Cross national comparisons across low, middle and high income countries of poor early life nutrition and diet and older adult diabetes, obesity and hypertension

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Abstract

The demographic transition of the 1930s-1960s which produced dramatic improvement in life expectancy in some developing countries may also have produced cohorts that are now more susceptible to the effects of poor early life conditions at older ages. Recent research using cross national data on older adults from the developing world born during this period suggests that conjectures regarding the importance of poor early life conditions (poor nutrition, infectious diseases) on older adult health conditions such as diabetes and obesity may have merit. However, results based on self-reported health questions may underestimate health conditions and lead to biased conclusions. In this paper we use a subset of recently compiled cross national Research on Early Life and Aging Trends and Effects (RELATE) data (n=147,278) in 20 low, middle and high income countries from Latin America but also Asia, Africa, US, UK and the Netherlands. We build on previous analyses by incorporating biomarkers when available for diabetes and measured hypertension. We then examine the association between early life conditions and adult diabetes, obesity and hypertension incorporating childhood birthplace and nutrition and diet, adult education, obesity, smoking, health problems and visits to a doctor. The results from previous analyses remain consistent—that is, that poor early life nutrition is associated with a higher risk of adult diabetes, obesity and hypertension in selected middle income countries. While the data have limitations, broad conclusions can be made regarding the importance of early life conditions. Developing health policy efforts to help mitigate the effects of poor early life conditions continues to be important.

Introduction

Projections show an increase in the burden of disease due to chronic conditions such as adult heart disease and diabetes throughout the world as aging populations increase. In many instances, chronic conditions will coexist with infectious diseases in developing countries with possible negative ramifications for adult health.[1-4] Under certain circumstances, these conditions may originate in *in utero*/early infancy due to poor nutrition at critical moments [5] or due to inflammatory processes.[6] Poor nutrition in early life increases the risk of infection and disease,[7-8] which may then lead to poor adult health.[9] Adult heart disease and diabetes may also result from an accumulation of adverse events and behaviors throughout the life course.[10] The composition of diet is important in that diets high in saturated fats, meat and dairy products can increase the risk of heart disease, hypertension and diabetes at older ages even among well-nourished populations.[11] Populations in the developing world may be at particular risk because the combination of poor nutrition early in life with a diet consisting of more saturated fat, meat and dairy products during adulthood may increase the risk of adult heart disease, hypertension and diabetes.[12-15]

Testing hypotheses regarding early life conditions presents difficulties in low and medium income countries where data on early life conditions for older adults born in the early 20th century are scarce or of unknown validity. However, population-based surveys of older adults born during the early 20thc century amidst the dramatic increase in life expectancy combined with historical data provide an opportunity to test associations between early life conditions and older adult health. The particular nature of the mortality decline during the 1930s-1960s produced a unique cohort of individuals comprised of an increasing pool of infants and children who survived poor early life

conditions. [16,17] Infant and child mortality decreased due to massive improvements in public health measures and medical technology but many infants and children continued to be exposed to stagnant economic conditions. This cohort was most at risk of having been affected by harsh early childhood experiences and, simultaneously, having had larger probabilities of surviving, and they were less affected by mortality-driven selection than the group of cohorts that preceded them. As the nature of mortality decline varied across countries, so did the composition of the unique cohorts. Countries which experienced a large and rapid increase in life expectancy during the 1930s-1960s produced cohorts comprised of a larger pool of survivors of poor early life conditions. They may be more susceptible to the effects of poor early life conditions at older ages. Decreasing mortality can result in increased frailty of surviving populations[18,19]—in this case, frailty due to increased chances of surviving poor early life conditions.

Figure 1 illustrates decreasing IMR from selected high, middle and low income countries classified according to mortality regime across the 20th century highlighting the period of dramatic improvement in mortality (1030s-1060s).[a] A group of developing countries experienced lower mortality amidst better socioeconomic conditions (Uruguay, Argentina) similar to the developed world (US, England, Netherlands).[17] Other countries experienced increasingly rapid decline in mortality mostly due to public health interventions but amidst continued poor socioeconomic conditions (Puerto Rico, Costa Rica, Chile, Mexico, Brazil, Barbados, Taiwan, South Africa). Countries such as China, Bangladesh, Ghana, India and Indonesia continued to experience high levels of mortality amidst very poor socioeconomic conditions.

[Insert Figure 1 about here]

While the largest change in mortality occurred mostly after 1945,[21] mortality was declining in some settings in the late 1920s but prior to 1945 (shaded gray in Figure 1) as a result of more massive public health interventions but with continued stagnant economic conditions. Puerto Rico—similar in many aspects to other countries in the LAC region—is an example. At the end of the 1920s, there were wide disparities in infant mortality rates (IMR) across the island, ranging from close to 150 to, in some areas, close to 400. By the mid 1940s, variation between counties had been dramatically reduced and overall IMR on the island was 80.[22] Cohorts of this period who reached at least age 60 by the year 2000 can be thus characterized by their increased survivorship of poor early life conditions. At the same time they are now experiencing an increasing prevalence of heart disease and diabetes[23] which have known associations with poor early conditions.[5,6] Older adults from Puerto Rico but also adults in similar settings (mostly living in middle income countries) may be able to provide insights into the relative importance of early life experiences in later life.[b]

This paper contributes to a better understanding of how early life nutrition, composition of diet, and infectious diseases are associated with adult diabetes, obesity and hypertension in low and middle income countries by comparing older adult health across a diverse group of countries. If hypotheses regarding the importance of early life conditions have merit, then the rapidly decreasing mortality of the 1930s-1960s which created larger pools of survivors of poor early life conditions also increased the frailty of the surviving population, the results of which impacted their health at older ages. A cross national comparison of older adult health is expected to demonstrate that

individual history, including nutritional status and diet, early experience with illnesses and deprivations experienced during early childhood, are closely associated with the prevalence of adult diabetes, obesity, hypertension, particularly in settings similar to Puerto Rico during the late 1920s through early 1940s. The larger pool of survivors of poor early life conditions, being more susceptible to the effects of poor early life conditions, should show higher prevalence of these conditions as compared with cohorts of similar current standards of living but different mortality regimes and as compared with what was historically experienced in the developed world.

Data and Methods

Data

The data are drawn from the Research on Early Life and Aging Trends and Effects (**RELATE**) data which is recently compiled data of major surveys of older adults or households in Latin America, Asia, Africa, the US, England and the Netherlands. [24]
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). We also have the Russian Federation (**SAGE-Russia**, n=4511). Most surveys are random samples and are representative of older adults in countries, regions or major cities.

Measures

Early life conditions.— Conditions in rural areas were precarious in many developing countries during the early 20th century with limited opportunity for socioeconomic advancement.[25-26] Rural birthplace is used as a proxy for low parental socioeconomic status (SES) and is defined according to questions asked of respondents regarding their birthplace and residence during childhood.[c] Lowest quartile of adult height is used as a marker of nutritional status during childhood. No schooling for respondent's father is used in some models. Country-level caloric intake is used as a crude measure reflecting early life nutritional environment. Historical pre-WWII data on daily caloric supply per capita and its composition (Figure 2)[27] reflect the degree of inadequate food supply which may have many consequences. Prime among them is the inability of parents to adequately provide for their children's food needs. Lack of adequate food also affects maternal health and the mother's ability to properly nourish the unborn and infants which can leave children vulnerable to infectious diseases. Countries were grouped according to caloric intake per capita using low (less than 2,100

calories reflecting severe nutritional deficiency), mid (2,100 but less than 2,800) and high (2,800 or higher).

[Insert Figure 2 about here]

Adult Health.— Elderly adult diabetes was defined by dichotomous variables from self-reports which are based on questions asked of the respondent about whether a doctor has ever diagnosed them with diabetes. Glycated hemoglobin, HbA1c, and the definition used by Yan et al. [28] were used to define high risk of diabetes: Not at risk (hba1c<5.7); at risk-impaired glucose control (hba1c>=5.7% and <6.5%); High risk (hba1c>6.5% or taking diabetes medication). A body mass index of greater than or equal to 30 identified obese individuals. High blood pressure was defined to be systolic >=140 mmHg or diastolic >=90 mmHG or taking medication to control hypertension. Difficulty with functionality was a harmonized measure using activities of daily living (ADLs).[29] Poor self-reported health was based on the general question asked regarding health and also harmonized. [17] Historical data on the prevalence of diabetes in the US, England and the Netherlands during the 1960s-1970s were obtained from several sources.[30-34]

Control Variables.—All statistical models control for age, gender, years of education and smoking. Smoking was defined according to whether a respondent ever smoked, smoked in the past or currently smokes based on self-reports. A dichotomous variable was created which reflected at least one visit to a doctor within the last year. Good caloric intake was defined to mean living at the time of the survey in a country which has

a higher than 2,700 daily caloric intake per capita (1=yes, 0=no); Bangladesh, India and Ghana were classified as lower caloric intake countries using data from the year 2000. Most higher caloric intake countries were in the mid caloric category in the 1930s.[35]

Sample selection for multivariate models.—Older adults who were born between the late 1920s and early 1940s were selected from the larger cross national dataset. Table 1 shows the sample characteristics for the sample selected according to mortality regime. A full justification for the categorization of countries into mortality regimes has been provided elsewhere.[17]

[Insert Table 1 about here]

Analyses

Age-standardized prevalence of older adult diabetes was computed and described in relation to caloric intake in early life and to mortality regimes of the early 20th century using self-reported diabetes. Nested multivariate models were estimated for diabetes and obesity beginning with basic age-gender models and then adding early life conditions (birthplace, country-level daily caloric supply per capita, interactions between caloric intake and birthplace-Model 1), adult SES and current country-level daily caloric supply per capita (Model 2), smoking and obesity (Model 3), adult health (functionality, poor self-reported health (Model 4) and whether or not the respondent visited a doctor at least once in the last year (Model 5). Available biomarkers for diabetes where used to compare initial estimates of the prevalence of diabetes. Similar models for measured hypertension in a subset of countries were estimated and using

this subset, models for diabetes and obesity were estimated again. Imputation methods were used to address missing values for models using hypertension.[36]

Results

Associations with early life and adult health

Figure 3 depicts the association between adult diabetes, early life caloric intake and the demographic transition of the early 20th century. The prevalence of diabetes is higher in countries with mid to low caloric intake prior to WWII than countries with high caloric intake such as US, England and the Netherlands, Argentina and Uruguay. The prevalence of diabetes is highest for Puerto Ricans (28%). The middle income but mid paced mortality regimes of Costa Rica and Chile have a higher prevalence than the middle income but earlier mortality regimes of Argentina and Uruguay. Older adults in SABE cities in Brazil, Mexico and Barbados born during late mortality regimes also have a higher prevalence of diabetes—possibly reflecting the earlier timing of mortality decline in urban areas.[d] The prevalence of diabetes is very low for countries that had low caloric intake and not yet experiencing a demographic transition during the late 1920s through early 1940s (severe mortality regimes of China, India and Indonesia).

[Insert Figure 3 about here]

Multivariate models (diabetes and obesity)

Being born in a mid caloric intake country increased the odds of adult diabetes by between 61-72% even after controlling for adult lifestyle and socioeconomic conditions although here were no significant interactions between rural birthplace and caloric

intake for the mid caloric countries (Table 2, Models 1-5). Being born in a low caloric intake country and being born in the rural countryside reduced the odds of diabetes by 40-45% as compared with being born in a country with good caloric intake. Obesity models produced similar results. Being born in a mid-caloric intake country increased the odds of obesity by between 46-53% as compared with being born in a country with good caloric intake (Table 3).

[Insert Tables 2-3]

Biomarkers

A comparison between the prevalence of diabetes using self-reported questions and using a biomarker for diabetes shows that underestimation may be more problematic in some developing countries such as China as compared with other developing and developed countries (Table 4). The results using biomarkers confirms the significance of Figure 3—namely, the high prevalence of diabetes among some developing countries according to a demographic transition. The prevalence of hypertension using measured blood pressure almost suggests a slightly higher prevalence of hypertension in the mid-caloric intake countries of Costa Rica, Mexico and South Africa (Table 5). In some instances (Costa Rica, Mexico, South Africa, Ghana, Indonesia and India), females have a higher prevalence of high blood pressure than males. When logistic models are estimated on the subsample of respondents where blood pressure was measured, a comparison across adult diabetes, obesity and hypertension shows a strong association between being born in a mid-caloric country and these adult health conditions (Table 6). The odds of reporting diabetes are between 47-77% higher in the mid-caloric countries

and 28-30% higher for having high blood pressure in the mid-caloric countries (Costa Rica, Mexico, South Africa) as compared with the low-caloric intake countries (China, Ghana, India, Indonesia).

[Insert Tables 4-6]

Discussion

Population-based surveys of older adults born during the late 1920s through early 1940s combined with historical country-level data on caloric intake were used to examine associations between early life conditions and older adult diabetes, obesity and hypertension. While country differences appear, cross national patterns suggest that the prevalence of adult diabetes and obesity is associated with poor nutritional circumstances in early life and that this is particularly relevant for cohorts of the early 1930s-1940s that can be characterized by their increased survivorship of poor early life conditions. Results from a smaller subset of countries and respondents suggest that this is also the case for hypertension.

Dietary volume and dietary quality can have different impacts on health,[8] but there have been few studies on older adults in low and middle income countries which have demonstrated how differences in early life nutrition and diet may be associated with older adult health.

The higher prevalence of diabetes in older adults shown for selected middle income countries was never as high historically in developed countries such as the US.[30-33] Similarly, the high prevalence of diabetes in Puerto Rico is higher than the prevalence reported for Puerto Rican men of similar age born at the turn of the 20th century in

Puerto Rico (10%).[34] The pattern of higher prevalence of diabetes in selected middle income countries as compared with the historical prevalence in the developed world of adults of similar age groups suggests different conditions and determinants of adult diabetes in these settings. It suggests the importance of a critical period, whether it be *in utero*, infancy or childhood. Although not directly tested in this paper, the pattern also suggests the validity of arguments regarding the interaction between poor early life nutrition combined with overnutrition at older ages.[15] The caloric intake and exposure to a more Western style diet high in saturated fats[11] for developing countries such as Costa Rica, Mexico, Puerto Rico, Chile was much higher during the adulthood of older adults born in the early 20th century than it was during their childhood.[35] The combination of a critical early period with nutritional and lifestyle changes in later life may thus be a lethal combination for some older adults that produces disease. The results are not surprising given the evidence showing that mortality due to diabetes has been increasing while mortality due to heart disease has been decreasing in some settings in the LAC region.[23] There may also be important gender differences in early life[38,39] which lead to adult diabetes which have not been explored in this paper. The results do, however, contradict the viewpoint that early life nutrition *in utero*/early infancy is a minor contributor to adult health in low and middle income countries.[11]

The nature of the study prohibits the possibility of disentangling precise mechanisms in early life associated with older adult health. Thus, it is not possible to disentangle poor nutrition and infectious diseases. Nor is it possible to delve deeper into the meaning of diet because there is little information on individual diet during childhood of older adult respondents in population-based studies. Averages do not take into account within-country variances that may be important.

The use of self-reports for adult diabetes presents the possibility of underestimation especially in countries where access to good quality health care is difficult. However, similar results for obesity (a measured quantity) suggest that underestimation may not be so problematic in some circumstances. There are available country-specific rating of health care systems by WHO for all of the countries in RELATE but it would be far preferable to have information about the quality of care received on a respondent level. Although self-reports show some validity,[40-42] biomarker data in studies such as WHO-SAGE will be invaluable when they become available. In the meantime, examining self-reports in the context of health insurance may be helpful under the assumption that private health insurance provides better care than public health insurance. However, this approach also presents challenges. A review of the studies in the RELATE data (results not shown) found that health insurance (as one can imagine) is complex because of the different types of health insurance policies from country to country. In the Latin American studies (SABE, CRELES, PREHCO, MHAS) there is a question asking about private insurance but the frequency varies quite a bit across countries. In Chile, in particular, a large proportion of respondents say they have the available public health insurance and only a small percentage have private insurance. Yet, according to WHO, the Chilean health care system is ranked high in terms of quality. Then, in the Asian countries there are a very large percentage of respondents who have no health insurance at all. In the WHO-SAGE countries the question about health insurance is rather vague; the question asks simply if the person has either mandatory or voluntary insurance. Then, there is the case of Cuba with public health plans and a good quality health care system. The Bangladesh survey was conducted in rural areas and almost no one has a private health insurance plan but some of the respondents lived in areas which

received interventions for maternal child health care and so perhaps may have been exposed to better health care in some way. If one standardizes (or weights) prevalence by the distribution of private health insurance one may perhaps have more confidence in the self-reported health questions in some instances where there is a substantial amount of people who have private health insurance (like Costa Rica, Puerto Rico, Brazil and Uruguay). However, in other instances, because the percent with private health insurance is very small, standardizing will not produce much difference. Another difficulty with using private health insurance to counteract underestimation is that not everyone can afford to have private health insurance coverage and if this is the case then standardizing by private health insurance to estimate diabetes introduces bias.

Birthplace is a broad measure that may also reflect epidemiological differences between rural and urban settings. The measure of caloric intake at the country level is a crude measure which may reflect either poor nutritional status and deprivations, infectious diseases or both. Compositional effects across countries may affect the comparability of caloric intake and require more examination as there are differences across countries in terms of the makeup of caloric intake. Earlier preliminary analyses (not shown here) estimated models using different definitions of poor nutrition (e.g. percent of cereals, grams of protein and the percent of protein from animal sources).

Differences in sampling strategies across studies mean that care must be taken in generalizing the results to the entire population of older adults. Most all surveys were random surveys but some are representative of older adults in countries (HRS, Costa Rica, PREHCO) and regions (SAGE) whereas others (SABE) reflect major cities of Latin America. WLS was a selection of high school graduates from Wisconsin in 1958. The question of bias in the prevalence estimates arises even before pooling of countries

because it could be that there are significant differences in prevalence of diabetes if we were able to obtain country-wide data for Latin America instead of data from major cities. It could also be argued that the selection of the countries introduces the possibility for bias---all studies come from major studies of aging. As a result the prevalence estimates for diabetes are conservative. Previous analyses (not shown here) included country-specific models using most of the variables in the final models and in general the results are similar.

In spite of these limitations, the topic of early life conditions and older adult health in the developing world remains important and the data available can provide insights. Further investigation is warranted to better understand the cross national patterns between diabetes and early life nutrition and diet and to examine the long term consequences of demographic transitions on older adult health. The question of how this line of research will impact health care policies is a complex one. There is some evidence that under some conditions the long term effects of poor early life conditions can be mitigated through appropriate health interventions at critical periods. Mostly, interventions earlier in the life span through either supplementing income/nutrition appear to be more effective. Modifying effects at older adults may be more difficult although the field of epigenetics holds promise for future interventions. In any event, contemporary health care policies will benefit from a closer examination of the determinants of older adult health among those born in the 1930s-1960s and the interventions that will help mitigate the long term effects of poor early life conditions.

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Table 1: Sample characteristics for cross national data on aging populations born during the late 1920s-early 1940s in selected low and middle income countries

Regime/ Country	F (%)	Age	Years School	Born rural (%)	Ever smoked (%)	Obese (%)	Limited function (%)	Poor health (%)	Diabetes (%)	Heart Disease (%)	Visited doctor (%)
Early											
Cuba	55	66 (4)	8 (4)	52	58	17	11	63	14	23	72
Uruguay	63	67 (4)	6 (4)	41	46	34	12	38	14	20	74
Mid-Paced											
Chile	58	66 (4)	7 (5)	47	51	34	16	60	14	31	72
Costa Rica	52	68 (5)	5 (4)	72	43	25	11	47	22	11	93
Puerto Rico	55	67 (5)	9 (5)	57	33	30	9	66	28	16	86
South Africa	64	69 (6)	6 (5)	38	33	44	27	19	13	10	70
Late											
Barbados	59	67 (4)	6 (4)	47	26	29	5	42	22	9	90
Brazil	59	66 (4)	4 (3)	64	49	23	14	53	18	18	84
Mexico MHAS	48	63 (5)	4 (4)	65	40	20	5	63	17	3	60
Mexico SABE	55	66 (4)	5 (5)	54	47	32	12	71	21	9	79
Mexico SAGE	53	72 (6)	4 (4)	32	41	27	22	13	19	12	40
Very Late											
Bangladesh	54	59 (6)	2 (3)	99	30	1	12	34	15	--	68
China SAGE	54	70 (5)	5 (5)	55	34	6	7	29	8	12	60
Ghana	50	70 (5)	3 (5)	60	25	8	27	21	5	14	68
India	48	69 (5)	3 (4)	73	58	2	32	28	6	22	89
Indonesia	54	62 (5)	4 (4)	84	50	3	6	22	3	4	10

Source: RELATE,[24] weighted where relevant. Omitted from the table are the very early regime countries of the US, England and the Netherlands. Also omitted are countries which did not measure obesity (Argentina, China-CLHLS) and for which information on rural/urban birthplace was not available (Taiwan, China-CHNS). The values above are based on a total sample of 27,105 respondents. Sample sizes for individual countries were: Cuba (1,007), Uruguay (810), Chile (704), Costa Rica (1,522), Puerto Rico

(2,395), South Africa (1,068), Barbados (735), Brazil (868), Mexico-MHAS (2,200), Mexico-SABE (727), Mexico-SAGE (938), Bangladesh (2,242), China-SAGE (4,231), Ghana (1,721), India (2,399), and Indonesia (3,538).

Notes: All numbers are either percentages (where indicated) or averages with standard deviations in parentheses. "F" refers to female. Age is at the time of the surveys. Bangladesh respondents are slightly younger and SAGE respondents are slightly older than other older adult respondents due to timing of the surveys. Limited function is having difficulty with at least one activity of daily living. This measure has been harmonized across countries. Poor health is poor self-reported health. This measure was also harmonized across countries. Visited doctor reflects if respondent had visited a doctor or similar medical professional at least once within the last year. This measure was also harmonized although the question in the Indonesian survey reflects a 5-year period. The averages appearing for diabetes are age-standardized and are shown in Figure 3.

Table 2: Caloric Intake and the Likelihood of Reporting Diabetes for Those Born in the Late 1920s - Early 1940s

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Demographic					
Female	1.25***	1.31***	1.16***	1.09*	1.05
Age	1.00	1.01	1.00	1.01*	1.00
Years education		1.06***	1.05***	1.06***	1.05***
Childhood					
Rural birthplace [a]	0.96	0.99	1.00	0.95	0.97
Low caloric intake [b]	0.93	0.82	0.83	1.02	1.20
Mid caloric intake [b]	1.68***	1.72***	1.61***	1.66***	1.69***
High (reference) [b]	1.00	1.00	1.00	1.00	1.00
Low X rural birthplace	0.55***	0.56***	0.59***	0.60***	0.60***
Mid X rural birthplace	1.07	1.07	1.06	1.03	0.98
Adult Lifestyle					
Good calorie country [c]		0.83*	0.84*	0.85*	1.06
Good calorie X education		0.96***	0.96***	0.96***	0.96***
Used to smoke			0.99	0.92	0.90*
Smokes now			0.67***	0.66***	0.67***
Never smoked (ref)			1.00	1.00	1.00
Obese [d]			1.30***	1.27***	1.25***
Adult Health					
Difficulty with functionality [e]				1.11*	1.10
Poor reported health				2.18***	2.02***
Systems					
Visited a doctor within the last year					2.01***
Log likelihood	-10119	-10088	-10040	-9825	-9715
BIC [f]	20320	20287	20223	19812	19603
Total observations	25,665	25,665	25,665	25,665	25,665

Source: RELATE[24] excluding high income countries—US, Netherlands, and England. Taiwan is not included because its survey did not have information on birthplace.

* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$.

Table 3: Caloric Intake and the Likelihood of Being Obese for Those Born in the Late 1920s - Early 1940s

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Demographic					
Female	2.41***	2.46***	2.23***	2.17***	2.15***
Age	0.99**	0.99**	0.99**	0.99***	0.99***
Years Education		1.08***	1.08***	1.08***	1.08***
Childhood					
Rural birthplace [a]	1.04	1.05	1.06	1.07	1.08
Low caloric intake [b]	0.26***	0.26***	0.24***	0.25***	0.27***
Mid caloric intake [b]	1.52***	1.53***	1.44***	1.45***	1.46***
High (reference) [b]	1.00	1.00	1.00	1.00	1.00
Low X rural birthplace	0.29***	0.33***	0.33***	0.33***	0.33***
Mid X rural birthplace	0.76*	0.76*	0.74*	0.73**	0.72**
Adult Lifestyle					
Good calorie country [c]		1.40**	1.41**	1.54***	1.64***
Good calorie X education		0.93***	0.93***	0.93***	0.93***
Used to smoke			0.94	0.92	0.92
Smokes now			0.58***	0.58***	0.58***
Never smoked (ref)			1.00	1.00	1.00
Adult Health					
Difficulty with functionality [d]				1.58***	1.57***
Poor reported health				1.03	1.01
System					
Visited a doctor within the last year					1.16***
Log likelihood	-9604	-9590	-9543	-9505	-9499
BIC [e]	19290	19292	19220	19163	19161
Total observations	27,105	27,105	27,105	27,105	27,105

Source: RELATE[24]; excluding high income countries—US, Netherlands, and England. Taiwan is not included because its survey did not have information on birthplace.

* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$.

Table 4: Prevalence of diabetes using self-reported questions and using biomarker

Study (year)	Self-report	Biomarker
High caloric intake		
England-ELSA (2004)	8	9
US-HRS (2006)	22	24
US-HRS (2008)	25	24
Mid caloric intake		
Costa Rica-CRELES (2003)	23	26
Taiwan-SEBAS (2000)	14	16
Low caloric intake		
China-CHNS (2009)	5	15

Source: RELATE[24], those born late 1920s-early 1940s.
Notes: Using the biomarker for glycated hemoglobin, HbA1c, and using the definition of Yan et al.[28] to define high risk of diabetes: Not at risk (hba1c<5.7); at risk-impaired glucose control (hba1c>=5.7% and <6.5%); High risk (hba1c>6.5% or taking diabetes medication). Prevalence is shown as a percentage. These numbers are not directly comparable with Figure 3 because in some cases the biomarkers and self reports were collected at a different time period: HRS 2006, 2008 versus the original data HRS 2000; CHNS 2009 versus original data 2000. The studies are grouped according to country-level caloric intake in the 1930s.

Table 5: Prevalence of hypertension

Study	Overall	Males	Females
High caloric intake			
England-ELSA, 2008	63	65	62
US-HRS 2006, 2008	73	74	72
Mid caloric intake			
Costa Rica CRELES 2003	74	71	77
Mexico-SAGE, 2007-08	74	68	78
S Africa-SAGE, 2007-08	80	77	83
Taiwan-SEBAS, 2000	52	51	53
Low caloric intake			
China-CLHLS 2002	51	51	52
China-CHNS, 2009	56	56	56
China-SAGE, 2007-08	69	69	69
Ghana-SAGE, 2007-08	60	56	64
Indonesia-IFLS 2007	63	58	68
India-SAGE, 2007-08	40	37	45

Source: RELATE[24], those born late 1920s – early 1940s.

Notes: Prevalence is shown as a percentage and high blood pressure was defined to be systolic >=140 mmHg or diastolic >=90 mmHG or taking medication to control hypertension (mmHG is millimeters of mercury—the units used to measure blood pressure). In some cases cannot directly compare prevalence (CLHLS, SEBAS) because cohort was younger (2000, 2002) than members of the 1930s-1940s cohort in other studies (2007-2009). The CLHLS study also did not have a question about medication for hypertension and this may explain its lower prevalence. CLHLS and SEBAS are excluded from further analysis because of this. The studies are grouped according to country-level caloric intake in the 1930s.

Table 6: Comparison of the effects of early childhood conditions on older adult diabetes, obesity and hypertension

Childhood	Diabetes		Obesity		Hypertension	
	Coef.	p-value	Coef.	p-value	Coef.	p-value
Group A (n=17,136)						
Born rural	0.47	0.000	0.51	0.000	0.88	0.004
Mid caloric country	1.57	0.000	6.83	0.000	1.23	0.002
Mid X rural	1.55	0.000	1.31	0.031	1.07	0.447
Group B (n=15,392)						
No father education	0.69	0.000	1.13	0.293	0.98	0.734
Mid caloric country	1.47	0.002	12.35	0.000	1.30	0.003
Mid X no education	1.37	0.065	0.74	0.052	1.05	0.632
Group C (n=17,136)						
Low height	0.72	0.000	1.43	0.000	0.94	0.152
Mid caloric country	1.77	0.000	7.64	0.000	1.28	0.000
Mid X low height	1.22	0.118	1.18	0.165	0.94	0.529

Source: RELATE[24]; those during the late 1920s-early 1940s; studies with biomarkers and measured hypertension. Self-reported diabetes, obesity based on BMI, measured hypertension.
Notes: Models also controlled for age, gender, education, country-level caloric intake in 2000 and interaction with education, smoking, obesity, functionality, poor health, health utilization. Countries: low caloric: China, Ghana, India, Indonesia; mid caloric: Costa Rica, Mexico, South Africa. Groups A and C included Indonesia, Costa Rica and SAGE; Group B included only Indonesia and SAGE. Sample sizes differ because Costa Rica did not ask about father's education.

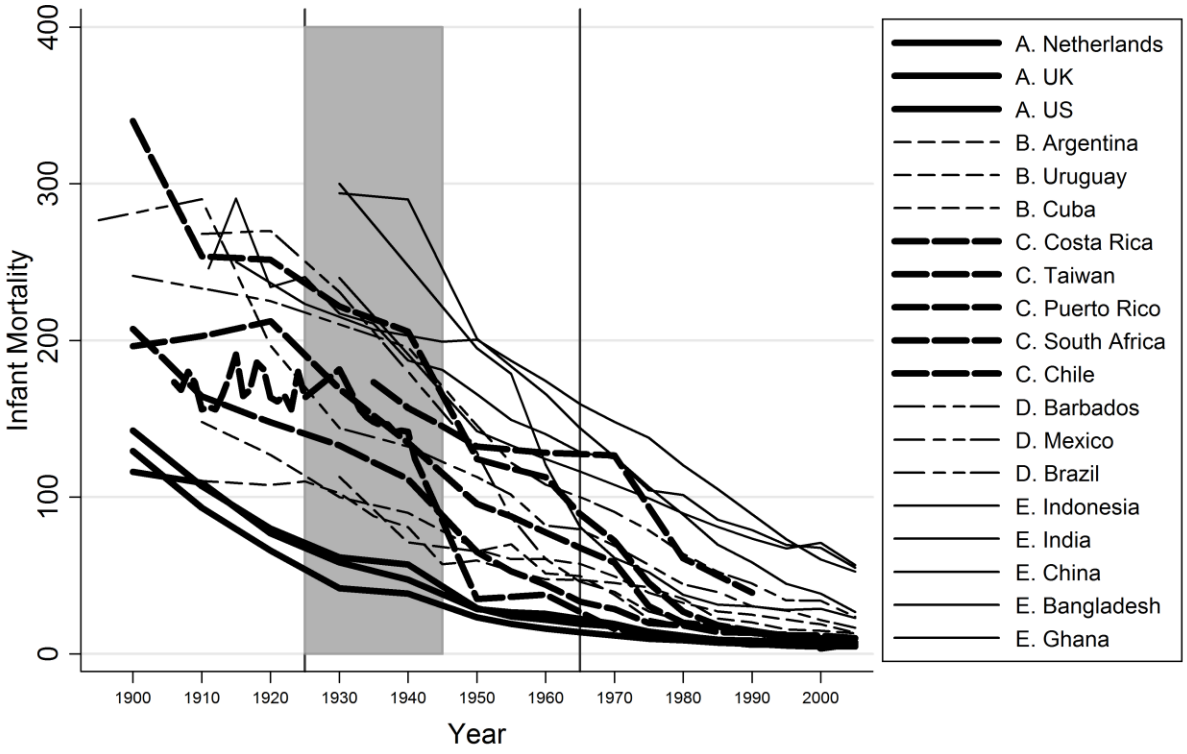


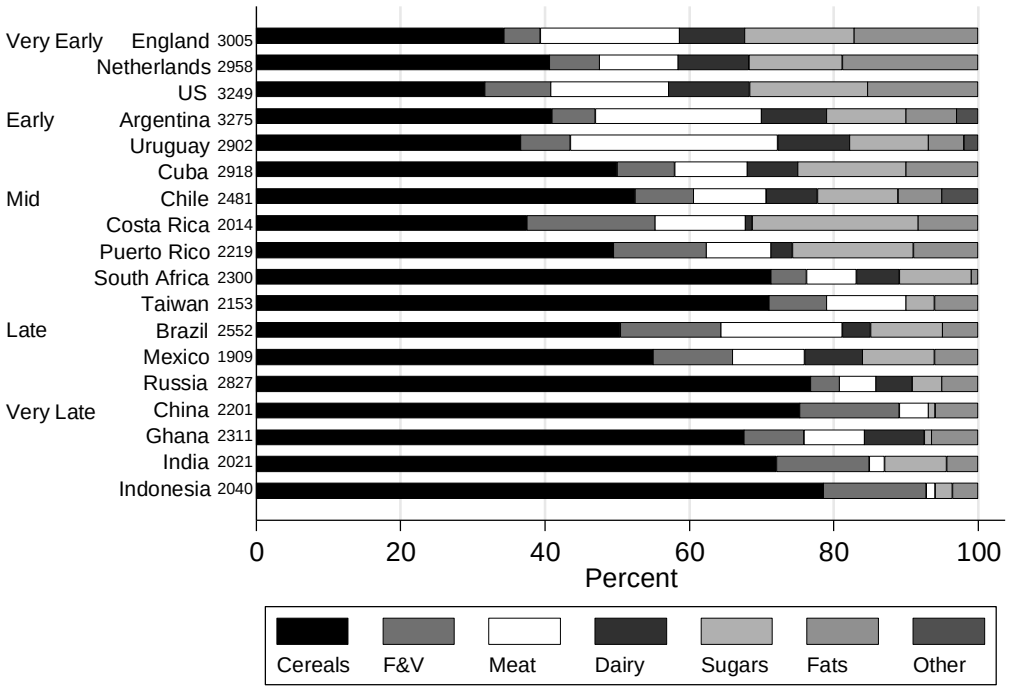
Figure 1: Infant mortality in selected countries and mortality regimes

Source: McEniry, 2014.[17]

Notes: Countries listed from highest to lowest life expectancy in 1930 by infant mortality. The shaded gray area from the late 1920s to the early 1940s is the time period of interest.

Mortality regimes: A=Very Early, B=Early, C=Mid, D=Late, E=Very Late.

The classification of high, middle and low income countries used by the World Bank,[20] the countries referenced above: England, Netherlands, US, Puerto Rico, Taiwan, and Barbados (high income); Argentina, Cuba, Uruguay, Chile, Costa Rica, South Africa, Brazil, Mexico, and Russia (upper middle income); China, India, and Indonesia (lower middle income); and Bangladesh and Ghana (low income). Although Taiwan and Barbados appear with middle income countries in their demographic transition, they are classified as high income countries.



Note: Graph shows mortality regimes, countries, caloric supplies and composition of diet.
Cereals includes cereals, roots and tubers; F&V includes fruits, vegetables and pulses.

Figure 2: Components of daily caloric intake per capita in the 1930s

Source: FAO (Table 2);[27] author's calculation of percentages based on this table. The number of total calories appearing in this table (to the right of the name of each country) is an estimation for daily caloric intake per capita prior to WWII.

Notes: Countries are divided into mortality regimes according to the demographic transition of the early 20th century. Earlier regimes experienced an earlier and more gradual mortality decline at higher standards of living; mid and late regimes experienced more rapid decline during the late 1920s through 1940s and the very late regimes experienced mortality decline during the late 1940s and 1950s.[17]

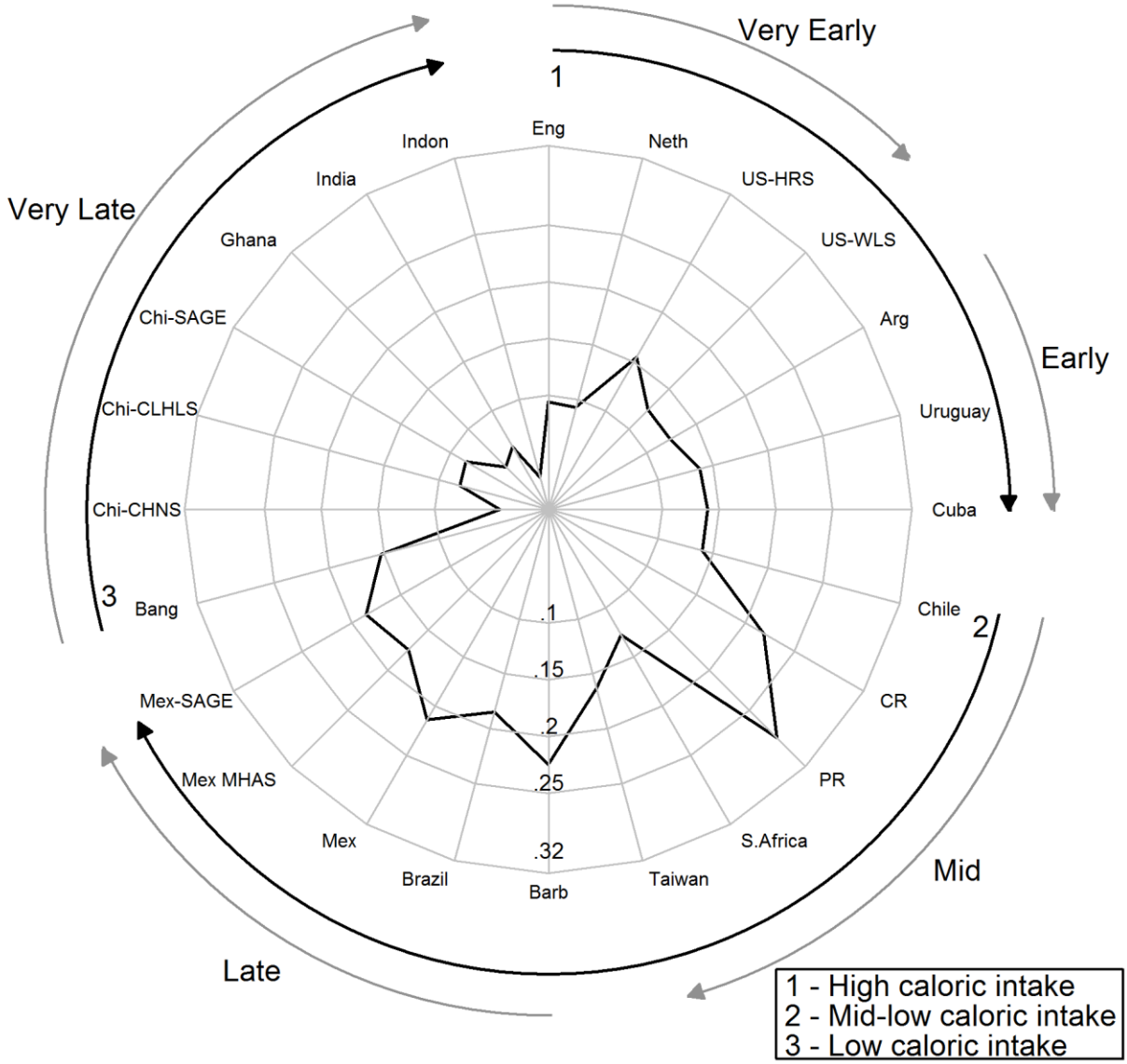


Figure 3: Proportion reporting diabetes in relation to demographic transition and early life caloric intake in the early 20th century

Sources: Age-standardized prevalence based on RELATE[24] for those born during the late 1920s and early 1940s using WHO standards.[37] Order of countries appearing in graph is according to mortality regime (see below). Countries were grouped into three broad categories according to daily caloric intake per capita based on Food and Agriculture Organization of the United Nations[27] and in the case of Barbados and Ghana according to other historical records.

Notes:

SAGE older adults born in the late 1920s-early 1940s are older at the time of the survey (2007-08) than older adults from other surveys (2000-2005). Similarly, Indonesia data for diabetes

was obtained in 2007. The SABE survey represents older adults in major cities of Latin America and the Caribbean.

FAO[26] did not identify caloric supply for these countries although historical evidence describing environmental and nutritional conditions during the 1930s indicate that caloric supply must have been very low. FAO in fact identifies surrounding countries in French West Africa as having a caloric intake of 2311.

Mortality regimes along with countries are depicted in the graph as: A. Very early; B. Early; C. Mid; D; Late; and E. Very late.[17]

Country-specific daily caloric intake per capita were defined as follows:
Low = less than 2100 daily caloric intake per capita in the 1930s.
Mid = greater than 2100 and less than 2800 daily caloric intake per capita in the 1930s.
High = greater than 2800 daily caloric intake per capita in the 1930s.

[a] Partially based on these data, mortality regimes according to the timing, pace and reason for mortality decline were defined: Very early (England, Netherlands, US), early (Argentina, Uruguay, Cuba), mid-paced (Puerto Rico, Costa Rica, Chile, Taiwan, South Africa), late (Barbados, Brazil, Mexico, Russia); very late (Bangladesh, China, Ghana, India, Indonesia).[17]

[b] The demographic transition described here during the beginning of the late 1920s through early 1940s produced increasing changes in poorer developing countries which are now mostly upper middle income countries: Chile, Costa Rica, South Africa, Brazil, Mexico.

[c] A more suitable measure would have been questions regarding the educational attainment of the respondent's father or mother. However, there were not a sufficient number of countries in the sample which collected data on parental education. Where available in the cross national data, there were strong associations between parental education and rural birthplace—rural birthplace being strongly associated with lower educational attainment. Thus, birthplace was used as a proxy for low parental SES. The limitation of using rural/urban birthplace is that it is very broad and there may be important rural and urban differences in epidemiology environment which confound the meaning of rural birthplace.