Biological health risks and economic development

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September 2014

The WHO estimates that noncommunicable diseases (NCDs) were the primary cause of nearly 40 million deaths in 2012 - over two-thirds of all deaths across the globe. About half of those deaths are attributed to metabolic-related diseases including heart disease, hypertension, diabetes and stroke. While these causes account for less than 1 in 6 deaths in low income countries, they are the most common cause of death in higher income countries, accounting for 1 in 4 deaths in low-middle income countries, almost half all deaths in upper-middle income countries and about the same percentage in high income countries.

Figure 1a

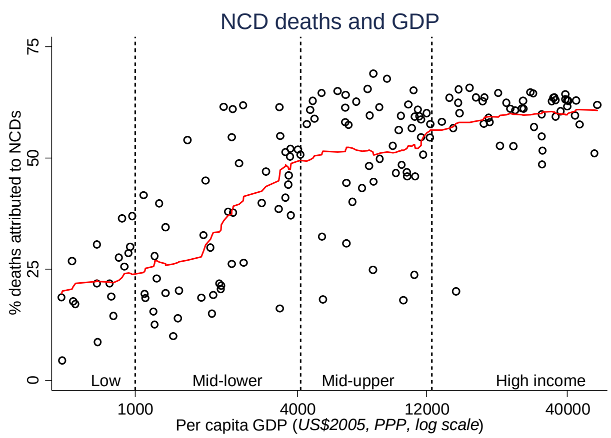
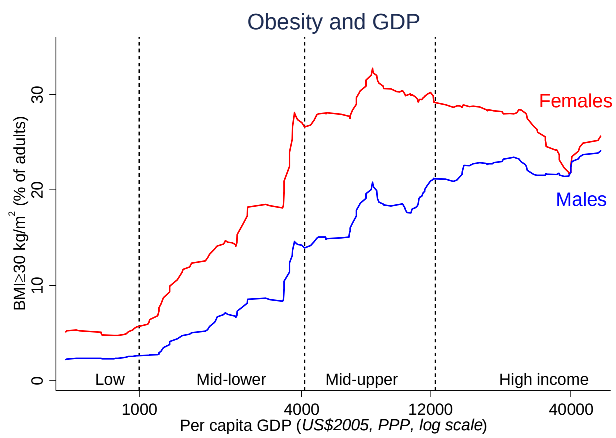


Figure 1b



Sources: WHO Mortality database and Global Burden of Disease Risk Factors database and Penn World Tables. Locally weighted smoother scatter plots with biweight weighting function and 10% bandwidths.

Figure 1a displays the fraction of deaths attributable to NCDs (as reported by the WHO) and per capita gross domestic product, GDP (in purchasing power parity constant US $), for 181 countries in 2008. Cut-offs for the World Bank definitions of low, lower middle, upper middle and high income countries are marked on the GDP axis which is displayed using a logarithmic scale. Non-parametric estimates of the relationship are in red. Roughly speaking, the patterns track the nutrition transition – and the associated epidemic of obesity – that is sweeping across the globe (Popkin 1994, 2004; Popkin, Adair & Ng, 2012) which is illustrated in Figure 1b. That figure displays non-parametric estimates of the relationship between per capita GDP and the fraction of the male and female adult population (age≥25) that is obese (body mass index, BMI≥30kg/m^2).

Three facts are immediate from the figures. First, among middle income countries, as GDP increases, both the fraction of deaths attributed to NCDs and the fraction of the population that is obese rise rapidly, especially among lower middle income countries. Second, the relationship between level of GDP and fractions obese differs for males and females. Among females most of the rise in obesity rates with GPD is concentrated in lower middle income countries (for which obesity rises from 5% to about one-third), whereas for males obesity rates increase with GDP for all middle income countries and reach a maximum of around one-fifth of the population. Third, both the fraction of deaths attributed to NCDs and the rates of obesity are essentially constant (albeit at very different levels) for the poorest and for the richest countries. Obesity rates are low in the poorest countries and, as GDP increases in the richest countries, obesity rates are constant (for males) and fall (for females).

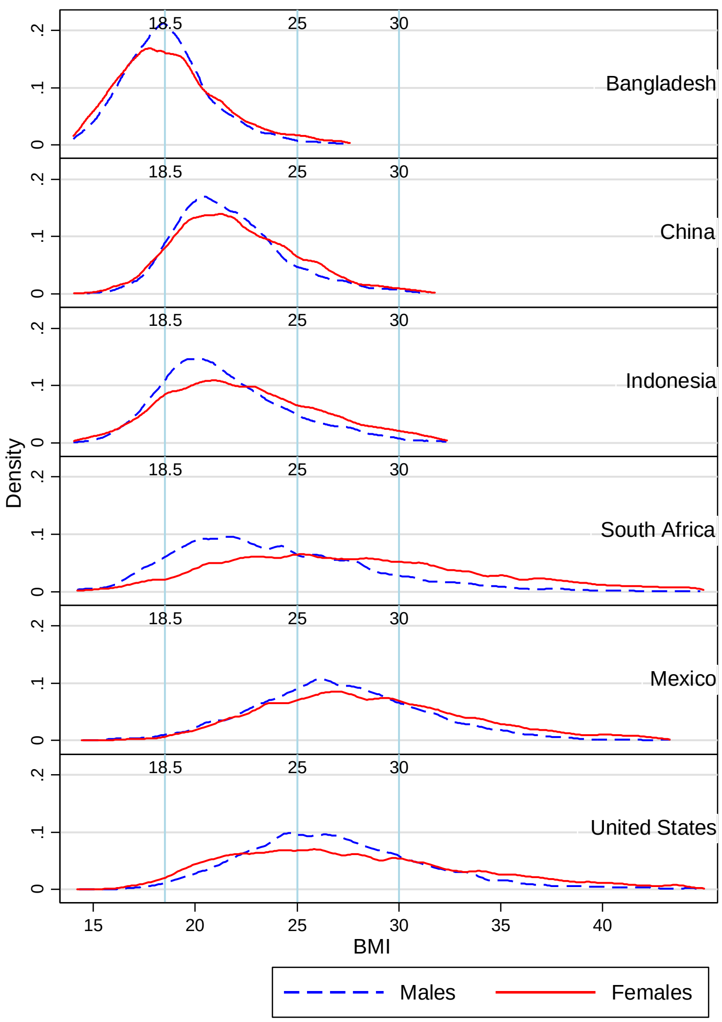
BMI has proved to be an extremely useful summary measure of overall health, particularly for adults. Extreme values of BMI (obesity and being underweight, i.e. BMI≤18.5) have been shown to be associated with elevated morbidity and mortality (Waaler 1984; Fogel 2004; Preston 2005; Preston et al. 2014). However, a rich literature has documented a set of additional behavioral and biological risk factors that are associated with metabolic-related diseases and elevated mortality.

Contribution

This paper aims to provide a broad summary of how major biological risk factors vary across the globe and how they vary within countries. Specifically, using large-scale population-representative survey data, we describe variation in the prevalence of elevated risks across by age, gender and socio-economic status in the poorest and richest countries in the world. We focus on three biomarkers that have been shown to be key predictors of metabolic-related disease: BMI, hypertension and cholesterol levels in the blood.

Beginning with BMI, Figure 2 displays the distribution for adult males and females (age 22 through 75) using survey data from six countries. The countries are arrayed from poorest (at the top) to richest (at the bottom).[1] Echoing the pattern in Figure 1b, the distribution of BMI shifts to the right as development proceeds.

Figure 2: BMI across the globe

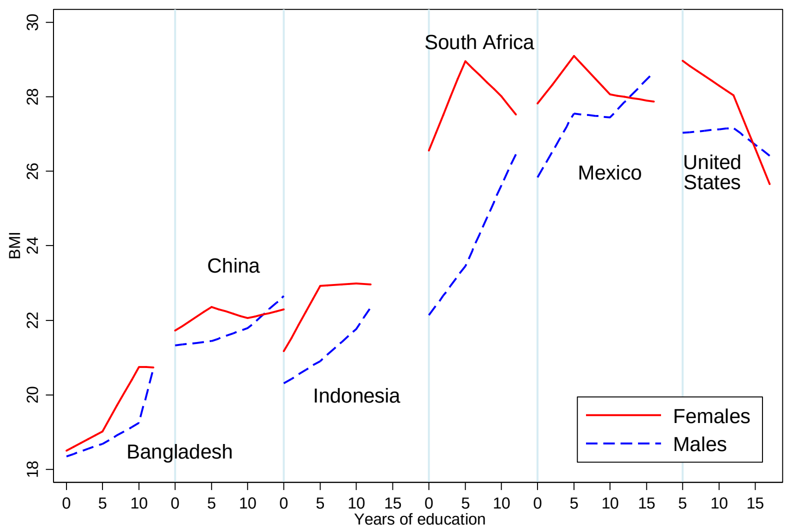


In Bangladesh, over half the adult population is underweight and less than 5% are overweight (BMI≥30kg/m^2). Moving up the GDP distribution to China, only about 10% of the population is underweight whereas about 15% is overweight. Generally, women are more likely to be overweight than men, but gender differences are particularly dramatic in South Africa. The co-existence of under-nutrition and over-nutrition is a hallmark of many LDCs as they move through the nutrition transition.

Continuing up the GDP ladder, in Mexico, undernutrition is rare but almost three-quarters of the population is overweight or obese. The Mexican and United States distributions are very similar – although income per capita is about 4 times higher in the US than in Mexico. In terms of BMI, the developing world is catching up or surpassing the developed world, although incomes lag far behind.

[1] Data are drawn from a subset of the surveys listed in Table 1. The South African, Mexican and United States surveys are nationally representative; the Indonesian survey is representative of about 80% of the Indonesian population; the Chinese survey is representative of 9 provinces and the Bangladesh survey is representative of one district. Figure 2 presents non-parametric estimates of the shapes of the BMI distributions.

Figure 3: BMI and education



Figures 1 and 2 indicate that BMI rises with aggregate income. Does BMI increase with SES at the individual level? To answer this question, Figure 3 displays the relationship between BMI and education for males and females controlling age, in a regression framework. Again, the countries are ordered according to GDP.

In the five developing countries, BMI of males is positively correlated with education at all levels of education but in the United States, BMI and education are not correlated among male high school dropouts and negatively correlated for better educated males. Among females in developing countries, there tends to be a positive correlation between BMI and education at the bottom of the education distribution which turns negative at higher levels of schooling.

Recall that, on average, females have higher BMI than males. This is true at lower levels of education but at the top of the education distribution in China, Mexico and the United States, males have higher BMI than females. Similarly, in South Africa the gap in BMI between males and females is very small among the best educated relative to those with no education.

The inverted U shape in Figure 3 is consistent with evidence in the literature indicating that as a population moves through the nutrition transition, it is the most educated (and highest income) who are the first to exit under-nutrition (Monteiro et al. 2004). They are also the first to adjust their diet and physical activity to avoid the deleterious effects of being overweight suggesting that behavioral changes have important impacts on health outcomes. Figure 3 also indicates that it is women who tend to lead this transition. The relative importance of information, resources, behavioral change, technology and other factors in these processes has not been established.

Behind these figures is substantial heterogeneity across age groups, some of which can be attributed to cohort differences. Table 1 displays the fraction of prime age adults and older adults who are underweight and overweight. In the three poorest countries, older adults are more likely to be underweight than prime age adults indicating that in terms of improved nutrition, younger adults benefit more from economic growth. In contrast, in the richer countries, older adults are more likely to be overweight than prime age adults suggesting that as populations move through the nutrition transition, it is the prime age adults who are more responsive to the negative effects of being overweight. In China (and among prime age Indonesians), twice as many females are overweight as underweight suggesting rapid change in the nutrition profile is underway in these countries.

Next Steps

With these facts as a foundation, this paper will proceed to provide new evidence on how BMI, hypertension, pulse pressure and cholesterol (total and HDL) vary with age, gender and SES across countries and relate these patterns to the evolution of the biomarkers with economic development. The information contained in each biomarker will be discussed with special attention being paid to whether or not the respondent has been diagnosed with the risk factor, uses medication to control the risk factor and whether the risk factor is, in fact, controlled. Hypertension provides a good example. Levels of diagnosis of hypertension in low income countries are very low and medication rates are even lower (typically less than 10% of the population). Yet in many of these populations, over 30% of the adults would be judged hypertensive based on biomarker

Table 1: Distribution of BMI in 6 countries

Indicator	Gender	Bangladesh	China	Indonesia	South Africa	Mexico	United States
All ages (22-70 yrs)							
BMI (Mean)	Male	18.7	21.8	21.5	24.0	27.2	27.1
	Female	18.7	22.2	22.5	28.2	28.7	28.1
% Underweight [BMI<=18.5]	Male	50.4	8.7	15.9	10.1	1.4	1.1
	Female	52.7	10.3	14.7	4.7	0.9	2.4
% Overweight [BMI>25]	Male	1.7	11.9	13.9	36.0	69.5	63.3
	Female	3.0	17.5	25.1	63.6	74.1	62.7
% Obese [BMI>30]	Male	0.1	1.2	1.3	11.4	23.8	22.5
	Female	0.3	2.5	4.8	35.1	36.0	32.9
Prime age (25-44 yrs)							
% Underweight [BMI<=18.5]	Male	43.5	6.4	13.6	10.0	1.3	1.1
	Female	45.2	8.3	10.5	5.0	0.8	2.7
% Overweight [BMI>25]	Male	1.8	9.5	13.5	31.6	68.7	59.3
	Female	3.3	14.3	25.2	59.9	70.9	57.0
Older age (45-64 yrs)							
% Underweight [BMI<=18.5]	Male	57.3	12.0	19.7	10.2	1.6	1.2
	Female	62.5	13.3	21.2	4.2	0.9	2.1
% Overweight [BMI>25]	Male	1.6	15.2	14.8	42.1	70.6	67.8
	Female	2.6	22.3	25.0	68.1	79.4	69.9
Sample size	Male	3,449	3,257	7,815	3,547	4,863	5,636
	Female	4,222	3,457	8,423	5,242	6,662	6,431

Table 2

Country	Survey	Type	Years	Markers
Bangladesh	Matlab Health and Socioeconomic Study	L	1996	Ht, wt
India	Study of Global Ageing and Adult Health	L	2007	Ht, wt, BP
China	China Health and Nutrition Survey	L	2009	Ht, wt, BP, Chol
	Study of Global Ageing and Adult Health	L	2007	Ht, wt, BP
Indonesia	Indonesia Family Life Survey	L	1993 1997 2000 2007	Ht, wt, BP, Chol
Mexico	Mexican Family Life Survey	L	2002 2005/6 2009/12	Ht, wt, BP, Chol
	Study of Global Ageing and Adult Health	L	2002/3 2009/10	Ht, wt, BP
South Africa	National Income Dynamics Survey	L	2008 2010 2012	Ht, wt, BP
	Demographic and Health Survey (NCD module)	C	2003	Ht, wt, BP
	Study of Global Ageing and Adult Health	L	2007/08	Ht, wt, BP
Russia	Russian Longitudinal Monitoring Study	L	1995-2013	Ht, wt
	Study of Global Ageing and Adult Health	L	2007/10	Ht, wt, BP
United States	National Health and Nutrition Examination Study	C	1990-2012	Ht, wt, BP, Chol

Notes: Type of survey: Longitudinal (L) or Cross-section (C) measurement in the field. The research will document how measured, controlled and uncontrolled hypertension and cholesterol vary across age, gender and education in a multivariate regression framework and how those relationships vary across countries. Drawing on different cross-sections and on longitudinal survey data, we will also document change over the life course for individuals or cohorts. (Addo, Smeeth and Leon, 2012; Basu and Millett, 2013)

Data will be drawn from surveys that have been conducted in the last 30 years in eight countries at varying levels of development and stages of the nutrition and epidemiological transitions. These include the six countries presented in Figures 2 and 3 – Bangladesh, China, Indonesia, Mexico, South Africa and the United States – along with India and Russia. We have selected surveys that are both population-representative and sample adults across all ages in order to document variation in the relationships across the life-course. The surveys are listed in Table 2. Several of the surveys are longitudinal in design and they will be exploited to separate cohort from age effects in the evolution of the risk factors.

Taken together, the results will provide new insights into the likely evolution of biological risk factors as economies grow and countries develop. In addition, these results will suggest potentially productive mechanisms for interventions designed to mitigate the impending epidemic of metabolic-related NCD morbidity and mortality in middle-income countries.

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