Cross national comparisons across low, middle and high income countries of poor early life nutrition and diet and older adult diabetes and heart disease[1]

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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 (Kinsella; He, 2009; Murray; Lopes, 1996). Under certain circumstances, these conditions may originate in *in utero*/early infancy due to poor nutrition at critical moments (Barker, 1998) or due to inflammatory processes (Finch; Crimmins, 2004). Poor nutrition in early life increases the risk of infection and disease (Scrimshaw, 1968; Floud et al., 2011), which may then lead to poor adult health (Elo; Preston, 1992). Adult heart disease and diabetes may also result from an accumulation of adverse events and behaviors throughout the life course (Kuh; Ben-Shlomo, 2004). The composition of diet is important in that diets high in saturated fats, meat and dairy products can increase the risk of heart disease and diabetes at older ages even among well-nourished populations (Popkin, 2006). 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 and diabetes (Schmidhuber; Shetty, 2005).

In some developing countries 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. Infant and child mortality rapidly 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 (Palloni; Pinto-Aguirre; Pelaez, 2002; McEniry, 2014). This cohort is most at risk of having been affected by harsh early childhood experiences and, simultaneously, having had larger probabilities of surviving; they are less affected by mortality-driven selection than the group of cohorts that preceded them. A large group of individuals within this cohort may now be at higher risk of poor

health as they age due to these early life circumstances. This may be particularly evident in the Latin American and Caribbean region. Using cross national data on older adults this paper examines the degree to which this conjecture has merit for heart disease and diabetes.

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 (RELATE, 2013). Most surveys are random samples and are representative of older adults in countries, regions or major cities.

Measures

Early life conditions — 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. Historical pre-WWII data on daily caloric supply per capita country-level caloric intake is used as a crude measure reflecting early life nutritional environment (FAO, 1946). Countries were grouped according to caloric intake per capita using low (less than 2,100 calories), mid (2,100 but less than 2,800) and high (2,800 or higher). This grouping roughly corresponds to previously defined mortality regimes of the 20th century: High caloric intake (A. Very early — developed countries; B. Early — Argentina, Uruguay); Mid caloric intake (C. Mid-Costa Rica, Puerto Rico, Chile, South Africa; D; Late — Mexico, Brazil, Barbados); and low caloric intake (E. Very late — Bangladesh, China, Ghana, India, Indonesia) (McEniry, 2014).

Adult Health — Self-reported questions were used to ascertain adult heart disease and diabetes although for some countries, well-validated symptom questions for coronary heart disease were also used (Rose, 1962). A body mass index of greater than or equal to 30 identified obese individuals. Difficulty with functionality was a harmonized measure using activities of daily living (ADLs) (McEniry, 2011). Poor self-reported health was based on a question regarding the overall health of a respondent and also harmonized (McEniry, 2014).

Control Variables — All statistical models control for age, gender, years of education and smoking (ever smoked, past smoker, current smoker). A dichotomous variable indicating good caloric intake was created for those living at the time of the survey in a country which had higher than 2,700 daily caloric intake per capita. A dichotomous variable was created to indicate at least one visit to a doctor within the last year.

Sample selection for multivariate models — Older adults who were born between the late 1920s and early 1940s were selected from RELATE (n=27,105) because most adults born in the later part of the 1930s-1960s have not yet reached the age of 60.

Analyses

Age-standardized prevalence of older adult heart disease and diabetes was computed and described in relation to caloric intake in early life and to mortality regimes of the early 20th century. Nested multivariate models were estimated for diabetes and heart disease 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), adult SES and current country-level daily caloric supply per capita, smoking and obesity, adult health (functionality, poor self-reported health and whether or not the respondent visited a doctor at least once in the last year. Imputation methods produced similar results and thus non-imputed results are presented.

Results

Associations with early life and adult health

Figure 1 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. 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).

In contrast, a similar graph for heart disease depicts a higher prevalence of heart disease in countries with a higher level caloric intake during the late 1920s through early 1940s and an earlier health transition (Figure 2). The prevalence of heart disease in middle income, earlier regimes of Argentina, Uruguay and Cuba is higher than that of middle income, mid paced regimes of Costa Rica, Puerto Rico, Mexico and Brazil. The prevalence of heart disease in lower income, severe mortality regimes of the early 20th century is low with the exception of India.

Figure 1
World (selected countires)
Proportion reporting diabetes in relation to demographic transition and early life caloric intake in the early 20th century
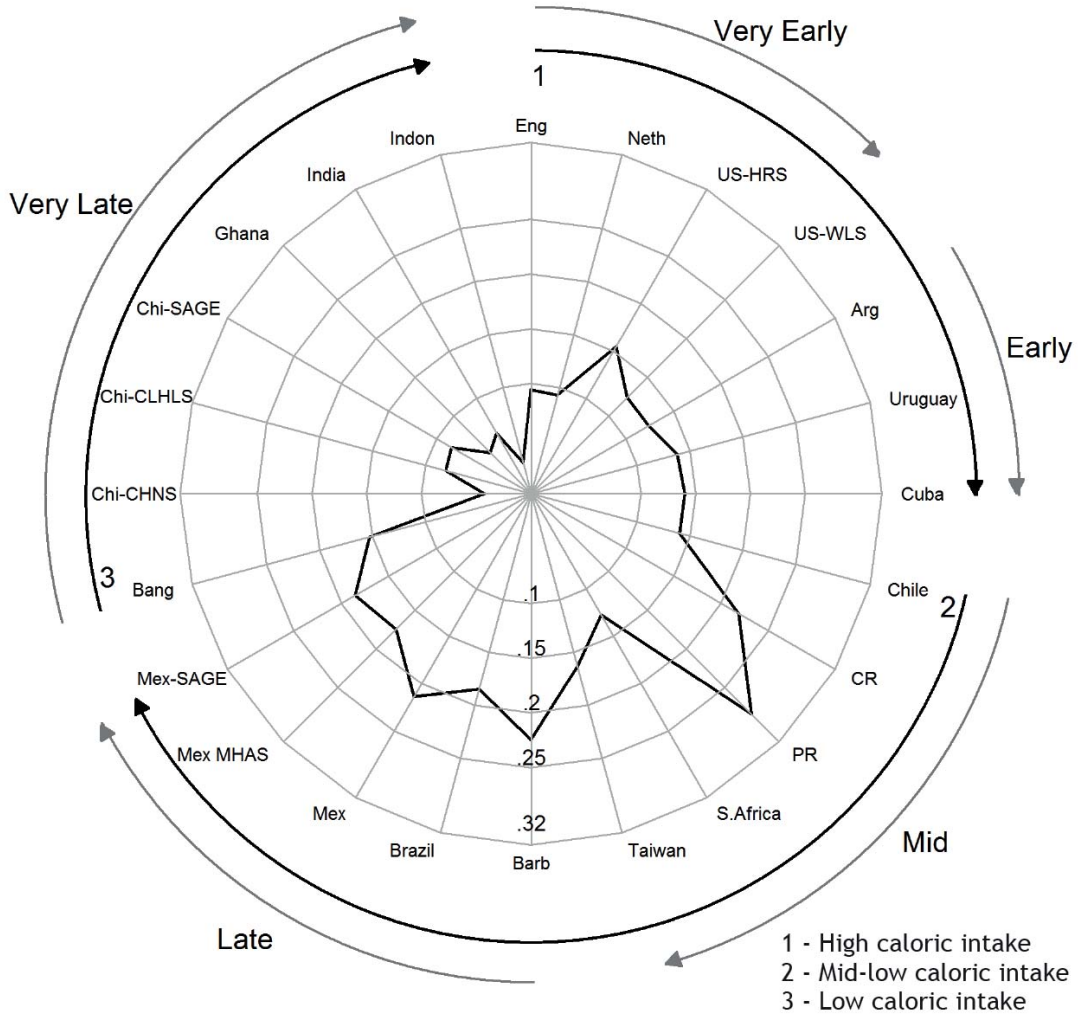
Sources: Age-standardized prevalence based on RELATE (2013) cross national data for those born during the late 1920s and early 1940s using WHO standards. Order of countries appearing in graph is according to mortality regime: A. Very early; B. Early; C. Mid; D; Late; and E. Very late. Countries were grouped into three broad categories according to daily caloric intake per capita.

Figure 2
World (selected countires)
Proportion reporting heart disease in relation to demographic transition and early life caloric intake in the early 20th century
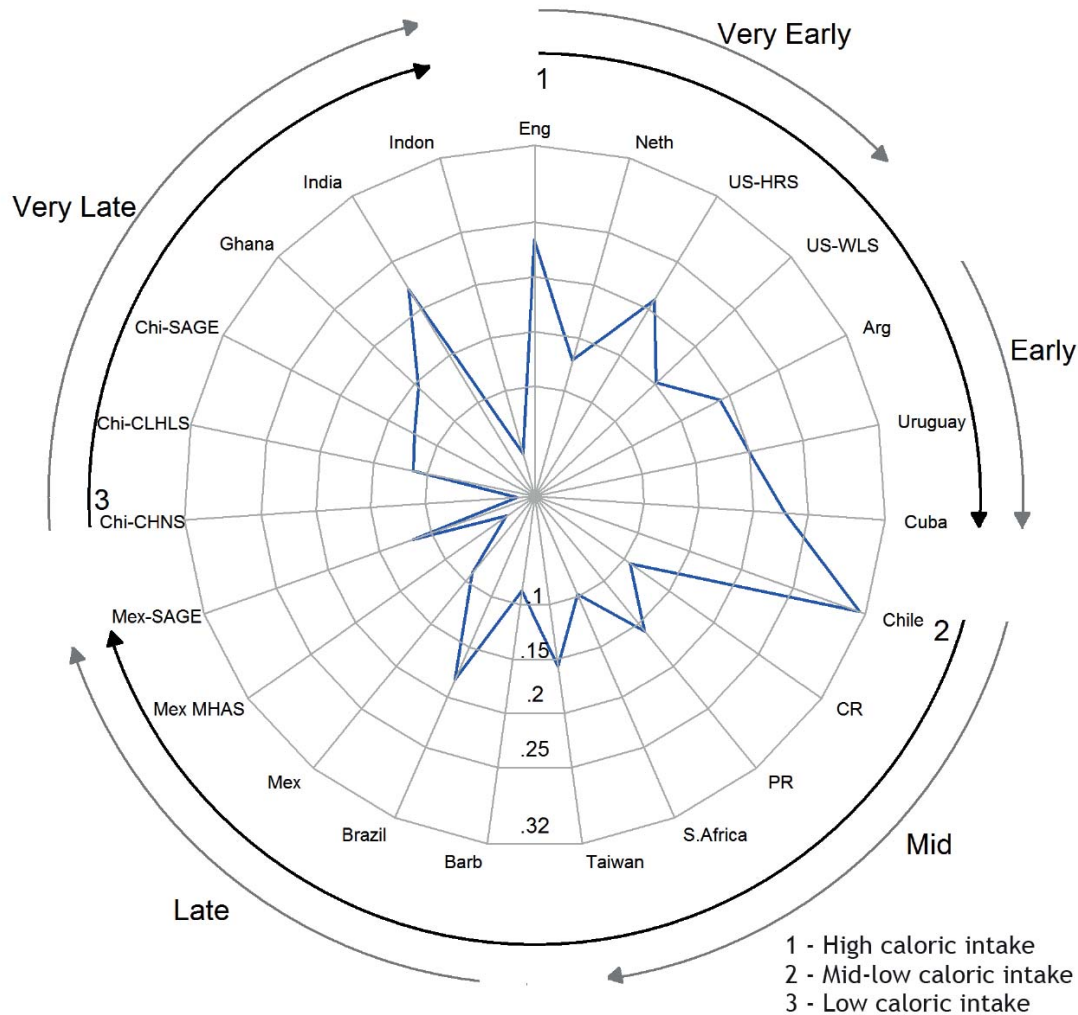
Sources: Age-standardized prevalence based on RELATE (2013) cross national data for those born during the late 1920s-early 1940s using WHO standards. Order of countries appearing in graph is according to mortality regime: : A. Very early; B. Early; C. Mid; D; Late; and E. Very late. Countries were grouped into three broad caloric categories according to daily caloric intake per capita.

Multivariate models

Logistic models generally confirm the graphical depiction of diabetes and heart disease in Figures 1 and 2. Being born in a mid caloric intake country increased the odds of adult diabetes by between 61-72%, controlling for adult lifestyle, health and socioeconomic conditions (Table 1). For heart disease, being born in a low or mid caloric country reduced the odds of heart disease by 30-60% (Table 2). However, in the case of heart disease being born in rural areas and a in mid caloric country increased the odds of heart disease by between 34-41 percent. Adding visits to a doctor eliminated the significance of these later results for the mid caloric countries.

Table 1
World (selected countires)
Odds of reporting diabetes for those born in the late 1920s-early 1940s

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Childhood					
Rural birthplace	0.96	0.99	1.00	0.95	0.97
Low caloric intake	0.93	0.82	0.83	1.02	1.20
Mid caloric intake	1.68[c]	1.72[c]	1.61[c]	1.66[c]	1.69[c]
High caloric intake (ref)	1.00	1.00	1.00	1.00	1.00
Low X rural birthplace	0.55[c]	0.56[c]	0.59[c]	0.60[c]	0.60[c]
Mid X rural birthplace	1.07	1.07	1.06	1.03	0.98
Total observations	**25,665**	**25,665**	**25,665**	**25,665**	**25,665**

Source: Cross national data set66 excluding high income countries — US, Netherlands, and England. Shown are odds ratios. [a]p<0.05, [b]p<0.01, [c]p<0.001.
Notes: Model 1 controls for age and gender; Model 2 adds adult SES and current country-level daily caloric supply per capita; Model 3 adds smoking and obesity, Model 4 adds adult health (functionality, poor self-reported health) and Model 5 adds whether or not the respondent visited a doctor at least once in the last year.

Table 2
World (selected countires)
Odds of reporting heart disease for those born in the late 1920s-early 1940s

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Childhood					
Rural birthplace	1.02	1.07	1.09	1.05	1.07
Low caloric intake	0.70[c]	0.61[c]	0.69[c]	0.91	1.04
Mid caloric intake	0.40[c]	0.41[c]	0.40[c]	0.40[c]	0.41[c]
High (reference)	1.00	1.00	1.00	1.00	1.00
Low X rural birthplace	0.75[a]	0.69[b]	0.70[b]	0.70[b]	0.70[b]
Mid X rural birthplace	1.40[b]	1.41[b]	1.40[b]	1.34[a]	1.28
Total observations	**21,672**	**21,672**	**21,672**	**21,672**	**21,672**

Source: Cross national data set excluding high income countries — US, Netherlands, and England. Shown are odds ratios. [a]p<0.05, [b]p<0.01, [c]p<0.001.
Notes: Model 1 controls for age and gender; Model 2 adds adult SES and current country-level daily caloric supply per capita; Model 3 adds smoking and obesity, Model 4 adds adult health (functionality, poor self-reported health) and Model 5 adds whether or not the respondent visited a doctor at least once in the last year.

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 heart disease and diabetes. While country differences appear, cross national patterns suggest that the prevalence of adult diabetes is directly 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. The results for heart disease suggest that poor early life nutritional circumstances and low income conditions are also associated with later adult heart disease in these cohorts.

Even with underestimation, 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 (McEniry, 2014). 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%) (McEniry, 2014). 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 (Schmidhuber; Shetty, 2005). The caloric intake and exposure to a more Western style diet high in saturated fats 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 (FAO, 2012). 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. There may also be important gender differences in early life (Eriksson et al., 2010) 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 (Popkin, 2006).

The case of heart disease is more complicated and less clear. In spite of underestimation, the prevalence of heart disease in some middle income countries is also higher than the historical prevalence in the developed world of adults of similar age groups (McEniry, 2014), suggesting different conditions and determinants of adult heart disease in these settings. There were no direct associations between poor early nutrition and heart disease as shown in Figure 2. However, the risk of heart disease increased for those born in middle income countries in rural areas in estimated models. Poor early life nutrition may have stronger direct effects on adult obesity and diabetes with consequences for heart disease (Popkin, 2006).

Dietary volume and dietary quality can also have different impacts on health. The results suggest that composition of diet in early life in nutritionally better off countries (the developed world but also Argentina and Uruguay) may be important — a surprising conclusion given that there has been more attention devoted to examining how poor early life nutrition is associated with older adult health than with examining how dietary quality (diet composition) in early life poses risks later in life. The consumption of processed red meats (e.g., hamburgers, hot dogs, sausage and bacon) reflects a Western diet that has been closely associated with a higher risk of diabetes than the consumption of unprocessed meats (Aune; Ursin; Veierød, 2009; Micha; Wallace; Mozaffarian, 2010; van Dam, 2002) whereas the consumption

of either processed or unprocessed red meat can be important risk factors for adult heart disease (Pan et al., 2012). In the early 20th century, if families in the developing world had access to red meat at all, much of it was unprocessed (Grigg, 1999). The consumption of a higher degree of unprocessed red meat in early life in nutritionally richer developing countries such as Argentina and Uruguay may have thus more greatly affected the risk of adult heart disease.

It may also be too premature to judge the results for adult heart disease. The effects of poor early life circumstances and a transition to a different diet later in life may have a more immediate effect on chronic conditions such as diabetes. It may take a generation before a similar cross national pattern of effects is observed for adult heart disease (Trowell; Burkitt, 1985).

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. It is not clear how the quality of the health care system may influence the self-reporting of these conditions and examining self-reports in the context of health insurance may be helpful. Although self-reports show some validity (Banks et al., 2006; Goldman et al., 2003) and the use of well-validated symptom questions for heart disease partially address concerns, biomarker data will better define adult health status in future efforts. 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. Differences in sampling strategies across studies mean that care must be taken in generalizing the results to the entire population of older adults.

The topic of early life conditions and older adult health in the developing world remains important. Further investigation is warranted to better understand the contrasting cross national patterns between adult heart disease and diabetes and early life nutrition and diet and to examine the long term consequences of demographic transitions on older adult health. 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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