The health transition and mortality among older adults

in Latin America, the Caribbean, Asia and Africa

Mary McEniry
Center for Demography & Ecology
Center for Demography of Health & Aging
University of Wisconsin-Madison

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Abstract

The dramatic mortality decline of the 1930s-1960s in developing countries may have created a larger pool of adult survivors of poor childhood conditions. If hypotheses regarding the importance of early life exposures on adult health have merit, we would expect to observe that the health of older adults from these cohorts would be unduly influenced by these exposures. We examined this conjecture by selecting a cross-national sample of adults 60 years and older that were born during different stages (regimes) of the health transition using data from major studies on aging in Latin America (Costa Rica, Mexico, major cities), the Caribbean (Puerto Rico), Asia (China, India, Indonesia, Bangladesh, Taiwan), Africa (Ghana, South Africa), the US, the UK and the Netherlands. We estimated mortality risk and constructed Waaler-type surfaces to estimate expected relative mortality risk. For countries with mortality data we found: (1) strong effects of early childhood conditions (markers of nutrition and indicators of childhood health) on adult heart disease and diabetes, especially in the mid-to-late regimes (Puerto Rico, Mexico); but (2) no significant effects or weaker effects of these early childhood conditions on adult mortality when heart disease and diabetes were controlled for, especially in the mid-to-late paced regimes; (3) higher observed relative risk for diabetics and those with heart disease but mixed results for obesity; (4) higher excess of relative risk of dying for diabetes and heart disease in mid to late regimes. Using modified Waaler surfaces for countries without mortality, we found higher expected relative risk of mortality in mid-to-late regimes. Implications: in some instances, future trends in life expectancy in the developing world may be negatively affected as a result of poor adverse childhood conditions in cohorts who are now experiencing increasing prevalence of heart disease and diabetes.

Introduction

The aim of this paper is to examine the degree to which there is evidence to support the conjecture that differences in the evolution of mortality in the developing world during the 20th century have important implications for mortality among elderly adults. Because the relatively compressed schedule of aging in countries (for example, in the Latin American and Caribbean region) can in part be traced to the medical and public health revolution that triggered the mortality decline over half a century ago (Preston, 1976; Palloni et al., 2007), it may be possible to observe differences in elderly mortality patterns according to the nature of (timing and speed) and reasons for mortality decline. These particular characteristics of mortality decline may have created cohorts with differential mortality experiences leading to different health patterns later in the life course.

Mortality began to decline in the early 20th century in some countries of the developing world and by the 1930s-1960s many countries experienced rapid mortality decline. The primary reasons for mortality decline in the early 20th century was a mixture of improvements in standards of living, public health interventions and medical technology (Preston, 1976) and countries differed according to the timing and pace of their health transition. Thus, different patterns of mortality decline emerged. Countries in the Latin American and Caribbean region such as Argentina and Uruguay which already had a relatively high standard of living in the early 20th century experienced a more graded mortality decline during the first part of the century. Other countries such as Chile, Costa Rica, Puerto Rico, South Africa and Taiwan could be considered more mid-paced regimes. For the most part they experienced an early but less graded mortality decline over the course of the first part of the 20th century. Consistent mortality

decline began in the 1920s and was due more to preventive public health interventions than to improvements in standard of living. Larger countries such as Brazil and Mexico experienced earlier mortality decline but the dramatic declines in mortality occurred after 1940. Very small countries such as Barbados also experienced late and rapid mortality decline after 1940 and other countries such as Indonesia, Bangladesh, India, China and Ghana experienced significant mortality decline during the 1950s.

The mortality decline during the 1930s-1960s was primarily due to public health interventions and improved medical technology (Preston, 1976), the gains of which were concentrated early in the life of individuals, between birth and age 5 or 10. However, while most countries experienced improvements in life expectancy during this period, the magnitude of the mortality decline at younger ages differed across countries according to the nature of (timing and pace) and reason for the mortality decline that had occurred--for the most part earlier regimes experienced less dramatic improvements and gains in infant and child mortality than did the mid to later regimes.

The relevance of the different mortality patterns experienced during the early 20th century to the health of today's aging population in the developing world is due to the increasing evidence of the importance of early childhood conditions on adult health. Exposure to poor nutrition during pregnancy can lead to adult chronic conditions such as diabetes and heart disease (Barker, 1998; Eriksson et al., 2001). Both poor childhood socioeconomic conditions (SES) and childhood health can also have substantial impacts on adult health and chronic conditions (Lundberg, 1991; Hertzman, 1994; Wadsworth et al., 2002; Wadsworth & Kuh, 1997; Davey Smith & Lynch, 2004; Elo & Preston, 1992). Chronic conditions such as heart disease and diabetes are projected to dramatically increase in the developing world (Murray & Lopez, 1996).

There are important public health ramifications regarding services for older adults and programs for mothers and children if poor early life exposures are important determinants of heart disease or diabetes.

The mid-paced (Costa Rica, Chile, Puerto Rico, Taiwan, South Africa) to late (Mexico, Brazil, Barbados) and very late, rapid (China, Bangladesh, India) mortality decline experienced by some cohorts born during the 1930s-1960s is of particular interest because it produced a larger cohort of individuals who survived poor early childhood conditions, many of whom may also have reached older adult ages. These cohorts are more at risk of having been affected by harsh early childhood experiences while at the same time had larger probabilities of surviving. Prior to the mid 1940s, the mid-paced regimes experienced important increases in infant and child survival whereas it was only after the 1940s that the later regimes experienced major improvements. Thus, older adults born in mid-paced cohorts prior to the mid 1940s may be able to provide some insights into whether early childhood experiences are indeed important in later life because they were less affected by mortality-driven selection than the group of cohorts who preceded them (those aged 75 and older) but were also less affected than the group of cohorts who were born in very late regimes during the same period.

If the Barker hypothesis (or any other hypothesis regarding the importance of childhood conditions) has merit, we would expect to observe that the adult health of these cohorts (and in particular the mid-paced regimes prior to the mid 1940s) has been unduly influenced by poor early childhood conditions. Building on previous research (Palloni & McEniry, 2007), if we are able to adequately capture early life conditions and control for other confounding factors, then upon examining adult mortality in older adults born during the late 1920s and early 1940s[1] we

[1] Data on 60-year old adults are, of course, not yet available for those born in the 1950s and for the most part we have data on adults born prior to 1945.

expect to observe the following regularities: (1) strong effects of early childhood conditions on adult heart disease and diabetes, especially in the mid-paced regimes; (2) no direct effects or weaker effects of early childhood conditions on adult mortality when heart disease and diabetes are controlled for, especially in the mid-paced regimes; (3) higher excess of relative risk of dying for diabetes, heart disease and obesity in the mid to late regimes compared with earlier and very late regimes.

Method

Data

The data used to test the conjecture come 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=7171), Puerto Rican Elderly: Health Conditions (**PREHCO**, first wave, n=4291), 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=2827). From Asia there are the China Health and Nutrition Study (**CHNS**, n=5772), Indonesia Family Life Survey (**IFLS**, wave 2000, n=3998), the Bangladesh Matlab Health and Socio-Economic Survey (**MHSS**, n= 3721), WHO Study on Global Ageing and Adult Health Study in India (**WHO-SAGE**, first wave, n=6559) and Social Environment and Biomarkers of Aging Study (**SEBAS**, n=1023). From Africa there are the WHO Study on Global Ageing and Adult Health Survey in Ghana (**WHO-SAGE**, pre-test, n=507) and South Africa (**WHO-SAGE**, first wave, n=3150). From the developed world there are the Health and Retirement Study (**HRS**, wave 2000, n=12,527), Wisconsin Longitudinal Study (**WLS**, wave 2004, n=7265), English Longitudinal Study of Ageing (**ELSA**, second wave, n=8780), and Survey of Health, Ageing and Retirement-Netherlands (**SHARE-Netherlands**, first wave, n= 2979).

Measures

Demographic regimes.—Countries were classified into different demographic regimes using historical data on life expectancy, infant mortality rates, GDP per capita and literacy rates according to the following characteristics of mortality decline during the health transition: 1) speed of mortality decline; 2) timing of the onset of mortality decline; 3) the degree to which mortality decline was due to exposure to public health interventions and medical technology; and 4) the degree to which mortality decline was due to improvements in standard of living (McEniry, 2009). The regimes are: (A) very early, graded mortality decline (Netherlands, UK, US); (B) early, graded mortality decline (Argentina, Uruguay, Cuba); (C) mid, less graded mortality decline (Chile, Costa Rica, Puerto Rico, Taiwan, South Africa); (D) late, rapid mortality decline (Mexico, Brazil, Barbados); and (E) little or no mortality decline prior to 1950 but rapid during the 1950s (India, Bangladesh, China, Indonesia, Ghana).

Childhood conditions.—Early life conditions included lowest quartile of height and knee height, an indicator of nutrition during early childhood and possibly earlier. A retrospective question asked respondents about socioeconomic conditions during childhood, mother's and father's educational level. In most surveys it was possible to ascertain if the respondent had been born and raised in rural areas during childhood.

Adult conditions.—These conditions included the number of years of education and adult behavior (smoking). The smoking variable was defined according to non-smokers (never smoked), former smokers and current smokers. Dummy variables for education were created to reflect no schooling, primary school and secondary school and above. In the case of HRS, no schooling and primary were combined and in the case of WLS a dummy variable was created to indicate completion of secondary education versus secondary plus.

Adult Health.— Elderly adult health was defined by dichotomous variables using self-reported heart disease and self-reported diabetes. These variables ask the respondent if a doctor has ever diagnosed them with heart disease or diabetes. We defined a dummy variable to reflect different categories of Body Mass Index (BMI): underweight (<=18.5 BMI), normal (>18.5, <25 BMI), overweight (>=25, <30 BMI), obese (>=30 BMI). Mortality was defined as a dichotomous variable (0/1) for those countries which had available mortality data. For those countries with mortality data, crude mortality rates were calculated by gender and age group. We also used crude mortality rates to construct modified Waaler surfaces (see below). Age-specific mortality rates estimated from survey mortality data were compared against 2000 life tables (WHO, 2002) and in some cases reported research (Zimmer, Kaneda, & Spess, 2007) and were for the most part comparable for the 60-74-year olds.

Data preparation

We used multiple imputation procedures using ICE (Royston, 2004) in Stata to ensure that all cases were included. The number of missing values varied between countries in some cases because of the sampling frame used. In general, imputed results gave more conservative results and thus we present imputed results in the paper.

Analysis

There were two main parts to the mortality analysis. In the first part, we estimated a series of multivariate models using imputed data to estimate the effects of early childhood and adult conditions on heart disease, diabetes, obesity and mortality for those countries which had mortality data available (Mexico, Puerto Rico, Costa Rica, China, Indonesia, Bangladesh, US, UK). This analysis included examining the bivariate association between variables and then building a series of basic models controlling only for age and gender and then nested and full

models, the results of which are shown in this paper. We repeated this analysis using a subset of mid-demographic and very early regime countries which had more comparable early life variables. We then pooled the data and estimated several models using this data. For pooled data, we tested both constrained and non-constrained models[2] and the differences between countries.

In the second part of the analysis, we estimated several modified Waaler-type surfaces in order to obtain **expected relative mortality risk.** These surfaces, shown to be useful in depicting mortality risk (Waaler, 1984; Fogel, 2004; Palloni et al., 2007), are especially helpful in cases where no mortality data yet exists on individuals. Several surfaces were constructed using as standards or benchmarks (1) Waaler data (1984) and (2) mortality data from individuals in countries where panel data were available (Mexico, Puerto Rico, Costa Rica, China, Indonesia, Bangladesh, US)[3]. Expected mortality risk for a particular gender, age group and height-pair was defined in relation to the group's overall expected mortality risk by gender and age group. We first estimated morality risk by gender for the 60-74-year olds and then by height-weight category. By gender, we then calculated expected relative risk as the ratio between expected mortality risk for a particular height-weight category and expected mortality risk. We then estimated a quadratic regression model to model the function:

$$Ln(\text{relative risk of mortality}) = f(\text{height, weight})$$

We selected the CRELES surface for presentation in this paper in addition to the surface developed using Waaler (1984) data. Costa Rica is a small, upper middle income country, mid

[2] Constrained models assumed that country effects were all equal; unconstrained models assumed that there were differences among countries.
[3] No mortality data yet available for ELSA and waiting for respondent mortality data for Netherlands, wave 2.

demographic regime with high life expectancy at older ages and was deemed to be a suitable standard or benchmark in addition to using Waaler data (1984) to create a "true" Waaler surface. The surfaces are based on the following models[4]:

***Waaler 1984 mortality surface**:*

$$\ln(RR)=6.30+(.020*W)+(-.065*H)+(.0005*(W^2))+(.0003*(H^2))+(-.0006*H*W)$$

***CRELES mortality surface**:*

$$\ln(RR)=123.10+(.500*W)+(-1.71*H)+(.003*(W^2))+(.006*(H^2))+(-.006*H*W)$$

The surfaces were used to compare expected relative risk of mortality across 19 countries by using data on average height and weight to compute risk for different types of health conditions (e.g. obese and non-obese adults; adults with and without heart disease and with or without diabetes). The surfaces were also used to compare observed relative risk[5] with expected relative risk[6] and to calculate excess of relative risk of mortality[7] in eight countries where mortality data were available. Excess of relative risk of mortality is a measure of the deviation of observed relative risk of mortality from the expected relative risk of mortality using modified Waaler surfaces. Positive numbers indicate instances where the observed relative risk was higher than the expected relative risk. Larger numbers indicate a larger deviation from the average weight for a particular subgroup.

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[4] Coefficients have been rounded and so may not produce the exact graph as presented in this paper.
[5] Calculation for observed relative risk for 60-74-year old males (females): crude mortality for a particular health outcome divided by overall crude mortality for that gender.
[6] Calculation of expected mortality risk (Waaler, 1984): used the quadratic equation for either the Waaler 1984 mortality surface or the CRELES mortality surface to estimate given observed height and weight.
[7] Excess risk of relative risk of mortality was calculated in the following way: (1) used the quadratic equation for a particular surface to predict weight given a particular height and observed relative risk of mortality; (2) calculated (observed weight – predicted weight) / observed weight (Palloni & McEniry, 2007).

Results

Sample and Bivariate Associations

Sample characteristics of countries using imputed data with available morality data showed no major anomalies (Table 1). Female respondents were predominant with the exception of Bangladesh and as one moves from the very early regimes to later regimes there is an increase in the percentage of respondents with lower educational levels and who were born and lived in rural areas during childhood. There was also a high percentage of respondents with low knee height who reported poor childhood health and poor childhood SES in the mid-regimes and an increasing percentage of respondents whose parents had no schooling in later regimes. A higher percentage of respondents in later regimes report that they are still smoking. The prevalence of heart disease is similar between the very early and mid regimes but dramatically decreases in later regimes. Mid-regimes have a higher prevalence of diabetes. Being overweight and obese are predominant in the very early and mid regimes while being underweight is predominant among respondents in later regimes.

[Insert Table 1 about here.]

All childhood conditions showed at least one significant bivariate association with adult health outcomes. There were significant bivariate associations between childhood conditions and adult health outcomes in the following instances: **height:** heart disease (Mexico), diabetes (HRS), BMI category (all countries), adult death (Puerto Rico, Bangladesh), **knee height:** heart disease (Mexico), diabetes (Puerto Rico), BMI category (Mexico, Costa Rica), **poor childhood health:** heart disease (Puerto Rico, Mexico, HRS), diabetes (Mexico), adult death (HRS), **poor**

childhood SES: heart disease (HRS), diabetes (Costa Rica, Mexico, HRS), BMI category (Mexico, HRS), **born and lived in rural area as a child:** heart disease (Puerto Rico, Mexico, WLS), diabetes (Puerto Rico, Mexico, Bangladesh, China), BMI category (Mexico, China, Bangladesh, Puerto Rico), adult death (WLS), **no schooling for mother:** diabetes (Bangladesh), BMI category (Bangladesh), **no schooling for father:** BMI category (Bangladesh, Mexico), adult death (Puerto Rico, Mexico, Indonesia) (results not shown). Table 2 shows the most salient bivariate associations between no schooling for respondent's mother and other childhood and adult conditions. Of particular note are the consistent strong associations between mother's lack of education and low height, knee height, poor childhood health, the respondent being born and living in a rural area as a child and the respondent's education. Significant associations between the mother's lack of education and being underweight appeared in Mexico, Indonesia and Bangladesh and overweight and obesity in Indonesia. Mother's education was associated with the respondent's death in Puerto Rico.

[Insert Table 2 about here.]

Multivariate Models

The effects of low height on obesity were significant in the US and especially strong in Mexico but there were no significant effects of low height in mortality models when controlling for obesity (Table 3). Low height showed no significant effects on adult diabetes across countries but there were strong effects of obesity on diabetes in the US, Puerto Rico and Costa Rica. However, in mortality models, the strong positive effects of obesity disappeared in most

cases except for Costa Rica. Obesity appeared to have protective effects on mortality in Puerto Rico and Mexico.

[Insert Table 3 about here.]

As a side note for mortality models, basic models controlling for gender and age showed significant effects of low height (Puerto Rico, Bangladesh), no schooling for respondent's mother (Puerto Rico), no schooling for respondent's father (Indonesia), poor childhood health (US), education (Puerto Rico, US, Bangladesh, Indonesia), overweight or obesity (Puerto Rico, Costa Rica, Mexico, US), underweight (Mexico, US, Bangladesh, Indonesia), smoking (Puerto Rico, Mexico, US, Bangladesh, Indonesia), adult heart disease (Puerto Rico, Costa Rica, Mexico, US), adult diabetes (Puerto Rico, Costa Rica, Mexico, US) on adult mortality (results not shown). However, the final models showed that for the most part the effects of childhood variables disappeared with the exception of Bangladesh and low height (shown in Table 3) and of course, we note the strong effects of being underweight, overweight and obese on adult mortality. Being underweight increased the odds of death in the US, Mexico, Indonesia and Bangladesh but being overweight and obese in Puerto Rico and Mexico showed protective effects on adult mortality. Being obese in Costa Rica increased the odds of death by almost three times as compared with those who were not obese.

Final models using a subset of countries for selected mid-demographic regimes compared with very early regimes showed significant effects of poor childhood health on diabetes and heart disease in Puerto Rico, Mexico and the US and low height on obesity in Mexico and the US (Table 4). However, these effects disappeared in mortality models which also controlled for

heart disease and diabetes. In these models, the effects of adult diabetes, heart disease, obesity and smoking were strong across all countries. Being diabetic increased the odds of dying by between 2 and 2.5 times across countries as compared with those who were not diabetic. Having heart problems increased the odds of dying by between 1.6 and 2.7 times as compared with those who did not report heart disease. However, being obese in Puerto Rico and Mexico had protective effects.

[Insert Table 4 about here.]

Pooled models using constrained and unconstrained models for all countries showed strong effects of low height on obesity but these effects weaken in mortality models which also control for obesity (Table 5). Important differences existed between countries in terms of the odds of being obese and the odds of dying: Bangladesh and Indonesia versus China; Puerto Rico versus Costa Rica and Mexico. Within the mid-paced to late demographic regimes, there were significant effects of low height on adult obesity and of poor childhood health on diabetes and heart disease. There were also strong effects of obesity on diabetes and heart disease. However, these effects were either reduced or disappeared in mortality models when controlling also for heart disease, diabetes and obesity. The effects of being diabetic and having heart disease on dying were strong and significant, but being obese and overweight appeared to have protective effects. Again, there were significant differences between countries in terms of the odds of dying: Mexico and Costa Rica were more similar than Puerto Rico.

[Insert Table 5 about here.]

Modified Waaler-Type Surfaces

A modified Waaler-type surface for adult males based on Waaler mortality data (1984) is shown in Figure 1. Each curve in the graph shows the expected relative risk of mortality for a particular height-weight combination. The lowest mortality risk is found among taller males and the highest mortality risk is found among shorter and more obese males. If we start at a particular height and weight and decrease height, mortality risk increases and, given a particular height, an optimal weight line depicts the point at which mortality risk is minimized.

A comparison of obese and non-obese males given their average height and weight, made under the assumption that **Waaler 1984 Norwegian relative risk can be applied to other countries**, shows a clear pattern of higher expected relative risk for obese individuals than non-obese individuals. In most countries, obese males have higher expected relative mortality risk than non-obese males. The clustering of the countries is consistent for the most part with the country classification of demographic regimes. Towards the top of the graph are very early regimes (WLS, HRS, Netherlands, UK), followed by early regimes (Uruguay) and then the mid-to-late demographic regimes (Chile, Puerto Rico, Costa Rica, Taiwan, South Africa, Mexico, Brazil) and finally the very late demographic regimes (Indonesia, India, China-Rural, Bangladesh). Exceptions are China-Urban, Ghana and Barbados—late demographic regimes. China-Urban (not obese) is closer to mid-demographic regimes. Barbados (not obese) is closer to earlier regimes. The non-obese males in the very early demographic regimes appear closer to the optimal weight line followed by the non-obese males in the mid-to-late regimes. Non-obese males in the very late regimes are the farthest from the optimal weight line.

[Insert Figure 1 about here.]

A modified Waaler surface for males using Costa Rican relative risk is shown in Figure 2. The general descriptive patterns are similar to those described by the Waaler 1984 surface above. **If Costa Rican relative risk can be applied to other countries**, expected relative risk for obese males is consistently larger than for non-obese males. Ghanaian non-obese males now more closely align with other very late regimes. However, a comparison with the Waaler 1984 surface shows that using the Costa Rican surface produces relative mortality risks that are smaller for the mid-regimes and larger for the very early and very late regimes (see Appendix for examples in selected countries). In fact, the pattern of expected relative risk in the Costa Rican surface appears to be more U-shaped as very early and very late regimes have slightly higher expected relative risk than do the mid-regimes. This is in contrast with the Waaler 1984 surface where risk is more linear in that the very early regimes clearly have the lowest risk, followed by the mid-regimes and then by the very late regimes.

[Insert Figure 2 about here.]

A comparison between observed relative risk of mortality (from each country-specific mortality data) and expected relative risk of mortality (using either Waaler 1984 data or Costa Rican data) shows that in most cases the observed relative risk is greater than the expected relative risk of mortality for heart disease and diabetes whereas in the case of obesity the pattern is more mixed (see Appendix). The estimations for excess of relative risk of mortality reflect these patterns as we observe that in most cases the excess of relative risk of mortality is a

positive number for diabetes and heart disease and more mixed for obesity (Table 5). The mid-demographic regimes show a much higher excess of relative risk of mortality for diabetes and heart disease than do the very early regimes and the very late regime (in the case of diabetes and Bangladesh). Puerto Rico and Costa Rica have a smaller excess of relative risk of mortality for diabetes and heart disease than does Mexico.

[Insert Table 6 about here.]

Discussion

This paper tested a conjecture based on the nature of the health transition and mortality decline during the 1930s-1960s in developing countries which created a large pool of survivors of poor early life conditions. In countries where mortality data are available we found (1) strong effects of early childhood conditions (markers of nutrition and indicators of childhood health) on adult heart disease and diabetes, especially in the mid-to-late regimes using country-specific and pooled models; but (2) no significant effects or weaker effects of these early childhood conditions on adult mortality when heart disease and diabetes were controlled for, especially in the mid-paced regimes; (3) higher observed relative risk of mortality for diabetics and those with heart disease but mixed results for obesity; (4) higher excess of relative risk of dying for diabetes and heart disease in mid to late regimes (Costa Rica, Puerto Rico, Mexico). Using modified Waaler surfaces for countries without mortality, we found higher expected relative risk of mortality in mid-to-late regimes.

The results build on previous work (Palloni & McEniry, 2007) and provide evidence, albeit rather weak, in terms of finding important mortality differentials according to the timing, pace

and reason for the health transition that can be attributed to poor early life conditions. Cohorts born in mid-to-late regimes (Puerto Rico, Mexico, Costa Rica) showed a higher excess of relative mortality risk for heart disease and diabetes. They also were the same cohorts (born during the late 1920s and early 1940s) which were more at risk of having been affected by harsh early childhood experiences while at the same time having larger probabilities of surviving. It may be that, in some instances, future trends in life expectancy may be affected by poor early life circumstances.

Yet, the picture remains incomplete. The Waaler surfaces based on Costa Rican mortality data suggest similar expected relative risks for healthy older adults in mid-paced regimes but it is not clear the degree to which these potential mortality risks will translate into actual higher mortality rates at older ages. When mortality data from other mid-paced regimes become available, it will be possible to further illuminate our results by examining differences in mortality within the mid-paced regimes which experienced dramatic economic growth (Taiwan), have quality health care systems (Chile) or have struggled (South Africa). The results for obesity require more examination as the protective effects of obesity in some countries is puzzling. It may be that adult obesity also originates from childhood and that its effects on mortality are mediated by adult heart disease and diabetes. The very high expected relative risk for India and Indonesia may reflect extreme cases that reflect the very low prevalence of obesity in the very late regimes. Finally, there must be more scrutiny into Indonesia and China (perhaps by province) to understand why in neither case height was important in mortality and what explains the differences in mortality noted in China.

The Waaler 1984 surface, descriptive of a relatively healthy population and a high income country in the 1980s, clearly shows that taller men from very early regimes (UK, US,

Netherlands) are at lower risk than shorter males in the mid (Costa Rica, Puerto Rico, Chile, Taiwan, South Africa) and later regimes (Bangladesh, Ghana, India, Indonesia). The CRELES surface, descriptive of a middle income country in the 2000s, depicts a slightly different picture in that all of the mid-demographic regimes are at similar or even slightly lower risk than the very early regimes. Because the surfaces are descriptive, it is not surprising that we may indeed obtain different results based on different surfaces and therefore it is important to choose the appropriate surface. The major and glaring limitation of the surfaces is that they require a large amount of data to adequately model height-weight associations with mortality (Fogel, 2004; Waaler, 1984)—a limitation that is readily apparent with the development of the surfaces in this paper[8]. A refinement of the CRELES surface to identify more detailed height and weight categories may be helpful.

Important questions remain: To what degree has health care mediated early poor adverse conditions in the case of Costa Rica which has a quality primary health care system? To what degree do the non-significant results from Costa Rica reflect differences in health care systems? The observed similarity in the odds of dying between Costa Ricans and Wisconsinites as compared to Puerto Ricans is interesting and partially explained by Puerto Ricans having higher mortality at older ages. Yet older Puerto Ricans on average are slightly taller than Costa Ricans or Mexicans and their excess of relative risk of dying for heart disease and diabetes is similar to Costa Ricans or Mexicans as is their life expectancy at the age of 60[9]. Could the higher odds of dying in Puerto Rico reflect stronger influences of poor early life conditions in Puerto Rico than in a country such as Costa Rica which shared common adverse childhood conditions during the

[8] The R-squared was about .81 for the Waaler surface based on 1984 data and about .66 for the surface based on CRELES data.

[9] Life tables from WHO (2002) show that life expectancy at the age of 60 for males (females) is: 19.3 (22.8) in Costa Rica, 19.7 (21.7) in Mexico and 19.6 (23.1) in Puerto Rico (using US statistics).

late 1920s-early 1940s but which later developed an effective primary health care system? Similar questions could be asked of the differences noted between China on the one hand and Bangladesh and Indonesia on the other hand.

The challenge of finding evidence for the conjecture partially lies in being able to draw inferences from observing survivors but not complete cohorts of individuals. It also lies in the validity and reliability of health outcomes and childhood measures used in surveys, which because of underestimation of chronic conditions provides us with more conservative and lower bound estimates of the effects of early childhood conditions on adult health. In that respect, country-specific models using multivariate models were disappointing in particular for height (and also knee height). Height is one variable easily obtained across all cross national surveys and is a potential helpful marker of childhood nutrition and (as we also showed) is clearly associated with mother's and father's education. Studies have shown the strong association between height and adult mortality in the developed world (Waaler, 1984; Elo & Preston, 1992, Fogel, 2004). In our case, low height was only significant in the case of Bangladesh in final models and unfortunately, because the prevalence of chronic conditions in Bangladesh is low (especially for obesity), it is not possible to test the degree to which the effects of height are mediated through obesity. That the indicator of low height did not show stronger associations with mortality in other countries could partially be that there are no standards for measuring low height in adults. It may be that the measure that we used (lowest quartile of height) does not provide sufficient detail to capture the effects of low height on mortality and alternative indicators need to be tested[10].

In spite of the study limitations, the ramifications of the research are important. The findings give one pause in terms of future public policy. Heart disease and diabetes are increasing in

[10] We did try the ln of height and height divided into six categories but no significant effects were noted.

prevalence in the developing world (Murray & Lopez, 1996), and the cohorts born after 1945 (and before 1960) are approaching older adult ages. We do not know the degree to which the effects of adverse early conditions can be mediated through health care later in life nor do we have complete information on all mid-to-late regimes to estimate their increased predisposition to higher mortality risk from heart disease and diabetes due to early life conditions. We also do not know the degree to which later cohorts born after 1945 will also experience higher than average risk of heart disease and diabetes and mortality due to poor childhood conditions. Therefore, research efforts in this area continue to be important so that appropriate public policy decisions can be made if the conjecture has merit. This includes decisions regarding the types of interventions and programs that are needed not only for older adults to address the special health problems evident now and into the far future but also for mothers and children in the developing world to improve early life conditions and prevent heart disease and diabetes at older ages.

Appendix:

Comparison between expected relative risk and observed relative risk (males 60-74 yrs)

HEART	**----------Yes----------**			**----------No----------**		
	Waaler84	**CR**	**Observed**	**Waaler84**	**CR**	**Observed**
WLS	0.95	0.94	1.42	0.93	0.85	0.90
HRS	0.95	0.73	1.64	0.94	0.71	0.79
PR	1.09	0.46	1.56	1.13	0.44	1.42
CR	1.16	0.45	1.58	1.18	0.45	0.94
Mexico	1.29	0.51	2.64	1.22	0.46	0.94
China	1.26	0.50	0.67	1.30	0.59	1.00
DIABETES	**----------Yes----------**			**----------No----------**		
	Waaler84	**CR**	**Observed**	**Waaler84**	**CR**	**Observed**
WLS	0.99	1.20	1.86	0.93	0.84	0.86
HRS	0.98	0.82	1.64	0.94	0.71	0.87
PR	1.12	0.46	1.58	1.12	0.44	0.76
CR	1.17	0.48	2.03	1.18	0.45	0.74
Mexico	1.23	0.47	1.95	1.22	0.46	0.87
China	1.20	0.47	0.81	1.30	0.60	1.02
Bangladesh	1.89	2.41	1.59	1.84	2.12	0.89
OBESITY	**----------Yes----------**			**----------No----------**		
	Waaler84	**CR**	**Observed**	**Waaler84**	**CR**	**Observed**
WLS	1.15	2.91	1.12	0.92	0.80	0.84
HRS	1.17	2.79	0.99	0.94	0.72	1.00
PR	1.27	1.31	0.43	1.14	0.46	1.02
CR	1.25	1.02	1.00	1.21	0.47	0.95
Mexico	1.25	0.95	0.99	1.25	0.48	0.97
Indonesia	1.23	0.68	1.17	1.65	1.17	0.68
China	1.44	2.24	0.26	1.32	0.64	0.99

Expected Relative Risk is based on Waaler surfaces (Waaler84 and CRELES).
Observed Relative Risk is based on observed mortality rates from survey data. A relative risk of 1.00 for a particular health condition means that the risk of death is equal to the overall average risk of death in a particular population of males. A relative risk of >1.00 means that the risk is greater than the average risk for that population and a relative risk of <1.00 means that the risk is less than the average risk for that population.

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Table 1: Sample characteristics for the 60-74-year olds

Regime/Country	Very early		Mid-paced		Late	Very late		
	HRS (n=8360)	WLS (n=7265)	Puerto Rico (n=2693)	Costa Rica (n=1317)	Mexico (n=5440)	China (n=1529)	Indonesia (n=3495)	Bangladesh (n=1879)
Demographic								
Female (%)	57	54	55	52	52	52	54	48
Age Group (%)								
60-64	36	62	40	42	42	40	49	43
65-69	34	38	34	33	34	34	28	27
70-74	30	n.a.	27	25	23	26	22	0
Education (%)								
No school	1	--	4	12	33	41	45	62
Primary	4	--	34	65	52	37	49	29
Secondary+	95	100	62	23	15	22	6	9
Early Childhood								
Low height (%)	24	24	21	23	23	25	25	25
Low knee height (%)	--	--	24	25	29	--	--	--
Poor child health (%)	6	3	22	9	9	--	--	--
Poor child SES (%)	32	--	34	59	73	--	--	--
Rural (%)	--	18	56	50	56	61	84	99
No school-father	--	--	35	--	57	--	68	72
No school-mother	--	--	39	29	64	--	81	94
Adult								
Never smoked (%)	65	39	66	58	56	62	46	64
Past smoker (%)	19	47	25	31	28	10	11	12
Smokes now? (%)	16	14	9	11	16	28	43	24
Health Outcomes								
Heart (%)	22	15	16	11	3	2	--	--
Diabetes (%)	16	12	28	22	17	3	--	15
Underweight (%)	1	1	2	2	2	10	31	63
Normal (%)	33	26	27	30	37	61	56	35
Overweight (%)	41	42	42	42	39	23	11	2
Obese (%)	25	31	29	27	22	6	2	0.04
Dead (#)	1062	311	285	73	237	206	853	395

Notes: Results are imputed, weighted averages except for WLS and China (no weights). "--" means that the variable is not included in survey. WLS interviewed high school graduates only and HRS combined no school with primary.

Table 2: Bivariate associations between "no schooling" for respondent's mother and other childhood and adult variables

Regime/Country	Mid-paced Puerto Rico (n=2693)	Costa Rica (n=1317)	Late Mexico (n=5440)	Very Late Indonesia (n=3495)	Bangladesh (n=1879)
Childhood					
Low height	11.3(1)***	11.1(1)***	80.2(1)***	17.5(1)***	11.4(1)***
Low knee height	20.7(1)***	1.9(1)	0.3(1)	--	--
Poor child health	12.7(1)***	15.0(1)***	0.3(1)	--	--
No school-father	595.3(1)***	--	2100 ***	1.400***	364.1(1)***
Rural	117.8(1)***	2.1(1)	170.1(1)***	54.8(1)***	40.2(1)***
Adult					
Education	284.1(2)***	97.3(2)***	995.9(2)***	50.3(3)***	143.7(3)***
Heart	5.0(1)*	2.4(1)	0.1(1)	--	0.1(1)
Diabetes	1.5(1)	0.8(1)	0.1(1)	--	3.9(1)*
Underweight	3.5(1)	0.4(1)	7.7(1)**	62.9(1)***	4.0(1)*
Overweight	3.5(1)	2.0(1)	2.5(1)	34.8(1)*** [a]	2.0(1)
Obese	1.5(1)	1.5(1)	2.4(1)	26.2(1)*** [a]	0.1(1)
Dead	10.9(1)***	1.4(1)	0.1(1)	13.7(1)*** [a]	0.4(1)

*p<0.05, **p<0.01, ***p<0.001. Shown are chi-square associations with degrees of freedom in parentheses.
"--" means that the indicated variable was not asked in the country-specific survey.

Notes:
[a] More education is associated with overweight, obesity and dead in Indonesia.

Table 3: Predicting obesity, diabetes and death using all countries

Regime/Country	Very Early		Mid-paced		Late	Very Late		
	US-HRS[a]	US-WLS[a]	Puerto Rico	Costa Rica	Mexico	Indonesia	China	Bangladesh
Health Outcome								
Obesity								
Low height	1.15(.07)*	1.16(.08)*	1.20(.13)	1.15(.20)	1.65(.14)***	0.81(.26)	1.44(.36)	n.a.
Diabetes								
Low height	1.07(.07)	1.09(.09)	1.06(.11)	0.84(.15)	0.95(.10)	n.a.	0.94(.38)	0.91(.17)
Obese	2.57(.16)***	3.26(.27)***	1.36(.13)***	1.97(.30)***	1.15(.10)	n.a.	1.65(.91)	1.00(.16)[c]
Mortality								
Low height	1.09(.09)	0.96(.16)	1.39(.24)	1.38(.39)	1.14(.22)	0.96(.12)	0.91(.17)	1.48(.19)**
Underweight	4.04(.92)***	2.72(1.25)*	1.44(.53)	2.43(1.74)	2.58(.82)**	1.50(.13)***	1.51(.37)	1.39(.19)*
Normal (ref)								
Overweight	0.87(.07)	1.03(.19)	0.60(.10)**	1.28(.45)	0.62(.11)**	1.01(.15)	0.98(.21)	0.62(.34)
Obese	1.09(.10)	1.30(.28)	0.59(.11)**	2.70(.95)**	0.61(.15)*	1.48(.46)	0.70(.40)	n.a.
# observations	8360	7265	2693	1317	5440	3495	1529	1879

*p<0.05, **p<0.01, ***p<0.001; Using imputed country data. Models also controlled for gender, age, education and smoking. **Notes:** [a]No schooling is combined with primary for HRS and WLS shows secondary school against reference group of secondary plus. Bangladesh had very few cases of obese respondents and thus this variable is excluded from the model. [b]The multiple imputation procedure required us to work with five alternative completed data sets. In this case, it was not clear how to calculate conventional statistics, such as chi-square, all of which are functions of data-specific log-likelihood functions. As a partial resolution to the conundrum, we used the range of values for the chosen statistics obtained after estimating models for each of the imputed data sets using non-imputed data. All models presented in the table are better than the null model with the exception of Indonesia and obesity. [c]We used underweight and not obese in the case of Bangladesh since there were so few cases of obesity in Bangladesh.

Table 4: Predicting obesity, diabetes, heart disease and death in selected countries

Regime/Country	Mid-Paced		Late	Very Early	
Health Outcome	**Puerto Rico**	**Costa Rica**	**Mexico**	**US-HRS[a]**	**US-WLS[a]**
Obesity					
Low height[a]	1.20(.13)	1.16(.20)	1.65(.14)***	1.15(.07)*	1.16(.08)*
Poor child health	.80(.09)	0.87(.21)	0.91(.13)	1.00(.10)	0.80(.13)
Diabetes					
Low height	1.06(.11)	0.84(.15)	0.94(.09)	1.07(.07)	1.09(.09)
Poor child health	1.25(.13)*	0.81(.20)	1.48(.16)***	1.19(.14)	0.72(.19)
Heart Disease					
Low height	0.97(.14)	0.81(.19)	0.66(.14)*	0.95(.06)	1.09(.11)
Poor child health	1.51(.19)***	0.66(.28)	1.92(.43)**	1.64(.17)***	1.30(.25)
Mortality					
Low height	1.37(.24)	1.46(.40)	1.15(.22)	1.08(.09)	0.94(.15)
Poor child health	0.87(.15)	0.69(.42)	0.80(.21)	1.27(.17)*	0.45(.21)
Heart disease	1.55(.25)**	2.03(.63)*	2.74(.64)***	2.26(.15)***	1.90(.26)***
Diabetes	2.32(.34)***	2.46(.64)*	1.94(.31)***	2.01(.18)***	2.19(.33)***
Obese	0.69(.09)*	1.98(.53)*	0.69(.14)	0.86(.08)	1.04(.19)
# of observations[b]	2693	1317	5440	8360	7265

*p<0.05, **p<0.01, ***p<0.001. Using imputed country-specific data. Models also controlled for age, gender, education and smoking. In models for diabetes and heart disease, we also control for obesity. **Notes:** [a]We also tried models including low knee height for the mid-paced and later regimes instead of low height and found significant effects only for Puerto Rico. [b]The multiple imputation procedure required us to work with five alternative completed data sets. In this case, it was not clear how to calculate conventional statistics, such as chi-square, all of which are functions of data-specific log-likelihood functions. As a partial resolution to the conundrum, we used the range of values for the chosen statistics obtained after estimating models for each of the imputed data sets using non-imputed data. All models presented in this table were a significantly better fit than the null model.

Table 5: Pooled results predicting obesity, diabetes, heart disease and mortality

	All Countries		Mid-paced and Later Regimes			
	Obesity	**Death**	**Obesity**	**Diabetes**	**Heart Disease**	**Death**
Childhood						
Low height	1.26(.04)***	1.09(.05)*	1.41(.08)***	0.96(.06)	0.86(.08)	1.35(.13)**
Poor child health			0.84(.06)*	1.27(.09)***	1.57(.15)***	0.77(.10)*
Poor child SES			1.00(.05)	0.92(.05)	0.98(.08)	1.05(.10)
Adult Health						
Heart						1.88(.22)***
Diabetes						2.33(.21)***
Underweight		1.50(.09)***		0.76(.16)	0.84(.26)	2.22(.48)***
Normal (ref)	(ref)	(ref)		(ref)	(ref)	(ref)
Overweight		0.86(.04)**		1.37(.09)***	1.10(.11)	0.59(.06)***
Obese		0.98(.06)		1.57(.11)***	1.63(.16)***	0.60(.07)***
Country						
US-WLS	(ref)	(ref)				
US-HRS	0.84(.03)***	2.97(.21)***				
Puerto Rico	0.98(.05)	2.29(.21)***	(ref)	(ref)	(ref)	(ref)
Costa Rica	0.75(.06)***	1.02(.14)	0.78(.06)**	0.69(.06)***	0.56(.06)***	0.45(.07)***
Mexico	0.65(.04)***	0.81(.09)*	0.68(.04)***	0.54(.04)***	0.20(.02)***	0.36(.04)***
Indonesia	0.06(.01)***	9.56(.94)***				
China	0.15(.02)***	2.83(.32)***				
Bangladesh	0.001(.001)***	10.64(1.15)***				
Log likelihood[a]	-15135	-10,421	-5201	-4865	-2542	-2062
Chi-square (df)[a]	3370(15)***	3805(18)***	321(12)***	251(15)***	505(15)***	393(17)***
# observations	31,978	31,978	9450	9450	9450	9450

*p<0.05, **p<0.01, ***p<0.001. Results obtained using imputed data. All models also controlled for gender, age, education and smoking. Model 1 is based on Table 3 and Models 2 and 3 on Table 4. **Notes:** [a]We tested for differences between constrained models (country effects assumed to be zero) and unconstrained models. In all cases, unconstrained models were an improved fit and so we present them here. To prevent cluttering, we show only the results from childhood and health outcomes.

Table 6: Excess of relative risk of mortality

Regime/Country	Very Early		Mid-Paced		Late	Very Late		
	US-HRS	US-WLS	Costa Rica	Puerto Rico	Mexico	Indonesia[a]	Bangladesh	China[a]
Diabetes								
Yes	.10	.05	.23	.21	.30	--	-.08	**.14**
No	.08	.01	.16	.17	.19	--	-.19	.11
Heart Disease								
Yes	.14	.07	.23	.21	.33	--	--	**.09**
No	.05	.02	.21	.19	.21	--	--	.11
Obesity								
Yes	-.10	-.09	-.003	-.21	.004	**.08**	--	**-.25**
No	.10	.03	.17	.19	.19	-.15	--	-.19

Notes: based on observed RR and expected RR from CRELES surface (Figure 1). There were no data on diabetes and heart disease for the respondents of the 2000 IFLS (Indonesia) and on heart disease for the respondents of the 1996 MHSS (Bangladesh). There were so few cases of obesity in Bangladesh that obesity was not calculated.

Excess of relative risk of mortality is a measure of the deviation of the observed relative risk of mortality from the expected relative risk of mortality using the modified Waaler surface. Positive numbers indicate instances where the observed relative risk was higher than the expected relative risk. Larger numbers indicate a larger deviation from the average weight for a particular subgroup. See appendix for more information.

[a]In the case of Indonesia and China, the prevalence of obesity, diabetes or heart disease was very small and thus the number of deaths for these conditions is also very small, leading to a possible overestimation of the number appearing in the table.

Figure 1: Surface from a very early demographic regime, high income country

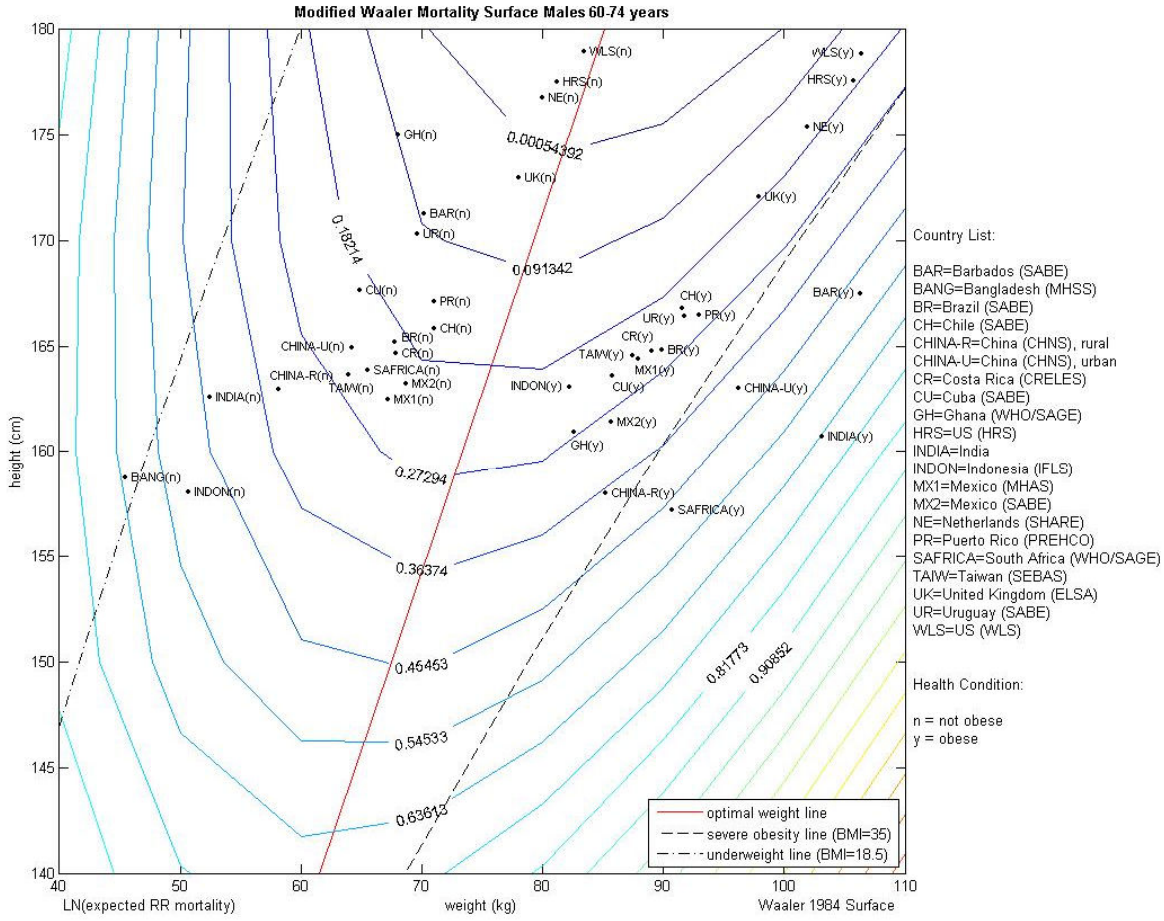

Figure 2: Surface from a mid-paced demographic regime, middle income country