures 2-4 about here]

Several points are worthy of mention regarding associations between birthplace and other variables of interest. **First**, across most countries, being born in the countryside was strongly associated with several indicators of early life conditions including nutritional status, being hungry as a child and poor childhood health and economic conditions (Table 2, Panel A). Birthplace thus appears to have good validity in reflecting poor early life conditions in some countries even though it is a broad indicator of those conditions. In most cases conditions in rural areas in the developing world during the early 20th century were not as good as conditions in urban areas. Being born in rural areas was strongly associated with low adult height (Mexico, China, Brazil and in pooled SABE data), knee height (China, Barbados (but in the opposite direction), Mexico but not in pooled SABE data[2]), being hungry during childhood (China, Argentina, Mexico and Uruguay but not in other SABE cities although pooled data from SABE show strong associations), reporting poor child health (Puerto Rico but not in any of the SABE cities, although pooled SABE data show strong associations) and poor socioeconomic conditions during childhood (Costa Rica, Puerto Rico, Mexico, Argentina, Uruguay, Cuba but not in other SABE cities) and parents with no schooling (all relevant countries). Differences between rural and urban areas

[2] Results not shown for pooled SABE data.

in low height and knee height were particularly noticeable in later mortality regimes.

[Insert Table 2 about here]

Second, across all countries there were differences in parental educational attainment, which was lower in rural areas (Table 2, Panel B). The discrepancy in parental educational attainment appears to have an important effect on adult educational attainment because birthplace was also strongly associated with adult education across all countries except for Barbados, suggesting a long term effect of poor early life conditions (results not shown). Those born in rural areas have lower level of educational attainment than those born in urban areas. A higher percent of older adult respondents who were born in rural areas had not gone to school. With the exception of Barbados, a higher percent of older adults who were born in urban areas had achieved at least secondary education.

Third, there were also significant associations between birthplace and adult health outcomes such as adult heart disease, diabetes, obesity, disability and mortality across regimes, although again a reverse pattern appeared and not all countries showed an association (Table 3). In Costa Rica and Puerto Rico there was a higher prevalence of heart disease among respondents born in rural areas whereas the pattern was just the opposite in Mexico, India, Ghana and China. In Puerto Rico there was a higher prevalence of diabetes in rural areas whereas the pattern was just the opposite in Mexico, China, India, Ghana, and South Africa. An examination of adult education with birthplace and prevalence of health outcomes showed that, in many countries, education was strongly associated with adult heart disease and diabetes although a reverse pattern appears in very late regimes with a higher prevalence of adult heart disease and diabetes among those born in urban areas (results not shown)[3]. Urban/rural birthplace is also associated with adult functionality but not so strongly with adult mortality.

[Insert Table 3 about here.]

Multivariate Models—Birthplace and older adult health

Several insights are obtained upon examining models estimating the effects of rural birthplace on older adult health (Table 4). **First,** a strong pattern emerges that reflects a protective effect of rural birthplace on chronic conditions such as heart disease and diabetes for the later regimes but a strong positive effect for mid-mortality regimes for heart disease in particular (Costa Rica and Puerto Rico) (Table 4, Models 1-2). Sensitivity analysis making different assumptions about the prevalence of heart disease and diabetes in the very late regimes produced similar results and suggests that underestimation of reporting of adult heart disease and diabetes may not have serious consequences in model estimations. **Second**, the pattern changes slightly when examining ADLs (Table 4, Models 3-5). There are strong associations between birth place and ADLs, especially in the later regimes. This suggests a direct link with functionality from childhood that is especially strong in the later regimes. **Third**, there are stronger

[3] However, it is interesting to note that the reverse pattern does not appear when using the indicator for heart disease based on symptoms. This suggests we need the need for further sensitivity analyses to better understand the impact of underestimation of self-reported health.

associations between rural birthplace and poor self-reported adult health than there are between rural birthplace and mortality (Table 4, Models 6-11). Curiously, in the case of China, there is a protective effect of rural birthplace on adult mortality. **Fourth**, heart disease and diabetes have consistently strong positive effects on functionality, poor self-reported health and mortality across countries.

[Insert Table 4 about here]

Multivariate Models—Height and adult health

As expected, low height – a potential measure for stunting in early life but still a very imprecise measure of *in utero* exposures - showed no associations across countries with older adult heart disease and diabetes (Table 5, Models 1-2). However, there were strong associations with ADLs in the later regimes (Table 5, Models 3-5), poor self-reported health in several earlier regimes (Table 5, Models 6-8) but not as strong for adult mortality (Table 5, Models 9-11). Not surprisingly and as in previous models with birthplace, there are consistently strong associations between heart disease, diabetes and adult functionality, poor self-reported health and mortality.

[Insert Table 5 about here]

Multivariate Models—Poor childhood health and adult health

There was a pattern of strong associations between poor childhood health and older adult heart disease and diabetes across surveys which asked respondents about their childhood health (Table 6, Models 1-2). No significant results appeared for Costa Rica but this result may be due to either the different measure of poor childhood health used or the potentially mediating effect that a good quality primary health care system (as is the case in Costa Rica) can have at older ages. There were also strong direct associations between poor childhood health and functionality which did not appear to greatly attenuate after adding heart disease or diabetes (Table 6, Models 3-5). There were also strong associations with adult poor self-reported health (Table 6, Models 6-8) but fewer associations with adult mortality (Table 6, Models 9-11). Similar strong associations between heart disease, diabetes and other measures of adult health appeared.

[Insert Table 6 about here]

Multivariate Models—Season of birth and adult health

There were strong associations between having been born at the end of the lean season (4^{th} quarter of birth) and adult heart disease and diabetes (as previously reported in McEniry et al., 2008) (Table 7, Models 1-2) but these associations disappear when examining ADLs, poor self-reported health and mortality suggesting that in the case of Puerto Rico the effects of poor early life conditions on adult heart disease and diabetes originate in very early life and that these chronic conditions then exhibit very strong effects on adult functionality and mortality (Table 7, Models 3-8).

[Insert Table 7 about here]

Multivariate Models—Height and associations with parental and adult SES

The results for parental SES, adult SES and height suggest a pathway to adult health originating in early life with mother's education and continuing through adult height and SES and then possibly appearing in health disparities. There were very strong associations between the lack of formal schooling for the respondent's mother and adult low height (Table 8, Model 1) and adult SES (Table 8, Models 2-3) across most countries and mortality regimes. As expected, there were no strong associations between low height and adult heart disease for earlier regimes whereas low height appears to have a protective effect on health for later regimes (Table 8, Models 4-5). There were strong associations between low height and adult functionality for the later regimes (Table 8, Model 6). Later regimes also show stronger associations with poor self-reported health (Table 8, Model 7). Only Puerto Rico and Bangladesh showed strong positive associations between low height and adult mortality (Table 8, Model 8).

[Insert Table 8 about here]

Discussion

This paper examined the conjecture that historical demographic forces in the early 20^{th} century produced a larger pool of survivors of poor early life conditions and that these survivors may be more susceptible to the effects of these conditions at older adult ages. Using a recently compiled cross national data set of over 130,000 older adults in 19 low, middle and high income countries representing different timing and pace of mortality decline in the early 20^{th} century (early, mid- and late mortality regimes), we tested the conjecture that the effects of poor early life conditions on adult chronic conditions (heart disease and diabetes) and subsequently adult disability and mortality are stronger among older adults born during the late 1920s-early 1940s in countries which were beginning to have more consistent but rapid mortality decline due to widespread public health initiatives and medical technology (mid-mortality regimes). We found a pattern of effects that suggests that (1) there are strong positive effects of poor early life conditions (poor nutrition, infectious diseases and socioeconomic status) on adult chronic conditions (heart disease and diabetes) among older adults born in mortality regimes which during the late 1920s and early 1940s most probably produced a larger number of survivors of poor early childhood conditions and who are now experiencing a higher prevalence of heart disease and diabetes; and (2) there are weaker positive effects of these conditions among older adults born in harsher mortality regimes and who now have much lower prevalence of chronic conditions. The conclusions remain essentially the same when alternative indicators using biomarkers and symptom questions were used and when a subset of respondents who had visited a doctor at least once in the last year was used.

The results suggest some evidence of the merit of the conjecture although it is not overwhelming evidence. The results confirm results from other studies showing the association between early life conditions and adult heart disease and diabetes (Palloni et al., 2005). They also confirm studies which have shown a strong association between adult chronic conditions and disability and mortality (Kuh & Ben-Shlomo, 2004). Although the conjecture has some merit that is not to say that early life conditions do not also impact adult health in very late regimes as demonstrated by associations with functionality, poor self-reported health and mortality. Rather it suggests a more direct pathway to adult disability and mortality from early life. These low income countries in fact have yet to see the large increase in heart disease and diabetes as have Costa Rica or Puerto Rico.

The results of the sensitivity analysis suggest that the explanation for the initially observed protective effects on adult heart disease and diabetes for China, Bangladesh and India may in fact reflect differences in environmental conditions in early life rather than differences in underreporting of chronic conditions using survey self-reports. Poorer conditions in urban areas do not appear to explain the observed pattern as conditions in rural areas in most of these countries were much worse than in urban areas (e.g. Banister, 1987). In the case of Puerto Rico, conditions had begun to improve in rural areas and mortality decline had begun because of improvements in child and infant mortality. Thus, the higher prevalence of heart disease and diabetes may indeed have its origins in early life in these countries (the tip of the iceberg). In Puerto Rico we expected to see

Barker-type effects in country-born more than the urban-born respondents because conditions were worse than in the urban-born, while at the same time conditions had begun to improve.

The major limitation of the paper is one of measurement in population studies in terms of (1) standard and harmonized measures across surveys and countries; (2) definition and underestimation of adult chronic conditions, (3) imprecise measures of early life conditions (retrospective), (4) lack of richer and more objective data linking early life conditions to individual older adults, (5) imprecision of mortality regimes and the small number of countries within some regimes, (6) nature of some surveys such as SABE which represent cities and not countries; and (7) difficulty controlling for other factors such as the effects of health care systems at older ages. The measure for disability using ADLs showed good validity and reliability, but the use of self-reports to test the conjecture presents the possibility of unknown measurement error. While studies have shown that self-reports do in some circumstances show good validity with more objective measures (Banks et al., 2006; Goldman et al., 2003), other studies suggest that in the case of Latin America and the Caribbean self-reports may grossly underestimate the true prevalence of chronic conditions (Andrade, 2008). In addition, questions asked regarding heart disease do vary slightly across countries and thus it is not clear what type of heart disease is being captured in the more general question in SABE cities (heart attack, coronary heart disease, congestive heart failure, angina, or other heart problems) versus a question that asks directly about being diagnosed with angina (e.g. SAGE). Imprecise measurement of early life conditions may also be problematic since respondents are asked if they were born in a rural or urban area without a clear definition of rural or urban. In addition, questions varied across countries in terms of the number of years lived in rural/urban areas as a young child. Birthplace was used in this paper in an attempt to include as many countries as possible but it is not the only measure for early life conditions and other measures such as poor childhood health require using a smaller sample of countries by which to compare health. It may be that until there are better measures of health outcomes using biomarkers and complementary data on early life conditions, it may not be possible to fully examine conjectures such as the one presented in this paper. Trying to be precise is difficult in the imprecise world of population studies.

Testing the conjecture in the midst of these circumstances is challenging to say the least. Wanting to have "better" and more precise data along with a cohort of data which more directly links individuals to their early life circumstances is ideal but unachievable to-date. Yet, even if the data are not the best in terms of being able to more rigorously examine the effects of early life exposures on older adult health, results from this study suggest that the endeavour is not completely in vain. The mere ability to examine for the first time cross national data on older adult health from so many diverse and major studies on aging in low and middle income countries has the value of being able to observe the whole, confirm the expected and yet discover quite unexpected patterns. In that regard, the observed cross national patterns presented in this paper lead us to not completely discard the possibilities of the conjecture—a conjecture which is admittedly very difficult to fully test. In the future, it will be important to continue to refine the results of this study and to move forward to (1) pursue the possibility of obtaining historical data which could complement these survey data if not with all countries at least with some; (2) include other country-specific measures of early life conditions and examine individual countries more carefully; (3) further examine the validity of the harmonized ADLs by comparing them with more objective measures of mobility across pertinent countries; and (4) use imputed data to ensure that all relevant cases are included in the analysis.

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Table 1: Sample Characteristics for those born during the late 1920s – early 1940sm **(continued on next page)**

Country/Regime (Sample size)	% female	age (sd)	education (sd)	% born rural	% visited doctor within last year	% heart disease	% diabetes	% at least one ADL	% obese
Early Regime									
Argentina (n=745)	61	67 (4.2)	7.1 (4.6)	39.5	81.0	19.6	12.9	12.0	n.a.[a]
Cuba (n=1234)	59	66.4 (4.4)	7.7 (3.9)	50.7	72.8	22.5	14.4	12.3	16.4
Uruguay (n=1013)	63	67 (4.1)	6.8 (4.6)	39.1	74.5	20.8	13.4	12.1	33.6
Mid-Paced Regime									
Chile (n=858)	63	66.8 (4.2)	5.8 (4.5)	49.9	72.7	32.7	13.5	18.0	33.4
Costa Rica (n=1317)	54	67.5 (4.0)	4.5 (4.0)	72.8	92.4	11.0	22.8	12.3	25.3
Puerto Rico (n=2693)	60	66.6 (4.2)	8.6 (4.8)	56.9	85.4	16.9	29.7	11.7	31.4
Taiwan (n=546)	42	67.5 (4.6)	5.3 (4.3)		37.5	16.5	16.3	3.8	8.3
S Africa (n=1390)	61	70.5 (4.8)	5.3 (4.7)	37.6	64.6	6.4	12.3	24.4	41.3
Late Regime									
Barbados (n=923)	60	67.1 (4.1)	5.6 (3.6)	47.2	90.2	9.2	21.8	6.3	29.6
Brazil (n=1141)	61	66.6 (4.3)	3.6 (3.5)	61.6	83.3	18.4	18.7	15.4	24.1
Mexico-MHAS (n=5440)	53	65.9 (4.2)	3.8 (4.1)	48.2	66.1	4.0	18.2	10.4	22.0
Mexico (n=923)	59	66.1 (4.3)	4.8 (4.6)	54.5	78.6	8.9	21.6	13.1	32.2
Very Late									
Bangladesh (n=1879)	48	62.2 (3.8)	1.8 (3.0)	98.6	69.0		15.4	15.9	0.1
China-CLHLS (n=3323)	50	69.5 (2.9)	3.1 (4.0)	83.1	92.4	20.4	14.6	4.5	

Country/Regime (Sample size)	% female	age (sd)	education (sd)	% born rural	% visited doctor within last year	% heart disease	% diabetes	% at least one ADL	% obese
China-CHNS (n=1592)	52	66.3 (3.9)	3.7 (4.4)	61.6		1.7	4.0	30.6	4.5
China-SAGE (n=4693)	52	71.3 (4.7)	4.5 (4.7)	58.1	61.4	12.9	8.8	6.7	5.6
Ghana (n=1766)	52	71.1 (4.8)	2.8 (4.7)	51.5	67.7	4.3	4.1	28.4	7.3
India (n=2409)	45	69.9 (4.7)	3.1 (4.4)	77.8	86.9	6.5	8.1	30.8	2.8
Indonesia (n=3482)	54	66 (4.2)	3.2 (4.0)	83.3	12.2			10.4	2.3

Source: Cross national data; results not weighted.
Note: MHAS respondents were asked about heart attacks and not about heart disease. In the case of Argentina, anthropometric measures were not obtained.

Table 2: Association between birthplace and early life conditions

PANEL A	% Low height			% Low knee height			% Hungry as children			% Poor child health			% Poor child SES		
Regimes	**Born urban**	**Born rural**	**p-value**	**Born urban**	**Born rural**	**p-value**	**Born urban**	**Born rural**	**p-value**	**Born urban**	**Born rural**	**p-value**	**Born urban**	**Born rural**	**p-value**
Early Regime															
Argentina							6.7	16.1	0.000	2.1	4.9	0.060	50.4	66.0	0.000
Cuba	18.6	18.9	0.901	24.4	23.6	0.741	23.3	27.6	0.084	4.2	5.7	0.220	73.2	78.8	0.022
Uruguay	16.0	18.5	0.329	18.7	18.6	0.955	10.0	15.1	0.020	2.8	5.0	0.088	62.8	70.4	0.018
Mid-Paced Regime															
Chile	18.9	19.9	0.723	22.2	20.8	0.624	24.6	23.7	0.778	7.3	7.4	0.977	63.5	62.0	0.650
Costa Rica	13.0	16.6	0.135	19.2	22.5	0.213				9.0	9.3	0.842	56.4	62.9	0.044
Puerto Rico	18.0	19.2	0.472	25.1	24.7	0.828				17.7	25.1	0.000	76.2	81.5	0.002
South Africa	29.3	29.8	0.846										48.5	72.8	0.000
Late Regime															
Barbados	19.3	16.1	0.250	22.7	16.4	0.022	18.7	16.2	0.346	1.2	2.1	0.298	81.8	84.1	0.386
Brazil	11.5	21.1	0.000	15.7	20.8	0.052	17.5	22.1	0.072	5.9	6.9	0.510	67.2	72.3	0.073
Mexico-MHAS	15.8	20.9	0.008	20.7	29.0	0.087				8.8	10.0	0.497	57.0	90.0	0.000
Mexico	13.4	21.9	0.002	19.9	27.1	0.019	25.1	35.6	0.001	5.3	4.2	0.445	77.8	55.3	0.294
Very Late Regime															
Bangladesh	33.3	24.7	0.364												
China-CLHLS				16.2	20.5	0.021	44.1	68.2	0.000						
China-CHNS	23.1	38.6	0.000												
China-SAGE	21.8	41.9	0.000												
Ghana	29.2	29.2	0.994												
India	30.1	32.4	0.321												
Indonesia	30.9	36.2	0.042												

Table 2 Continued

PANEL B		% Respondents with Mother's Education				% Respondents with Father's Education			
Regimes		No school	Primary	Secondary	More than	No school	Primary	Secondary	More than
Mid-Paced Regime									
Costa Rica	Rural	34.5	64.0	1.0	0.5				
	Urban	22.3	69.9	6.1	1.7				
	P-value	0.000							
Puerto Rico	Rural	47.4	45.4	7.2		40.9	48.6	10.5	
	Urban	27.5	47.1	25.4		21.7	46.5	31.8	
	P-value	0.000				0.000			
South Africa	Rural	81.2	15.2	3.2	0.5	72.8	20.9	5.1	1.3
	Urban	58.2	31.5	7.4	2.9	48.5	36.5	13.0	2.0
	P-value	0.000				0.000			
Late Regime									
Mexico-MHAS	Rural	74.6	24.4	1.0		69.4	29.3	1.4	
	Urban	51.5	44.9	3.7		45.6	48.1	6.4	
	P-value	0.000				0.000			
Very Late Regime									
Bangladesh	Rural	93.1	6.3	0.4	0.2	74.3	15.5	9.8	0.4
	Urban	70.8	16.7	12.5	0.0	36.0	16.0	48.0	0.0
	P-value	0.000				0.000			
China-SAGE	Rural	97.2	2.6	0.2	0.0	85.0	12.6	2.3	0.3
	Urban	86.7	9.6	3.0	0.7	63.0	24.6	10.1	2.3
	P-value	0.000				0.000			
Ghana	Rural	98.2	1.5	0.3	0.0	92.1	4.6	2.7	0.6
	Urban	94.7	3.0	2.1	0.2	82.9	7.7	8.3	1.0
	P-value	0.000				0.000			
India	Rural	95.3	4.3	0.3	0.1	76.1	18.4	4.7	0.9
	Urban	77.3	17.4	4.9	0.4	45.8	33.5	14.3	6.4
	P-value	0.000				0.000			
Indonesia	Rural	86.7	12.4	0.9		74.5	23.8	1.7	
	Urban	74.0	21.8	4.2		56.6	33.0	10.4	
	P-value	0.000				0.000			

Table 3: Association between birthplace and adult health outcomes for those born late 1920s-early 1940s

Country	% Corazon			% Diabetes			% Obese			% At least one ADL			Died during waves		
	Born urban	Born rural	p-value	Born urban	Born rural	p-value	Born urban	Born rural	p-value	Born urban	Born rural	p-value	Born urban	Born rural	p-value
Early Regime															
Argentina	19.6	19.8	0.949	10.6	16.2	0.043				11.2	12.7	0.575			
Cuba	22.7	22.6	0.971	15.5	13.2	0.267	16.0	16.9	0.711	14.0	10.8	0.097			
Uruguay	21.5	21.9	0.909	12.5	14.7	0.321	31.9	35.0	0.341	12.2	12.3	0.967			
Mid-Paced Regime															
Chile	31.2	34.0	0.379	14.0	13.3	0.774	35.0	32.2	0.411	16.1	20.0	0.143			
Costa Rica	8.0	12.5	0.027	23.3	22.9	0.890	26.6	24.5	0.462	11.5	12.7	0.572	7.6	5.7	0.212
Puerto Rico	13.9	19.7	0.000	27.6	31.6	0.037	34.6	29.6	0.011	9.7	13.2	0.008	9.2	9.1	0.929
South Africa	7.5	4.7	0.062	15.2	7.8	0.000	42.5	37.1	0.071	21.2	29.2	0.002			
Late Regime															
Barbados	8.6	10.3	0.387	20.1	23.1	0.303	30.2	27.2	0.349	6.8	5.2	0.363			
Brazil	17.9	18.8	0.726	15.5	20.1	0.058	30.3	20.7	0.001	13.2	18.0	0.042			
Mexico-MHAS	4.8	2.4	0.004	21.6	13.9	0.000	24.0	19.2	0.024	9.3	9.0	0.792	4.1	3.8	0.732
Mexico	9.6	7.7	0.297	19.9	23.2	0.226	35.2	30.1	0.129	13.5	13.0	0.828			
Very Late Regime															
Bangladesh				28.0	15.2	0.078	0.0	0.1	0.908	8.3	16.0	0.310	40.0	32.1	0.404
China-CLHLS	28.0	18.9	0.000	22.3	13.1	0.000				5.0	4.4	0.538	9.5	9.0	0.737
China-CHNS	2.0	1.5	0.494	6.7	2.3	0.000	5.5	3.8	0.145	28.7	31.9	0.235	34.5	25.1	0.000
China-SAGE	17.3	9.7	0.000	13.2	5.6	0.000	7.0	4.7	0.001	5.1	7.9	0.000			
Ghana	5.4	3.4	0.041	5.3	2.8	0.009	10.9	3.9	0.000	27.8	29.3	0.502			
India	10.5	5.5	0.000	17.1	5.6	0.000	4.2	2.5	0.046	26.9	32.0	0.025			
Indonesia							3.6	2.0	0.050	11.7	10.1	0.317	26.6	24.0	0.250

Table 4: Effects of rural birthplace on older adult health (continued on next page)

	Model 1: Heart Disease	Model 2: Diabetes	Model 3: ADLs	Model 4: ADLs	Model 5: ADLs	Model 6: Poor health	Model 7: Poor health	Model 8: Poor health	Model 9: Mortality	Model 10: Mortality	Model 11: Mortality
Very Early Regimes											
US-WLS											
Rural	0.88	0.86				0.95			0.73		
Heart Disease											
Diabetes											
Early to Late Regimes											
Pooled SABE											
Rural	1.03	1.07	0.89	0.89	0.88	1.15*	1.15*	1.14*			
Heart Disease				2.10***			3.14***	2.54***			
Diabetes					1.59***						
Mid-Paced Regimes											
Costa Rica	1.74*	0.95	0.98	0.98	0.98	1.31*	1.29	1.33*	0.73	0.70	0.74
Rural				1.61			2.79***			2.13*	
Heart Disease					1.39			1.90***			2.85***
Diabetes											
Puerto Rico											
Rural	1.44**	1.20	1.27	1.20	1.24	1.38***	1.30**	1.32**	0.84	0.80	0.81
Heart Disease				2.37***			2.79***			1.66**	
Diabetes					1.68***			2.75***			2.00***
South Africa-SAGE											
Rural	0.61	0.60*	1.58**	1.64***	1.65***	1.45*	1.33	1.39			
Heart Disease				2.44***			2.03*				
Diabetes					1.89**			2.53***			
Late Regimes											
Mexico-MHAS											
Rural	0.47**	0.58***	0.89	0.87	0.90	1.16	1.17	1.23	0.80	0.75	0.78
Heart Disease				1.87			2.75**			3.86***	
Diabetes					1.94***			3.64***			2.33**

	Model 1: Heart Disease	Model 2: Diabetes	Model 3: ADLs	Model 4: ADLs	Model 5: ADLs	Model 6: Poor health	Model 7: Poor health	Model 8: Poor health	Model 9: Mortality	Model 10: Mortality	Model 11: Mortality
Very Late Regimes											
Bangladesh											
Rural		0.41	1.18		1.30	2.02		2.21	0.52		0.62
Heart Disease											
Diabetes					2.02***			2.07***			1.67***
China-Duke											
Rural	0.74**	0.66***	0.80	0.83	0.82	0.98	1.03	1.04	0.83	0.87	0.90
Heart Disease				1.76**			1.94***			1.19	
Diabetes					1.51			1.42*			1.94***
China-Popkin											
Rural	0.64	0.36**	1.28	1.28	1.39*	1.07	1.06	1.06	0.70**	0.72*	0.71*
Heart Disease				3.31*			2.61			0.63	
Diabetes					2.96***			2.25*			1.32
China-SAGE											
Rural	0.67***	0.54***	1.50**	1.56**	1.53**	1.56***	1.61***	1.57***			
Heart Disease				2.07***			2.93***				
Diabetes					1.69**			2.19***			
Ghana-SAGE											
Rural	0.59*	0.66	1.07	1.08	1.08	0.90	0.92	0.92			
Heart Disease				1.69*			2.27***				
Diabetes					1.70*			2.84***			
India-SAGE											
Rural	0.54***	0.41***	1.08	1.09	1.11	1.23	1.23	1.25			
Heart Disease				1.39			1.44				
Diabetes					1.38			1.52*			
Indonesia											
Rural			0.90			1.10			0.90		
Heart Disease											
Diabetes											

Note: Numbers in tables are odds ratios. All models control for sex, age, education, and smoking status. ELSA and the SHARE-Netherlands did not have a variable to indicate rural/urban birthplace. *p<0.05, **p<0.01, ***p<0.001.

Table 5: Effects of low height on older adult health (continued on next pages)

	Model 1: Heart Disease	Model 2: Diabetes	Model 3: ADLs	Model 4: ADLs	Model 5: ADLs	Model 6: Poor health	Model 7: Poor health	Model 8: Poor health	Model 9: Mortality	Model 10: Mortality	Model 11: Mortality
Very Early Regimes											
ELSA											
Height	1.15	0.76	1.21	1.20	1.24*	1.47***	1.44***	1.50***			
Heart Disease				1.72***			2.91***				
Diabetes					2.12***			2.70***			
Netherlands											
Height	1.02	1.15	1.26	1.27	1.27	1.39*	1.41*	1.35*	1.09	0.97	0.98
Heart Disease				1.58			5.42***			1.12	
Diabetes					0.84			2.06***			0.97
US-HRS											
Height	0.96	1.04	0.95	0.96	0.95	1.18*	1.21*	1.19*	1.07	1.06	1.03
Heart Disease				2.60***			3.09***			2.01***	
Diabetes					2.35***			3.52***			2.25***
US-WLS											
Height	1.12	1.15				1.23*			1.04		
Heart Disease											
Diabetes											
Early to Late Regimes											
Pooled SABE											
Height	0.86	1.07	1.00	1.02	1.00	1.19*	1.22**	1.18*			
Heart Disease				1.91***			2.90***	2.43***			
Diabetes					1.37**						

	Model 1: Heart Disease	Model 2: Diabetes	Model 3: ADLs	Model 4: ADLs	Model 5: ADLs	Model 6: Poor health	Model 7: Poor health	Model 8: Poor health	Model 9: Mortality	Model 10: Mortality	Model 11: Mortality
Mid Regimes											
Costa Rica											
Height	0.70	0.93	0.96	0.99	0.93	0.76	0.76	0.75	1.27	1.32	1.27
Heart Disease				1.69*			2.55***			1.70	
Diabetes					1.15			1.90***			2.62***
Puerto Rico											
Height	1.03	1.08	1.35	1.37	1.35	1.11	1.07	1.08	1.42*	1.39	1.38
Heart Disease				2.54***			2.66***			1.51*	
Diabetes					1.54**			2.67***			1.97***
South Africa-SAGE											
Height	0.99	1.17	1.07	1.07	1.06	1.58**	1.60**	1.57*			
Heart Disease				2.24**			2.04*				
Diabetes					1.82**			2.63***			
Taiwan											
Height	1.54	0.86	3.52*	3.49*	3.83*	0.98	0.81	0.89			
Heart Disease				1.33			2.59***				
Diabetes					3.13*			2.39***			
Late Regimes											
Mexico-MHAS											
Height	0.70	0.93	1.24	1.29	1.27	1.17	1.17	1.17	1.01	1.12	1.13
Heart Disease				2.53***			3.16***			2.04*	
Diabetes					1.74***			3.09***			1.76**

	Model 1: Heart Disease	Model 2: Diabetes	Model 3: ADLs	Model 4: ADLs	Model 5: ADLs	Model 6: Poor health	Model 7: Poor health	Model 8: Poor health	Model 9: Mortality	Model 10: Mortality	Model 11: Mortality
Very Late Regimes											
Bangladesh											
Height		0.93	1.41*		1.42*	1.09		1.05	1.32*		1.28
Heart Disease											
Diabetes					1.79**			1.97***			1.57**
China-Popkin											
Height	1.59	0.83	1.19	1.17	1.23	1.27	1.24	1.21	0.83	0.82	0.84
Heart Disease				3.19*			2.61			0.69	
Diabetes					2.76**			2.25*			1.47
China-SAGE											
Height	0.64	0.68	1.33*	1.39*	1.36*	1.30***	1.34***	1.29***			
Heart Disease				2.01***			2.78***				
Diabetes					1.74**			1.94***			
Ghana-SAGE											
Height	0.77	1.53	1.33*	1.34*	1.32*	1.10	1.06	1.03			
Heart Disease				1.90*			2.37***				
Diabetes					1.59			2.52***			
India-SAGE											
Height	0.71	0.85	1.33**	1.34**	1.34**	1.18	1.11	1.10			
Heart Disease				1.35			1.46				
Diabetes					1.28			1.32			
Indonesia											
Height			1.50**			1.16			0.91		
Heart Disease											
Diabetes											

Notes: Numbers in tables are odds ratios. All models control for sex, age, education, and smoking status. Low height is defined as the gender-specific lowest quartile of height. *p<0.05, **p<0.01, ***p<0.001.

Table 6: Effects of poor childhood health on older adult health

	Model 1: Heart Disease	Model 2: Diabetes	Model 3: ADLs	Model 4: ADLs	Model 5: ADLs	Model 6: Poor health	Model 7: Poor health	Model 8: Poor health	Model 9: Mortality	Model 10: Mortality	Model 11: Mortality
Very Early Regimes											
US-HRS											
Poor health	1.64***	1.15	2.41***	2.24***	2.41***	2.37***	1.87***	2.03***	1.40**	1.18	1.25
Heart Disease				2.53***			3.06***			2.00***	
Diabetes					2.35***			3.56***			2.25***
US-WLS											
Poor health	1.20	0.71				1.54*			0.54		
Heart Disease											
Diabetes											
Early to Late Regimes											
Pooled SABE											
Poor health	1.34*	1.15	1.79***	1.70***	1.78***	1.75***	1.70***	1.74***			
Heart Disease				2.01***			3.06***				
Diabetes					1.57***			2.51***			
Mid Regimes											
Costa Rica											
Poor health	0.66	0.79	0.95	0.97	0.95	1.47	1.55*	1.55*	0.52	0.54	0.57
Heart Disease				1.39			2.68***			2.12*	
Diabetes					1.20			1.96***			2.83***
Puerto Rico											
Poor health	1.50***	1.23*	1.92***	1.88***	1.89***	2.75***	2.48***	2.59***	0.88	0.83	0.82
Heart Disease				2.29***			2.57***			1.63**	
Diabetes					1.59***			2.74***			2.09***
Late Regimes											
Mexico-MHAS											
Poor health	1.75**	1.49***	1.37*	1.31	1.30	1.39**	1.31*	1.27*	0.92	0.87	0.84
Heart Disease				2.33***			3.40***			2.39***	
Diabetes					1.75***			3.15***			2.01***

Note: Numbers in tables are odds ratios. All models control for sex, age, education, and smoking status.
*p<0.05, **p<0.01, ***p<0.001.

Table 7: Effects of season of birth on older adult health in Puerto Rico

	Model 1: Heart Disease	**Model 2: Diabetes**	**Model 3: ADLs**	**Model 4: ADLs**	**Model 5: Poor health**	**Model 6: Poor health**	**Model 7: Mortality**	**Model 8: Mortality**
1st quarter	1.51*		0.89	0.85	0.89	0.84	0.89	0.86
2nd quarter (reference)								
3rd quarter	1.52*		0.88	0.83	1.08	1.05	1.08	1.02
4th quarter	1.98***		1.03	0.92	1.16	1.06	0.92	0.86
Lean Period		1.68*						
Heart Disease				2.38***		2.92***		1.73*
At least 1 ADL						7.89***		1.57

Note: Numbers in tables are odds ratios. All models control for sex, age, education, and smoking status. Models 3-8 using lean period and incorporating diabetes produced similar results as for quarter of birth and are not shown here.
*p<0.05, **p<0.01, ***p<0.001.

Table 8: Effects of mother's education on adult low height, SES and health (continued on next page)

	Model 1: Low Height	Model 2: Adult SES	Model 3: Adult SES	Model 4: Heart Disease	Model 5: Diabetes	Model 6: ADLs	Model 7: Poor health	Model 8: Mortality
Mid Regimes								
Costa Rica								
Mother's Education	1.54*	3.85***	3.71***	1.40	1.08	0.98	1.70***	0.73
Low height			1.91**	0.80	0.97	0.99	0.75	1.12
Respondent's Education				1.00	1.34	1.33	2.36***	1.62
Puerto Rico								
Mother's Education	1.56***	5.90***	6.20***	1.23	1.09	1.20	1.89***	1.59**
Low height			1.33	1.15	1.10	1.32	1.18	1.64*
Respondent's Education				1.63	1.23	2.64**	1.67	1.27
South Africa-SAGE								
Mother's Education	1.49*	13.91***	13.40***	1.54	0.80	0.69*	1.30	
Low height			0.98	1.05	1.05	0.96	1.67**	
Respondent's Education				1.06	0.68	1.28	1.29	
Late Regimes								
Mexico-MHAS								
Mother's Education	1.87***	6.38***	6.29***	1.36	1.12	1.35*	1.32***	0.92
Low height			1.66***	0.61	0.86	1.26	1.21*	1.02
Respondent's Education				0.87	1.00	1.00	1.45***	1.96***

	Model 1: Low Height	Model 2: Adult SES	Model 3: Adult SES	Model 4: Heart Disease	Model 5: Diabetes	Model 6: ADLs	Model 7: Poor health	Model 8: Mortality
Very Late Regimes								
Bangladesh								
Mother's Education	1.94*	8.99***	8.82***		0.77	1.17	1.20	0.86
Low height			1.01		0.93	1.33	1.09	1.48**
Respondent's Education					0.95	1.21	1.38*	1.21
China-SAGE								
Mother's Education	2.32***	12.46***	11.27***	0.99	0.98	1.07	1.58**	
Low height			2.38***	0.62***	0.63***	1.41**	1.40***	
Respondent's Education				0.52***	0.45***	1.38*	1.63***	
Ghana-SAGE								
Mother's Education	0.82	5.79***	5.91***	0.50	1.83	1.48	1.88	
Low height			1.25	0.80	1.42	136**	1.08	
Respondent's Education				1.30	0.32***	0.94	1.05	
India-SAGE								
Mother's Education	1.58**	19.43***	18.95***	0.87	0.36***	1.57*	1.69**	
Low height			1.01	0.69	0.81	1.33**	1.20	
Respondent's Education				0.50***	0.41***	1.38**	1.45***	
Indonesia								
Mother's Education	1.53**	13.63***	13.30***			0.66	0.98	0.83
Low height			1.15			1.56*	1.15	0.93
Respondent's Education						0.83	0.87	0.97

Notes: Numbers in tables are odds ratios. All models control for sex and age. Mother's education reflects whether or not the respondent's mother had any schooling (value of 1). Respondent's education reflects whether or not the respondent had any schooling (value of 1). Low height is defined as the lowest quartile of height. *$p<0.05$, **$p<0.01$, ***$p<0.001$.

Figure 1: Pathways of interest leading to adult disability and death

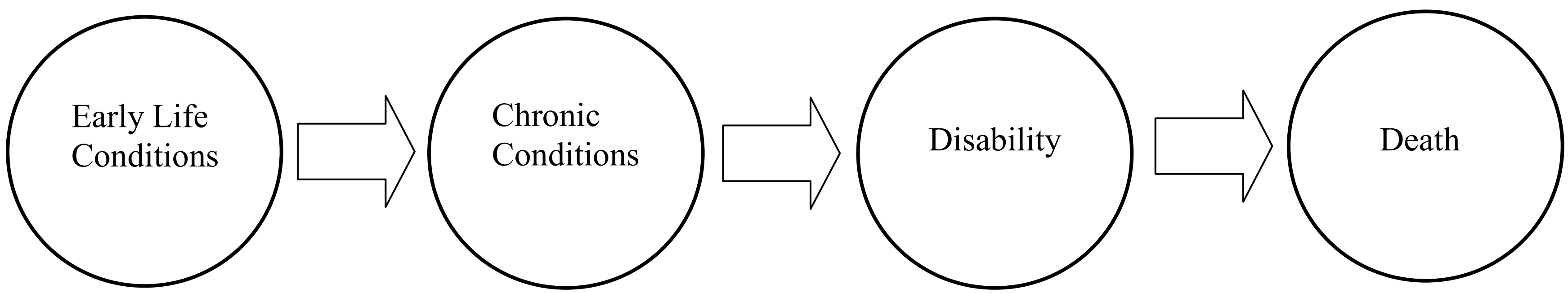


Figure 2: Adult heart disease across mortality regimes

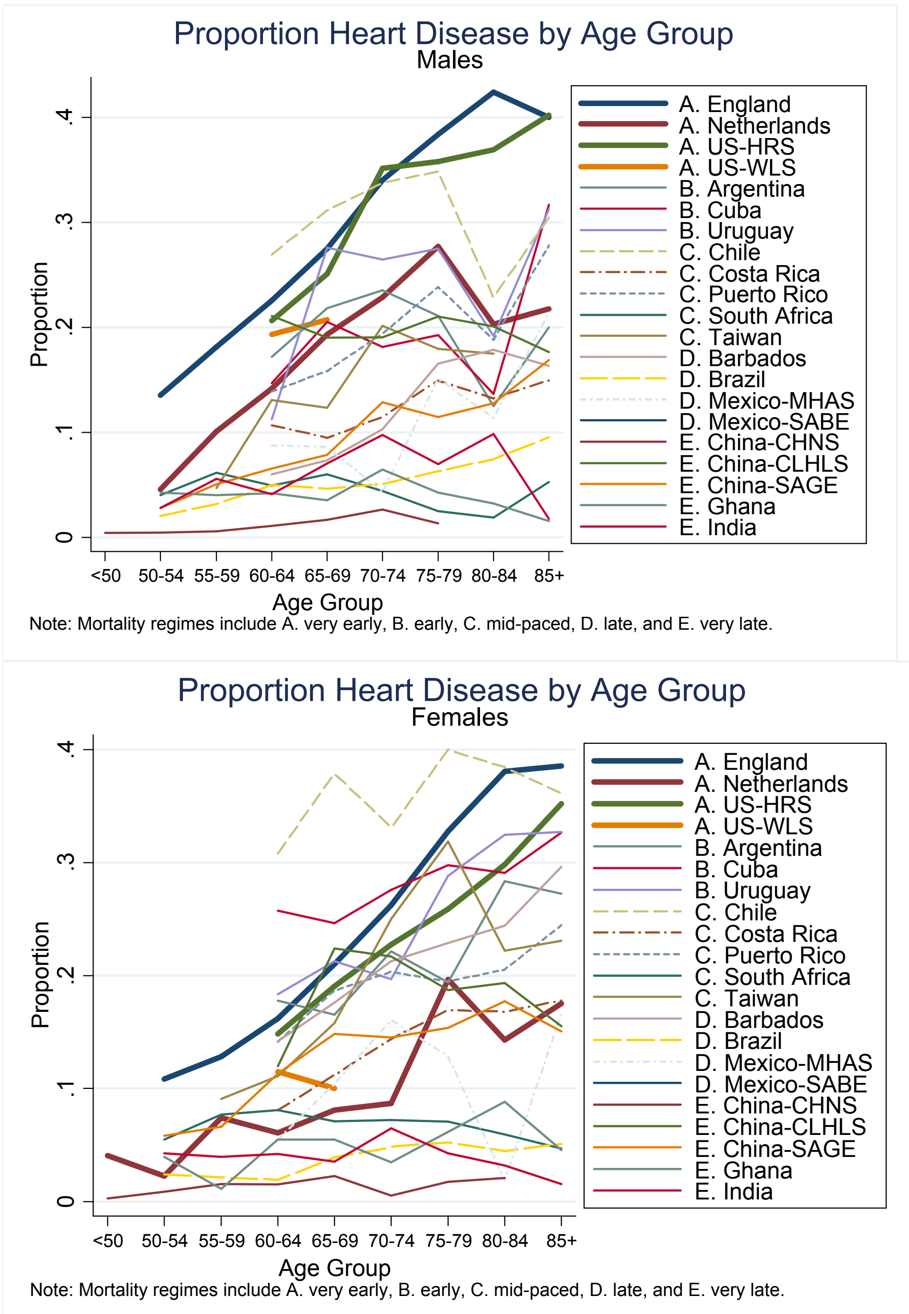
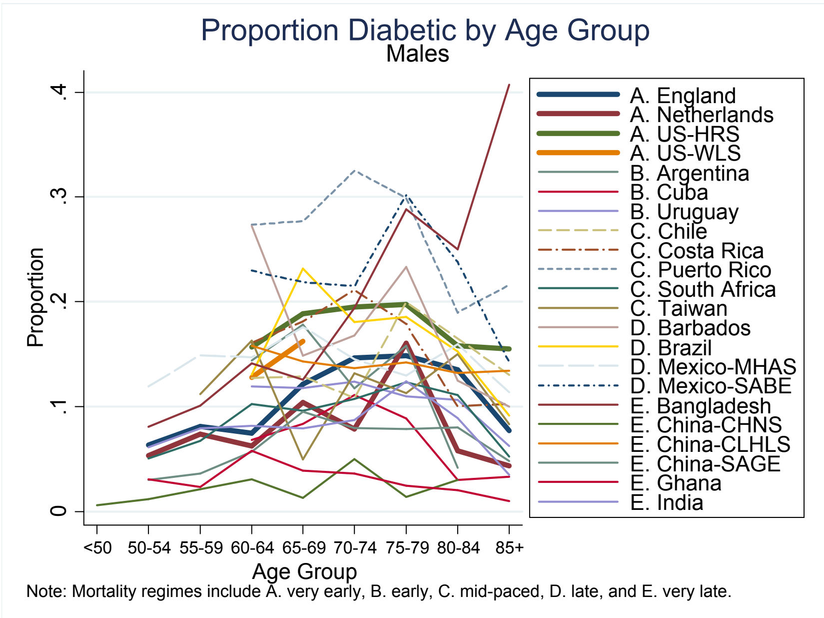


Figure 3: Adult diabetes across mortality regimes



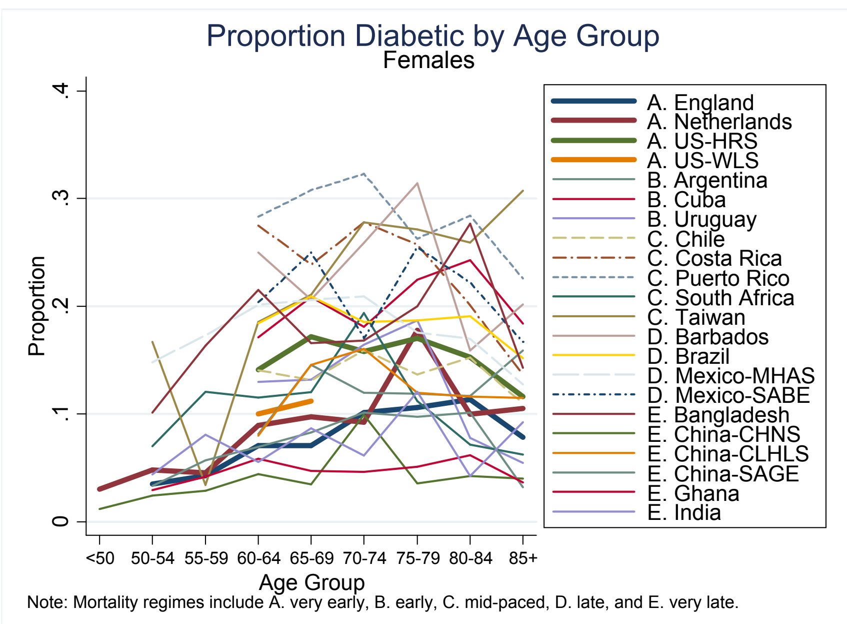


Figure 4: Adult disability across mortality regimes