Does health care expenditure counter adverse effects of obesity on health: Evidence from global data

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Abstract: There is evidence that obesity is a risk to health and longevity of life. This is the first paper to use cross-country data to analyze the effect of obesity levels on life expectancy, and the trade-off between health expenditure and obesity levels. It uses a panel data of 194 countries for the years 2002, 2005 and 2010. We find that life expectancy has non-monotonic relationship with obesity levels. At low prevalence of obesity, life expectancy is increasing in obesity levels, but beyond a certain threshold level of obesity prevalence, an increase in obesity level reduces life expectancy. Countries that spend more on health expenditure are able to counter the effects of increased obesity on life expectancy. Incremental effect of health expenditure in enhancing life expectancy is higher for countries where obesity prevalence is low. The impact of health expenditure on increasing life expectancy is higher for women. The results are consistent over

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three data sets: when the health indicator is life expectancy at birth, mortality rate between age group 15-60 years, and healthy life expectancy.

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There is growing evidence about the impacts of obesity on health, and health expenditure. However, there is not much quantitative knowledge about the impact of obesity on life expectancy and the trade-off between health expenditure and obesity levels globally. According to World Health Organization, there are more people suffering from overweight related problems than under-nutrition. In 2014, globally around 39% of adults were overweight and about 13% were obese as compared to about 11% undernourished (FAO 2014). Overweight and obesity were estimated to afflict nearly 1.5 billion adults worldwide in 2008. It is predicted that by 2030 globally an estimated 2.16 billion adults will be overweight, and 1.12 billion will be obese (Kastorini et al. 2011). Finkelstein et al. (2012) predict a 33% increase in obesity prevalence and a 130% increase in severe obesity prevalence over the next 2 decades. These large increases in obesity levels are likely to adversely affect health and entail huge health care costs.

The health effect of obesity may differ across countries due to physiological differences such as body composition, fat patterning, cardio-metabolic effects of higher Body Mass Index (BMI), etc. (Nguyen et al. 2009). The increasing rate of obesity among the poor has important implications for the distribution of health inequalities (Jones-Smith et al. 2011). The wide cross-country differences in obesity and its health consequences are matters of interest but have not been explored adequately. Of particular interest is the impact of obesity on life expectancy that is likely to vary among nations. This is the first paper to use cross country data to analyze the effect of obesity levels on life expectancy, and more importantly, the trade-off between health expenditure and obesity levels. It uses national data of 194 countries over time and demonstrates that obesity tends to reduce life expectancy, but health expenditure significantly reduces this adverse effect. The results are consistent across three indicators of health, viz., life expectancy at birth, adult mortality rate, and healthy life expectancy.

A number of micro level studies with developed country populations (mainly US) have been conducted to study the effect of overweight and obesity on health. In this paper, we use macro modeling in contrast to the micro modeling used thus far. The advantage of the macro analysis is that it allows us to get a broader picture and capture cross country heterogeneity. The disadvantage, however, is that instead of BMI data for individuals, we have to use an aggregate measure of obesity, the percentage of obese people in the population, for each country. Populations are heterogeneous, some people are overweight and others are underweight. Our one measure per country is an aggregation, and we assume that high prevalence of obesity is an indication of population where overweight dominates as a cause of death while low aggregate obesity rate is an indication of high prevalence of undernourishment.

The contribution of our macro level study is to capture how health expenditure that differs across countries mitigates the adverse effect of obesity. The key findings of the paper are --both obesity and underweight reduce life expectancy and increase probability of death. The adverse impact of obesity can be partially mitigated by medical expenditure.

We find that life expectancy (at birth) is increasing in the prevalence of obesity when the obesity prevalence rates are small. It, however, is decreasing in the prevalence of obesity when obesity levels reach a threshold of 33.4% for men and 41.2% for women. As expected, life expectancy is increasing in per capita health expenditure but the effectiveness of health expenditure on life expectancy differs between low obesity prevalence and high obesity prevalence countries. Obesity levels and health expenditure may be affecting men and women differently. We find that a dollar spent on health expenditure has a higher effect on women. Our results are consistent when we use alternative indicators of health, namely, healthy life expectancy (HALE) or adult mortality rate.

LITERATURE REVIEW

A large body of micro level studies have examined the economic and health implications of obesity. Lehnert et al. (2013) found that the increased obesity results in direct health care costs and indirect costs of lost productivity due to illness. Thorpe et al. (2004) report that 27% of the rise in inflation-adjusted medical expenditures between 1987 and 2001 was due to the rising prevalence and costs of obesity. Finkelstein et al. (2009) estimate that the costs of obesity for the US for the year 2008 may be as high as $147 billion per year, or roughly 9% of annual medical expenditures. Cawley et al. (2012) reports that up to 20% of total annual US healthcare expenditures (around 190 billion USD) may have been spent on obesity related medical care in 2005. MacEwan et al. (2014) estimate social costs (or externality) of obesity by estimating the marginal increase in public health expenditure associated with a change in obesity prevalence. They predict that a one-unit increase in BMI for every adult in the United States would increase annual public medical expenditures by $6.0 billion. Stewert et al. (2009) attempt to understand joint effects of increasing obesity levels and reduction in smoking on US life expectancy. They conclude that the negative effects of increasing BMI outweighed the positive decline in smoking.

These results raise a major question - to what extent do the increase in the cost of health care due to increased obesity have an impact on life expectancy?

Reynolds et al. (2005) study on the impacts of obesity in the US suggests that obesity has little effect on life expectancy in adults aged 70 years and older. However, the obese are more likely to become disabled. Flegal and Graubard (2009) also find that the association between mortality and obesity to be weak. Stevens et al. (1999) find that the average years of life lost per person among obese in the US varies with age and sex. Amongst the obese subjects aged 30-39 years, it was 0.91 years for women and 1.06 years for men. Fontaine et al. (2003) estimate expected number of years of life lost (YLL) due to obesity in the US and find obesity to have a profound effect on longevity (much larger than those found by the previous study), YLL varies widely across races and gender. Olshansky et al. (2005) estimate the effect of obesity on US life expectancy using NHANES III risk factors. The estimated effects of obesity on US life expectancy ranged from 0.28 years to 0.88 years. Preston and Stokes (2011) estimate the effect of obesity on life expectancy by combining the prevalence of obesity in a population with the mortality risks for people in particular BMI categories for 16 countries in North America and Europe. They find that obesity has reduced the US life expectancy by 0.6 years for males and 0.9 years for females. In a meta analysis of 97 studies on association between BMI categories and mortality rates in the US, Flegal et al. (2013) find that relative to normal weight, mild obesity level $(30 \leq \text{BMI} < 35)$ was not associated with higher mortality. Severe obesity levels $(\text{BMI} \geq 35)$, however, were associated with higher all cause mortality. Challenging the last study, Global BMI Mortality Collaboration (2016) analyzed individual-participant data from 239 prospective studies in 32 countries in Asia, Australia and New Zealand, Europe, or North America. Their analysis shows that both overweight and obesity (all grades) were associated with increased all-cause mortality.

The available empirical evidence on impact of obesity on mortality comes almost exclusively from high-income countries that have relatively small populations, particularly North America and Europe, and there are not much studies that look at the effect of obesity on health from a global perspective. The results of these, mostly micro level studies, vary and some do not find very significant effect of obesity on health. These studies do not take into account the impact of health expenditure in countering the adverse effect of obesity on life expectancy. Moreover, these studies were from developed countries, which have well established health systems and, therefore, suffer less from increased obesity prevalence. Paarlberg (2015) states that providing treatment is now the United States' primary policy response to the increase in obesity.

The impact of health expenditure on life expectancy may be recovered by including data from resource constrained poor countries with lower capacity to spend on health care. But developing countries are suffering from the "dual burden" of under-nutrition and obesity. It is common to see the problems of underweight, stunting, and micronutrient deficiencies side by side with increasing rates of obesity (Griffiths and Bentley 2001). Thus if we include both developed and developing countries we need to find how both high and low rates of obesity affect life expectancy and to what extent these impacts are related to health expenditure. The literature suggests a substitution between life expectancy and health expenditure that is likely to vary by country and gender - our purpose is to test and qualify these hypotheses.

CONCEPTUAL FRAMEWORK AND EMPIRICAL METHODOLOGY

Johansen (1972) developed an aggregation framework that links micro and macro production functions. We will rely on his aggregation approach to conceptually develop macro level average life expectancy functions that will be used to generate hypotheses for our empirical estimation[2]. We will start with the micro relationship assuming that $l = f(\beta, m, G, t)$ is micro life expectancy function where l is life expectancy, β is BMI, m is health expenditure, G is gender and t is time. The function f is well behaved[3] in β and m. The relationship between life expectancy and weight is complex. Biologically there is an optimal micro level BMI, $\beta = \hat{\beta}$, at which life expectancy peaks. While a BMI lower than $\hat{\beta}$ reflects mostly problems of hunger and malnutrition, a BMI higher than $\hat{\beta}$ is associated with obesity. We hypothesize that life expectancy is increasing in β for $\beta \leq \hat{\beta}$, and decreasing in β for $\beta \geq \hat{\beta}$. This is consistent with the finding of a large prospective study with American participants; Adams et al. (2006) indeed find a U shaped relationship between BMI and risk of death for both men and women, with the highest risk in the lowest and the highest categories of BMI.

Let $f_\beta(\beta, m, G, t)$ be the first derivative of f with respect to β. In particular we will assume

$$f_\beta(\beta, m, G, t) \geq 0, f_{\beta\,\beta}(\beta, m, G, t) \leq 0 \;\; for\ \beta \leq \hat{\beta} \qquad (1)$$

$$f_\beta(\beta, m, G, t) \leq 0, f_{\beta\,\beta}(\beta, m, G, t) \leq 0 \;\; for\ \hat{\beta} \leq \beta \qquad (2)$$

We will also assume that life expectancy is non decreasing with medical expenditure, $f_m(\beta, m, G, t) \geq 0$. There is a debate in the literature as to how much does health care expenditure contributes to population health outcome (Nolte and McKee, 2004)). It is not clear how medical expenditure increases life expectancy directly. Following the logic of Lichtenberg

[2] Hochman and Zilberman (1978) expanded the Johansen framework to derive micro and macro pollution functions.
[3] Continuous and double differentiable.

and Zilberman (1986), we will assume that health care expenditure has an indirect effect on life expectancy. We view life expectancy to be equal to the potential life expectancy minus loss of years of life caused by the action of damaging agents and mitigated by medical treatment. Obesity, undernutrition, environmental conditions, and diseases that are caused randomly are risk factors that reduce life expectancy, and health expenditure is a damage control input that counters their effects.

We will assume that in each country the population is heterogeneous with respect to β and m. We will assume that β can assume values in the range $\beta_L \leq \beta \leq \beta_H$. Similarly , m assume values in the range $m_L \leq m \leq m_H$. The joint density function of β and m for a country, given gender and year, is $h(\beta, m, G, t)$, this function is well behaved given G and t, and $\int_{\beta_L}^{\beta_H} \int_{m_L}^{m_H} h(\beta, m, G, t) d\beta dm = 1$. With this notations the macro expected life expectancy is

$$L = \int_{\beta_L}^{\beta_H} \int_{m_L}^{m_H} f(\beta, m, G, t) h(\beta, m, G, t) d\beta dm. \qquad (3)$$

The aggregation method of Johansen (1972) suggests that if both the micro life expectancy function and the probability distributions of the micro level parameters are well behaved, the macro life expectancy is a function of micro level parameters and parameters of the distributions of β and m . We do not know all the parameters of these distributions. For β we only know the population share with a BMI > 30[4], which is an indicator of obesity prevalence. We will define it as

[4] We use obesity prevalence rather than average BMI because average BMI can obscure the prevalence of obesity, and we are interested in obesity.

$$O = \int_{\beta=30}^{\beta_H} \int_{m_L}^{m_H} \beta h(\beta, m, G, t) d\beta dm. \qquad (4)$$

We also have data on the expected medical expenditure, denoted by M where

$$M = \int_{\beta_L}^{\beta_H} \int_{m_L}^{m_H} m h(\beta, m, G, t) d\beta dm. \qquad (5)$$

Based on our assumptions and Johansen (1972) argumentation, the macro expected life expectancy can be approximated as a well behaved function of $O, M,\ G$ and t, denoted as $L(O, M, G, t)$. While the micro level relationship $l = f(\beta, m, G, t)$ is a biological/technical relationship, the macro level relationship $L(O, M, G, t)$ combines socio-economic parameters on the distribution of m and b with the micro level biological/technical parameters. Using the techniques introduced in Johansen (1972), we will hypothesize that (1) L is an inverse U shaped function of obesity prevalence O, i. e., L is increasing with O until O reaches a threshold and then it declines[5]. The intuition behind this hypothesis is that in populations with low obesity prevalence, most of the people have β below the critical $\hat{\beta}$ and the positive effect of increased BMI exceeds the negative effect in expectation. In populations with high obesity, however, a large share of population has β greater than $\hat{\beta}$ and the overweight effect overcome the underweight effect, and therefore, average life expectancy declines with average obesity[6]. We test this across nations using a quadratic relationship between L and O. (2) L is non decreasing with M. This reflects that medical expenditure reduces the life expectancy loss by treating

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[5] One can use the approach developed by Johansen (1972) to analyze the marginal properties of the production function in order to derive dL/dO.

[6] It is the distance from the optimal BMI that has adverse effect on life expectancy. Thus, ideally, we should have data on percentage of population that is obese, and also percentage of population that is under-nourished for each country. But we have only observations on obesity, country wise data on prevalence of BMI <18 amongst adults is not available.

diseases, etc. (3) Woman have larger life expectancy than man (Waldern, 1976), and (4) Life expectancy increases over time (Oeppen and Vaupel, 2002).

Figures 1 and 2 illustrate life expectancy as a function of prevalence of obesity in male and female population, respectively, for the year 2010. The X axis shows prevalence of obesity measured as the percentage of population having BMI > 30. The Y axis has life expectancy at birth. Each dot represents a country and the density of the dot represents per capita health expenditure of the country.

[insert Figure 1 here]

[insert Figure 2 here]

The graphical representation of data supports our hypothesis that the relationship between life-expectancy and obesity prevalence is inverted U-shaped, increasing at levels of low prevalence of obesity and decreasing after a certain threshold level has reached. The graphs also show trade-offs between health expenditure and obesity levels. For instance, Ethiopia a poor African country has near zero prevalence of obesity, extremely low per-capita health expenditure and very low life expectancy. It is on the rising part of the inverted U curve. On the other extreme, USA has very high obesity levels, the highest per capita health expenditure and a reasonably high life expectancy. In contrast, Mexico has high obesity levels but low per capita health expenditure and low life expectancy. Table 1 presents obesity prevalence, life expectancy and health expenditure of select countries.

For the econometric analysis, we estimate a random effects generalized least square (GLS) regression of a quadratic functional form for the relationship between obesity and life expectancy with robust standard errors[7].

We estimate the following model

$$Life\ expec = a + b\ Obesity + c\ Obesity^2 + d\ pc\ health\ expenditure + h\ Gender + t\ Year + \epsilon \quad (6)$$

Our measure of 'obesity prevalence' is the percentage of population in a country that is obese. We call countries with $\text{Obesity prevalence} \leq 15\%$ as 'low obesity countries' and remaining as high obesity countries. The random element ϵ includes country specific effects like weather, population characteristics, and random shocks.

The threshold level of obesity beyond which any increase in obesity results in reduced life expectancy can be computed as $(-b/2c)$ in equation (6). Below the threshold level, impact of undernourishment dominates that of obesity and gaining weight amongst non-obese people increases average life expectancy. If prevalence of obesity exceeds the threshold level, however, any further increase in percentage of obese population reduces life expectancy. Obesity prevalence becomes a serious concern if obesity prevalence crosses the threshold level.

DATA

We have sourced data from WHO website for 194 countries. National data on obesity prevalence in the age group 15-100 is available for the years 2002, 2005 and 2010. To capture country specific factors, we have constructed a panel data set for 194 countries for years 2002, 2005 and 2010 for variables life expectancy at birth, obesity prevalence and per capita health expenditure. The data on obesity and health indicators is given for males and females separately

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[7] According to Kumbhakar and Lovell (2000), page 106, with large number of countries and small number of years in a panel, a random effects approach based on GLS is clearly preferred to a fixed-effects approach based on LSDV.

for each country, however, data for per capita health expenditure is given for the country as a whole. To capture gender effects, we have used data for males as well as females for each country. Web links for the data our given in Appendix.

Summary Statistics of data is presented in table 2. Our data has equal number of observations on men and women. There is a wide variability in obesity prevalence across different nations, ranging from 0.004% to 84.6%. The mean obesity prevalence is 15.1%. We use 15% as a cut off for dividing countries into low obesity countries and high obesity countries. In our sample, 57.6% of the countries are low obesity countries and 42.4% are high obesity countries. The low obesity countries tend to be developing countries.

RESULTS

The regression results are presented in table 3. Columns 2-5 represent regression results with different formulations. We find that

1.In all specifications, (expected) life expectancy is concave in obesity for both men and women. Namely, life expectancy increases with obesity prevalence (positive coefficient) but declines with the square of obesity prevalence (negative coefficient), and the coefficients are highly statistically significant.

2.On average, women have a life expectancy of 1.7 years higher than men.

3. Life expectancy increases with per capita health expenditure in both low obesity and high obesity countries. In high obesity countries, the health expenditure can counter the adverse impact of obesity on life expectancy and in low obesity countries it can counter the effect of

under-nutrition.

4. For both men and women, the marginal effect of health expenditure on life expectancy is higher for the countries with low obesity prevalence as compared to countries that have a higher obesity prevalence, and the difference is statistically significant.

5. The marginal effect of per capita health expenditure on life expectancy is higher for women than men. That is, a dollar spent on health expenditure increases life expectancy of women more than men. The difference is statistically significant.

Our preferred model is model 3 as it has the highest R square and also allows us to examine differences in the effect of health expenditure on life expectancy in low obesity countries and high obesity countries as well as amongst men and women. The threshold level of obesity beyond which average life expectancy starts decreasing in prevalence of obesity is 33.4% for men and 41.2% for women ((0.5739)/(2*-0.0086)) =33.4); ((0.5739+0.0114)/(2*(- 0.0086 + 0.0015)) = 41.2). Below these thresholds, impact of under-nourishment dominates that of obesity and gaining weight amongst non-obese people increases average life expectancy. Obesity levels in countries such as USA and Argentina have passed these thresholds and many countries such as Mexico, Kuwait, etc. are fast approaching them.

Average global life expectancy is 62.4 years. Controlling for per capita health expenditure and obesity levels, average life expectancy seems to have reduced between 2002 and 2005 but increased by 1.1 years between 2005 and 2010. While life expectancy tends to increase over the years, literature has recognized there are periods when random variation across years results in lowering of life expectancy (Arias, 2005).

For the world as a whole, mean obesity level for men in 2010 is 12.1% and for women is 21.3%. The marginal effect of increasing obesity prevalence by 1% amongst men is increase in global average life expectancy for men by 0.37 years ((0.5739– (2*0.0086*12.1=0.37)) and for women is 0.28 years (0.5853– (2*0.0071*21.3) = 0.28). This implies that globally adverse effect of undernutrition dominates that of obesity. However, there are wide differences across countries. For instance, for the US, the marginal effect of obesity on life expectancy for men is loss of 0.19 years (0.5739– (2*0.0086*44.2) = -0.19). For women the similar figure is loss of 0.10 years (0.5853– (2*0.0071*48.3) = - 0.10).

We also attempt to compute average loss in life expectancy due to obesity for the US. Using model 3, we first estimate predicted life expectancy for the US men at the threshold level of obesity, i.e., 33.4% for year 2010. From this we subtract the predicted life expectancy for the US men at the obesity level actually prevailing, viz., 44.2%. We obtain the loss in life expectancy due to obesity in the US (exceeding the threshold level) to be 1.01 years for men. Following a similar procedure, we obtain the loss in life expectancy due to obesity for US women to be 0.36 years.

We next compute trade-off between obesity and health expenditure for the US for year 2010. We find that at the threshold level of obesity (33.4%), per capita health expenditure of USD 5738.89 results in the same average life expectancy for US men in 2010 as achieved by the actual per capita health expenditure of USD 8269.37 and the actual obesity level of 44.2%. Thus additional USD 2530.5 (8269.37-5738.89 =2530.5) per capita health expenditure is spent due to obesity levels in the US exceeding the threshold level. This can be interpreted as cost of obesity, which is about 30% of the actual health expenditure in 2010. Cawley et al. (2012) reports that up to

20% of total annual US healthcare expenditures may have been spent on obesity related medical care in 2005.

In low obesity countries, the cost of increasing life expectancy by 1 year for women is $435 (1/0.0023= 435) per capita health expenditure, and for men is $1111 (1/0.0009= 1111). Similar costs in high obesity countries are $588 (1/0.0017= 588) for women and $2500 (1/0.0004= 2500) for men. These differences are statistically significant. Concentrating health investments in low obesity countries, which tend to be developing countries, will increase global average life expectancy.

The strong impact of health expenditure on life expectancy found in this study compared to previous studies based on US data suggest that the international comparison we took may allow us to better detect the role of health expenditure in affecting life expectancy. Difference in health expenditures among people or regions in a country like the US may not sufficiently reflect differences in access to medical treatment and equipment made feasible by expenditures. But when comparing among countries, the cost differences may result in different capacity to treat diseases or counter the side effects of obesity and thus affect life expectancy.

CONCLUSION and DISCUSSION

This study aims at finding a simple reduced form relationship between obesity and life expectancy, and the role of health expenditure in countering the adverse effect of obesity on life expectancy. Using a panel data of 194 countries for the years 2002, 2005 and 2010, we find that life expectancy is increasing in obesity levels until they reach 33.4% for men and 41.2% for women and starts declining beyond these thresholds. Even though females have higher life expectancy, the marginal contribution of health expenditure on life expectancy is higher for women. This suggests that societies may be allocating health expenditure biased in favor of males. We also find the marginal effect of health expenditure is higher in less obese countries - that tend to be developing countries. For the world as a whole, the marginal effect of undernutrition still dominates that of overweight. However, for the countries where obesity prevalence has crossed the threshold levels, the marginal effect of obesity is loss in life expectancy years. The loss in life expectancy due to obesity in the US is 1.1 years for men and 0.36 years for women.

This is the first macro level nation wide statistical comparison of its kind but the results are consistent with micro studies at least for the US that suggest that in the US obesity has around one year (or less) effect on life expectancy but leads to a large increase in medical expenditure (Stevens et al., 1999; Olshansky et al., 2005; Flegal and Graubard, 2009; Preston and Stokes 2011; Flegal et al., 2013; Cawley et al., 2012).

The policy implications from our analysis is that the effect of obesity on life expectancy can be addressed through additional health expenditures, which suggests a significant economic gain from reducing obesity rates. Second, health expenditures targeted at females result in a greater life expectancy gains. Third, in some developing countries effects of undernourishment dominate those of obesity; but in others, obesity has become a dominant threat to longevity. Fourth, life expectancy in developing countries will gain significantly from increased health expenditures. And finally, effort to reduce obesity can serve as a major means to reduce medical expenditure in developed countries. The multi country comparisons we conducted allowed us to better see the role of expenditure in affecting life expectancy and countering the impact of obesity.

To check robustness of our results we use two other indicators of health, namely, probability of mortality in the age group 15 – 60 years[8], and healthy life expectancy at birth (HALE) [9]. For data availability reasons, we construct a two-year panel data set for these two indicators. For the sake of comparison across three indicators of health, and also to check robustness of our results, we also report regression results of a two-year panel (2005 and 2012) for life expectancy at birth. The comparative regression results are reported in table 4. The results are consistent across three indicators of health. It can be seen that obesity prevalence has the same concave relationship with the three health indicators, and the coefficients of obesity as well as obesity square are highly statistically significant. The threshold levels of obesity are 33.9% for men and 38.07% for women for the indicator healthy life expectancy. Similar threshold levels for the indicator adult mortality rate are 37.4% and 38.8%. The threshold levels are lowest for the quality of life indicator, suggesting that obesity affects quality of life more than probability of dying.

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[8] Adult mortality (probability of mortality per 1000) refers to the probability of dying between the ages of 15 and 60 years (per 1 000 population) per year among a hypothetical cohort of 100 000 people that would experience the age-specific mortality rate of the reporting year.

[9] Healthy Life expectancy refers to average number of years that a person can expect to live in "full health" by taking into account years lived in less than full health due to disease and/or injury.

This study entails national level comparisons comprising of countries of very different population sizes. A study with a data at a more disaggregated level would be helpful in better understanding of these complex relationships. The study design can be reapplied at lower levels of aggregation to study the same effect with in countries or regions.

The aggregate relationships that we capture is a macro relationship, which need to be further investigated. It should be accompanied by micro level studies, especially in developing countries.

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Table 1: Life Expectancy and Obesity Levels for Selected Countries for year 2010

Country	Life expectancy for men (in years)	Life expectancy for women (in years)	Percentage of male population aged 15 and above that is obese	Percentage of female population aged 15 and above that is obese	Per capita health expenditure in US dollars (PPP int. $)
Ethiopia	60.1	63.6	0.191	0.03	72.31
India	65.3	67.6	1.7	2.0	186.72
Mexico	72.8	78.4	30.1	41.0	974.86
United States of America	76.2	81.1	44.2	48.3	8269.37
Japan	79.5	86.3	2.3	1.1	3232.15

Table 2: Summary Statistics

Variable	No. of Observations	Mean	Std. Dev.	Min	Max
Female Dummy	1164	0.5	0.50	0	1
Life expectancy	1110	67.89	10.38	33.2	86.3
Obesity Prevalence(%)	1140	15.11	14.59	0.004	84.59
Per capita health expenditure (US$ ppp)	1128	925.8	1205.73	10.49	8269.37
Low Obesity Countries	1164	0.576	0.49	0	1
High Obesity Countries	1164	0.424	0.49	0	1

Table 3: Random Effect GLS Panel Data Analysis when Life Expectancy at Birth is the Dependent Variable (194 countries, years 2002, 2005 and 2010)

Life Expectancy at birth	Model 1 Coeff/SE	Model 2 Coeff/SE	Model 3 Coeff/SE
Female	1.7031*		
	(0.8667)		
Obesity	0.5283***	0.4619***	0.5739***
	(0.0932)	(0.0877)	(0.0824)
Obese2	-0.0067***	-0.0078***	-0.0086***
	(0.0013)	(0.002)	(0.0016)
HLEXP	0.0013***	0.0013***	
	(0.0002)	(0.0002)	
yeardummy2005	-0.8999***	-0.9027***	-0.9167***
	(0.1308)	(0.1319)	(0.132)
yeardummy2010	0.2328	0.2327	0.1887
	(0.1581)	(0.1657)	(0.1673)
Obese.F		0.139	0.0114
		(0.0715)	(0.0841)
(Obese.F)^2		0.0006	0.0015
		(0.0019)	(0.0017)
lowObese.M.HLEXP			0.0009***
			(0.0002)
lowObese.F. HLEXP			0.0023***
			(0.0003)
highObese.M. HLEXP			0.0004
			(0.0002)
highObese.F.HLEXP			0.0017***
			(0.0003)
Constant	61.9985***	62.7122***	62.3782***
	(0.8068)	(0.8622)	(0.8579)
No of Obs	1060	1060	1060
R square	0.467	0.453	0.4832
Threshold Obesity level	39.4		

Threshold Obesity level (Men)	29.7	33.4
Threshold Obesity level (Women)	41.8	41.2

Notes: life expectancy at birth (in years); Female: a dummy variable that takes value 1 if the data is for females; Obese: estimated obesity (BMI>30 kg/m^2) prevalence rate (age (15-100); Obese 2: Obese square; HLEXP: per capita total expenditure on health (PPP int. $); LowObese: a dummy variable that takes value 1 if the prevalence of obesity in a country is less than equal to 15; Yeardummy2005 and Yeardummy2010: dummy variables that takes value 1 if the year is 2005 and 2010, respectively; . denote interactions amongst variables; Threshold obesity gives threshold level of obesity beyond which life expectancy starts decreasing in obesity level; * significant at 10% level; ** significant at 5% level; *** significant at 1%; figures in parenthesis are Robust standard errors. Presented models were estimated using Stata/ SE12.

Table 4: Alternative Indicators of Health

	Model 1 (LEXP)	Model 2 (Mortality)	Model 3 (HALE)
(LEXP/mortality/ HALE)	Coefficient/SE	Coefficient/SE	Coefficient/SE
obesity	0.906***	-9.920***	0.937***
	(0.097)	(1.332)	(0.094)
Obese2	-0.013***	0.132***	-0.014***
	(0.002)	(0.026)	(0.002)
ObeseF	-0.038	-1.121	-0.13
	(0.093)	(1.309)	(0.085)
ObeseF2	0.002	0.01	0.003
	(0.002)	(0.028)	(0.002)
lowObese.M.HLEXP	0.002***	-0.031***	0.001***
	(0)	(0.004)	(0)
lowObese.F.HLEXP	0.004***	-0.042***	0.002***
	(0)	(0.005)	(0)
highObese.M.HLEXP	0.001**	-0.015**	0
	(0)	(0.005)	(0)
highObese.F.HLEXP	0.002***	-0.020***	0.001*
	(0)	(0.006)	(0)
YearDummy2010	3.208***	-44.135***	2.578***
	(0.246)	(4.139)	(0.254)
_cons	56.304***	355.219***	49.678***
	(0.843)	(12.278)	(0.8)
Overall R square	0.5625	0.4514	0.4595
No of Obs	730	730	730
Threshold Obesity (Men)	34.7	37.4	33.9
Threshold Obesity (women)	39.1	38.8	38.07

Notes: Model 1 is Random effect GLS Panel data analysis when life expectancy at birth is the dependent variable (194 countries, years 2005 and 2012), obesity prevalence is in the age group 15-100.

Model 2 is Random effect GLS Panel data analysis when probability of mortality is the dependent variable (194 countries, years 2005 and 2012).

Model 3 is Random effect GLS Panel data analysis when the dependent variable is HALE (healthy life expectancy at birth) (194 countries, for years 2002 and 2012).

Healthy Life expectancy is average number of years that a person can expect to live in "full health" by taking into account years lived in less than full health due to disease and/or injury.

Probability of mortality: probability that a 15 year old person will die before 60 years of age (per thousand population);

Female: a dummy variable that takes value 1 if the data is for females; Obese: estimated obesity(BMI>30 kg/m^2) prevalence rate (age (15-100) ; $Obese^2$: Obese square; HLEXP: per capita total expenditure on health (PPP int. $) ; LowObese: a dummy variable that takes value 1 if the prevalence of obesity is less than equal to 15; Yeardummy 2012: a dummy variable that takes value 1 if the year is 2012; . denote interactions amongst variables; threshold obesity gives threshold level of obesity beyond which life expectancy starts decreasing in obesity level (these have been computed using estimated coefficients up to 7 decimal points); * significant at 10% level; ** significant at 5% level; *** significant at 1%; figures in parenthesis are Robust standard errors. Presented models were estimated using Stata/ SE12.

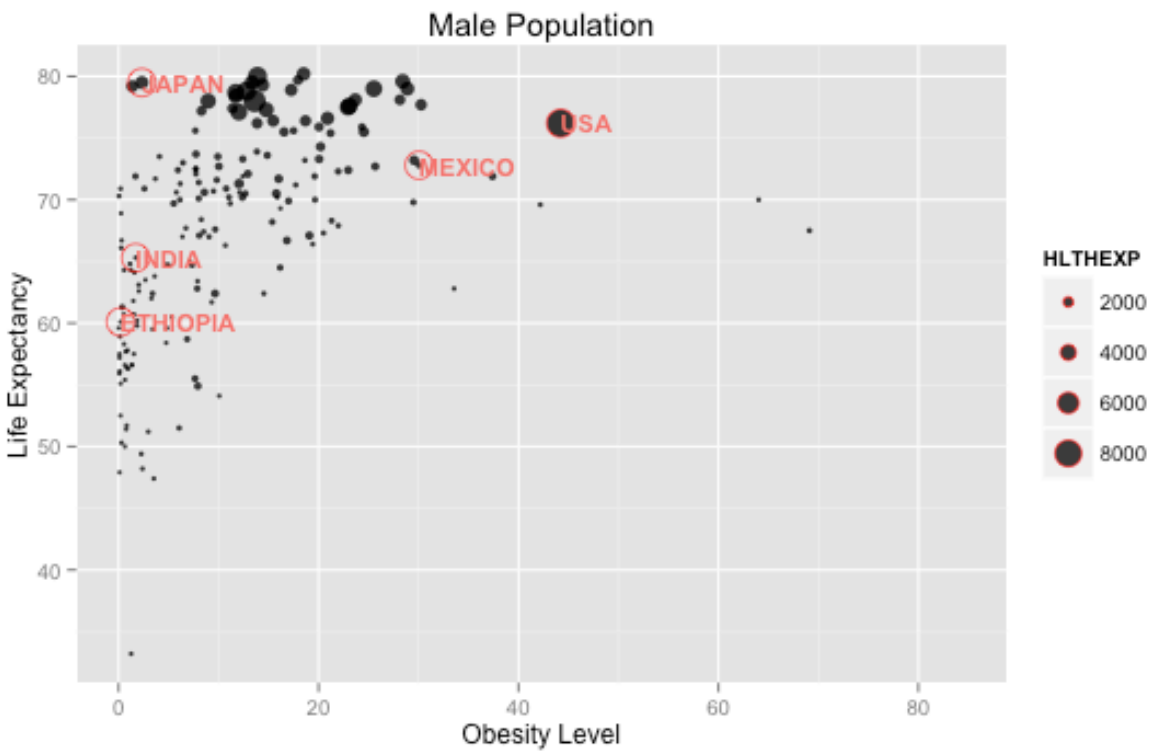

Figure 1: Country wise life expectancy of males (in year 2010) as a function of obesity prevalence (percentage of population aged 15 and above that has BMI >30) in 2010.

HLTHEXP is per capita health expenditure in US dollars (PPP int. $).

Each dot represents a country and the density of the dot represents per capita health expenditure of the country.

Figure 2: Country wise life expectancy of females (in year 2010) as a function of obesity prevalence (percentage of population aged 15 and above that has BMI >30) in 2010.

HLTHEXP is per capita health expenditure in US dollars (PPP int. $).

Each dot represents a country and the density of the dot represents per capita health expenditure of the country.

Appendix

Data Sources:

1) life expectancy male and female for years 2002, 2005, 2010

http://apps.who.int/gho/data/node.main.688?lang=en

2) Per capita health expenditure for years 2002, 2005, 2010:

http://data.worldbank.org/indicator/SH.XPD.PCAP.PP.KD?page=4

3) Obesity male and female:

https://apps.who.int/infobase/Comparisons.aspx?l=&NodeVal=GBD_10_mo.cc.059&DO=1&DDLReg=ALL&DDLSex=1&DDLAgeGrp=All_Ages&DDLYear=2004&DDLMethod=INTMDQUA&DDLCateNum=6&DDLMapsize=800x480&DDLMapLabels=none&DDLTmpRangBK=388.9088&DDLTmpColor=-3342388

Extracted on April 12, 2016

Data for alternative indicators of health

4) Adult mortality: Panel has considered data for 2005 and 2012.

for 2005 figures: World Health Statistics Report 2007, page 25

for 2012 figures: World Health Statistics Report 2014, page 60

5) HALE: Panel has considered data for 2002 and 2012.

for 2002 figures: World Health Statistics Report 2007, page 25

for 2012 figures: World Health Statistics Report 2014, around page 60