

The Impact of Health Expenditure on the Number of Chronic Diseases

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Abstract

We investigate the impact of health expenditure on health outcomes on a large sample of Europeans aged above 50 using individual and regional level data. We find a negative and significant effect of lagged health expenditure on subsequent changes in the number of chronic diseases. This effect varies according to age, health behavior, gender, income, and education. Our empirical findings are confirmed also when health expenditure is instrumented with parliament political composition.

Keywords: Health expenditure, Health outcome, Public health costs.

JEL Classification: I12 Health Behavior; I11 Analysis of Health Care Markets; I18 Government Policy · Regulation · Public Health.

1 Introduction

We investigate the impact of total health expenditure (HE) on health outcomes as proxied for by the change in the number of chronic diseases. The issue is of paramount importance in a historical phase in which 87 percent of deaths in high-income countries (and a substantial reduction of healthy life years) are caused by major and chronic diseases (WHO, 2011). In this scenario, it becomes of foremost importance to assess the productivity of domestic health expenditure and to go beyond mortality indicators as they do not take into account the quality of life that is fundamental for societal wellbeing.

Based on these considerations the goal of this paper is to measure the impact of HE to GDP (HEgdp) and HE per capita (HEpc) on the change in the number of chronic diseases after controlling for standard socio-demographic factors, healthy lifestyles, and health care quality on a large sample of Europeans aged above 50. Our empirical analysis also contributes to verify whether the well-known negative nexus between HE and mortality (Nixon and Ullman, 2006; Or, 2000) is driven by a reduction of chronic diseases.

One element of originality of our analysis is the change in the number of chronic diseases as health indicator. The prevalence of chronic diseases is rapidly increased worldwide, and so will be in the next years (Van Cleave et al., 2010; WHO, 2011). Whether this change is driven by a change in HE should be investigated for both economic and policy implications. The empirical literature often uses country-level data to analyse the impact of HE on mortality health outcomes such as life expectancy at a given age, premature mortality rate, and infant mortality rate. This approach could be profitably complemented with an analysis on diseases' insurgence, in particular if we focus on the effects of health status on human capital and National Health Service expenditure, which are more relevant from an economic perspective. As clearly pointed out by Nixon and Ullman (2006), the standard macroeconomic variables used in the literature such as infant mortality and life expectancy have two relevant limitations. They do not vary much in high income countries and they are determined by factors unrelated to health care systems, such as pollution, car accidents, and murders. Moreover, a morbidity measure approach is conceptually more suitable than generic mortality measures because it accounts for health gains due to specific treatments (Joumard et al., 2008). The need of a multimorbidity indicator was also highlighted by Anderson and Horvath (2004) – who show the heterogeneous prevalence of chronic diseases across US population – and Diederichs et al. (2012) – who investigate how to weight different diseases in a multimorbidity indicator. However, to the best of our knowledge the change in the number of chronic diseases has not been used so far as a morbidity indicator. These considerations lead us to focus on the change in the number of chronic diseases as synthetic health outcome indicator in our empirical analysis.

A second element of originality in our approach hinges on the use of individual data. Beyond the quality of health care systems, both mortality measures and many disease outcomes are affected by individual characteristics such as standard socio-demographic variables (e.g. gender, education, income, and family status), healthy lifestyles (e.g. diet, physical activity, alcohol consumption, and smoking), and the concurrent individual

health status which need to be controlled for. The use of individual-level data is also important since it allows to consider properly that part of individual variability which is lost when looking at the country-level data only. Estimates based on the latter generally consider correlations across country mean values, thereby ignoring that other quantiles in the distribution may have more relevance when dealing with health matters. For instance, more extreme percentiles in lifestyles such as intense drinking and smoking as well as extreme obesity would definitely have a stronger impact on health outcomes than their mean values. Therefore, matching inputs and outputs for each individual and checking the effect of specific combinations of socio-demographic factors on health at individual level may provide more accurate results than considering average socio-demographic factors for each country.

A third further advantage of our approach combining individual and country level data is that it allows to test whether the HE effect on health outcomes changes across different population subgroups. The comparison of such effect on different subgroups allows us to identify specific constituencies which are more sensitive to HE policies and specific healthy lifestyles (such as diet and physical activity), whose improvement will reduce HE without any negative effect on health outcomes.

These three advantages of our individual level data approach do not preclude a regional level analysis with aggregated observations, and this allows us to check whether significant findings persist at this level.

Our results show that there is a negative and significant impact of both HEgdp and HEpc on the change in the number of chronic diseases. The impact differs across different subgroups. The effect is higher for the elders, the women, the overweight or obese, the below-median income group, and the less educated vis-à-vis their complementary subgroups. The results remain stable when adopting different approaches, such as instrumental variable (IV) estimates and regional-level aggregated data.

The paper is divided into six sections. The second presents the main literature on the effect of HE on health outcomes as well as on the importance of individual characteristics on health outcomes. The third illustrates data and descriptive statistics. The fourth presents our econometric findings, testing their robustness with different specifications. The fifth discusses the results and their policy implications. The sixth section concludes.

2 Literature review

Public HE represents one of the largest government expenditure items (6 percent of GDP in the OECD area, Joumard et al., 2010) and one of the most important drivers of health policies determined at country-level. On the link between HE and health outcomes, Nixon and Ullman (2006) find a significant and positive effect of HE on health outcomes in EU countries and show that, between 1980 and 1995, health care expenditure has added 2.6 years to male life expectancy and reduced by 0.63 percent the infant mortality rate. Along this line Or (2000) documents that a high share of public HE is associated with lower premature mortality and infant and perinatal mortality, even though not affecting life

expectancy at 65. Other authors (Hitiris and Posnett, 1992) find that, even if mortality is negatively related to HEpc, the elasticity is very small, and therefore its economic significance is limited. Moreover, Elola et al. (1995) find that per capita health care expenditure may explain more the variance in infant mortality than would per capita GDP and that it is inversely correlated to female premature mortality, while positively correlated to female life expectancy. Conversely, a lower number of physicians and cuts in health care expenditure are associated with increased infant mortality, reduced life expectancy at age 65, and lower heart diseases. In particular, a 10 percent cut in health care expenditure is associated with a 6 month reduction in life expectancy for men and 3 month reduction for women (Crémieux et al., 1999; Or, 2000).

These mixed findings clearly imply that the driving factor is not just the magnitude of HE but also its quality and efficiency. Concerning the latter, Joumard et al. (2010) estimate that life expectancy at birth could be raised by more than two years on average, holding health care spending constant, if all countries were to become as efficient as the best performers. On the other hand, a 10 percent increase in health care spending would increase life expectancy by only 3 to 4 months if the distance from the efficient frontier remains unchanged. The same literature generally finds that institutional variables for funding arrangements are often not significant, with some exceptions (e.g. Or (2000) shows that countries with fee-for-service at the hospital level tend to have lower premature mortality but no longer life expectancy at 65).

The existing literature also emphasises the importance of individual factors. According to Thornton (2002) the role of socioeconomic factors and lifestyles in preventing diseases and improving life expectancy is much more significant than medical care, even though we argue that national health care policies may also include prevention campaigns which are likely to affect individuals' lifestyles. In particular, smoking, sport activities, and obesity explain why some countries achieve better health status than others while using comparable levels of health care resources (Afonso and St Aubyn, 2006). Another factor which has been acknowledged as having a crucial role on health is education. More educated individuals are modelled as people with "higher productivity" in combining market and non market inputs to produce health outcomes – in the productivity theory – and choose better combinations of inputs, especially healthy lifestyles and doctor advice, to obtain such results – in the allocative theory (Grossman, 2006; Feinstein et al., 2006). Joumard et al. (2010) calculate that education contributed to a gain of 0.5 years in life expectancy at birth for females out of a total improvement of 2.49 between 1991 and 2003, while health care expenditure contributes for 1.14. Similar results are found for males. Among other factors, occupation is also important for health status, not only in terms of exposure to specific workplace risks, but mainly due to its role in positioning people along a society's hierarchy (Blas and Kurup, 2010). In particular, it has been shown how work opportunities and work conditions for females affect socioeconomic status and, as a consequence, have an impact on behavioural and environmental risk factors for breast cancer in women (National Cancer Institute, 2011).

3 Data

We merge three sources of data. The first source is the cross-national panel data from the Survey of Health, Ageing and Retirement in Europe (SHARE). We use the first, second and fourth wave of SHARE implemented in 2004, 2006, and 2010 respectively and with observations covering the period 2004–2012 with the exception of 2008 and 2009. We exclude from our sample the third wave (SHARELIFE) since it is a retrospective survey of people life history and therefore not consistent with our study. The database contains information on health, socio-economic status, and social and family networks of a sample of Europeans aged above 50. More specifically, the SHARE survey is composed of 13 country-level representative samples for the following countries: Austria, Germany, Sweden, Netherlands, Spain, Italy, France, Denmark, Greece, Switzerland, Belgium, Czech Republic, and Poland. The second source of data is the cross-national panel from OECD Statistics dataset, which collects information on the total HE as a percentage of GDP and in per capita terms for all the 13 selected countries for the 2004–2012 period. OECD defines total health expenditure as the “sum of expenditure on activities that – through application of medical, paramedical, and nursing knowledge and technology – has the goals of: promoting health and preventing disease; curing illness and reducing premature mortality; caring for persons affected by chronic illness who require nursing care; caring for persons with health-related impairments, disability, and handicaps who require nursing care; assisting patients to die with dignity; providing and administering public health; providing and administering health programmes, health insurance and other funding arrangements” (OECD Health Statistics 2015). The third source is the EuroStat cross-national panel data from which we extract our control variable for the quality of health care, namely avoidable congestive heart failure (CHF) hospital admission rate of people aged 15+ per 100,000 inhabitants for the same 13 countries in the selected 2004–2012 period. Among the proxy variables for the quality of national health care system, avoidable CHF is considered as one of the most reliable (Joumard et al., 2010).

Our sample is composed of 101,747 observations, the mean age is 65.8 years, and females are 55.8 percent. The percentage of overweight people being 41.7 and that of obese 18.8. The percentage of smokers is 19.4 and almost half of the sample consume alcohol more than 1 day per month. The 43.4 percent of the people do not practice sport or other physical activities. Around half of the respondents suffer from long-term diseases. The most common disease is hypertension (36.2 percent), followed by high blood cholesterol (22.1 percent), arthritis (21.9 percent), and diabetes (11.6 percent). A list of the full set of variables is provided in Appendix A.

3.1 Dynamics of our variables of interest

We choose the first difference in the reported number of chronic diseases as our synthetic health outcome indicator. This variable is measured by asking respondents whether they received a doctor’s diagnosis on, and they still suffer from, a list of the following major 17 chronic diseases: Heart attack; High blood pressure or hypertension; High blood cholesterol; Stroke or cerebral vascular disease; Diabetes or high blood sugar; Chronic

lung diseases; Asthma; Arthritis or rheumatism; Osteoporosis; Cancer or malignant tumor; Stomach or duodenal ulcer, peptic ulcer; Parkinson disease; Cataracts; Hipfracture or femoral fracture; Other fractures; Alzheimer's; Benign tumor. Even though for some diseases in the list the recovery is very unlikely, many of them are nowadays subject to cure especially in high income countries.

Figure 1 shows descriptive pictures of the inverse relation between HEgdp and the number of chronic diseases. For values of HEgdp below the 25th percentile the number of chronic diseases is 1.65, falling to 1.19 for values above the 75th percentile. Note that, in case of reverse causality between HEgdp and the number of chronic diseases, we would expect a positive (rather than a negative) nexus, with the former growing as the latter increases. The link is negative also when considering the change in the number of chronic diseases. The value is around 0.22 for HEgdp below the 25th percentile and around 0.14 for HEgdp above the 75th percentile (Figure 1(c)). Differences in means for our health outcome variable are significant at 95 percent since confidence intervals do not overlap for both levels and first differences. Similar patterns are shown for HEpc (Figures 1(b) and 1(d)). The negative link between HE and the change in the number of chronic diseases is also confirmed for the subsample of "healthy" individuals (i.e., individuals with no chronic diseases ex ante). The change in the number of chronic diseases is 0.80 for values of HEgdp below the 25th percentile and 0.52 for values above the 75th percentile. Similar values for our health outcome variable (0.80 and 0.54) are shown when considering HEpc below the 25th percentile and above the 75th percentile, respectively (Figure 1(e) and 1(f)).

4 Econometric analysis

4.1 Baseline findings

Our econometric analysis aims to test the hypothesis that HE affects changes in health status after controlling for a large set of concurring factors. We regress the first difference in the number of several chronic diseases on the lagged HEgdp or, alternatively, on lagged HEpc. More specifically, in order to investigate the effect of HE on health status, we estimate the following regression

$$\begin{aligned} \Delta HealthStatus_{i,t} = & \alpha HE_{t-1} + \sum_k \beta_k SocioDem_{i,k,t-1} \\ & + \sum_l \gamma_l HealthyBehavior_{i,l,t-1} + \sum_m \delta_m \Delta Changes_{i,m,t} \\ & + \sum_r \xi_r D.Year_{i,r} + \mu HealthStatus_{i,t-1} \\ & + \phi HealthQuality_{i,t-1} + \varepsilon_{i,t} \end{aligned}$$

where $\Delta HealthStatus_{i,t} = HealthStatus_{i,t} - HealthStatus_{i,t-1}$ is the first difference in the number of chronic diseases for individual i in wave t and $HE_{C(i),t-1}$ is the HE provided

by all financial agents of the country where individual i was when interviewed (i.e., $C(i)$), measured as percentage of GDP (HEgdp) or, alternatively, in per capita terms (HEpc, US\$1,000, PPP) in wave $t - 1$. $SocioDem_{i,k,t-1}$ includes socio-demographic information of individual i in wave $t - 1$, such as gender, age, years of schooling, marital status, job status, number of children and grandchildren, and income; $HealthyBehavior_{i,l,t-1}$ includes lifestyle variables for individual i at wave $t - 1$ such as dummies for drinking, smoking, frequency of vigorous physical activities and BMI class (i.e., underweight, normal weight, overweight and obese). $\Delta changes_{i,m,t}$ captures changes in income, marital status, job status, lifestyles and the number of grandchildren, between current (t) and previous ($t - 1$) interview waves. The interview-year dummies for individual i are included in $D.Year_{i,r}$ in order to control for asynchronous survey administration in each wave. $HealthQuality_{C(i),t-1}$ controls for the quality of national health care systems of country $C(i)$ in wave $t - 1$ using the rate of avoidable CHF. The lagged health status level is introduced to take into account the obvious negative relationship between changes and levels of the outcome variable. Standard errors are clustered at NUTS2 level in all estimates.

Table 1 shows that the effect of HEgdp on the first difference in the number of chronic diseases is significant since the null hypothesis of $\alpha = 0$ is rejected. The first specification (Table 1, column 1) includes the basic set of controls, such as socio-demographic information and interview-year dummies. By assuming that the significant nexus implies causality (which we will test in what follows with IV estimates) we find that a 1 percent increase in HEgdp from its mean sample value reduces the change in the number of chronic diseases by 0.059. In other words, if all respondents were not affected ex ante by any chronic illness, a 1 percent increase in HEgdp would make 5.9 percent of the respondents not incur in the chronic illness they would have contracted otherwise in the next period.

The significance of our main finding persists when we extend the benchmark specification to changes in socio-demographic indicators (Table 1, column 2), healthy lifestyles (Table 1, column 3), and changes in healthy lifestyles (Table 1, column 4).

Among the socio-economic variables, we find that the impact of age and education on the change in the number of chronic diseases is significant. The relation between age and health status is as expected negative, while the negative impact of education is well supported by empirical evidence in the literature (see among others Grossman, 2006). Relational life also matters. For instance, being widowed has a positive effect on the change in the number of chronic diseases of around 0.13. Healthy lifestyles are as well of foremost importance since individuals reporting the lowest level of physical activity have a 0.183 impact, more than twice as much the impact of those reporting even moderate physical activity. The overweight or obese status increases the number of chronic diseases in the next period by 0.16 as well. The effect of this factor is confirmed when changes in lifestyles are included as regressors, with transition to the overweight/obese status producing a significant increase in the number of chronic diseases. Findings on the impact of drinking habits are nonlinear confirming the validity of our choice of not using a unique continuous variable. Drinking 3-4 times a week has a negative and significant

effect while all other frequencies are not significant, even though the highest drinking frequency is surprisingly negative. Our findings may be explained by two rationales. First, moderate drinking is beneficial for health. Second, some reverse causation may arise with individuals with chronic diseases being prescribed by doctors not to drink or to drink moderately.

In columns 5-8 specifications (Table 1) we repeat the first four estimates controlling for the quality of health care systems through the introduction of the avoidable CHF indicator. While the number of observations falls, HEgdp coefficient increases by around 0.015 indicating that the impact of HE is even larger when quality is adjusted.

We find very similar results when we replace HEgdp with HEpc as main independent variable (see Appendix A).

4.2 Subsample estimates

A question which has relevant policy implications in terms of potential support to HE is whether the impact of HE varies in different population groups. We split our sample of individuals aged above 50 into older and younger respondents and find that our hypothesis is supported by empirical evidence. The effect of HEgdp on our dependent variable is strongly significant for the elder. The coefficient for individuals aged above 65 is -0.121 (versus the overall sample coefficient of -0.096 in the corresponding specification) documenting as expected that the impact of HE becomes stronger with ageing (Table 2).

Other relevant subsamples where we find a higher significant effect of HE on health outcomes are those of women, the lower educated group (individuals without a university degree), the low income group (individuals below the median income in their country), and the overweight or obese individuals vis-à-vis their complementary samples (Table 2).

On the one hand, this implies that some population groups are more sensitive than others to policies aimed at increasing HE. On the other hand, our subsample results suggest that improvements in lifestyles could reduce HE without negatively affecting health outcomes.

4.3 Instrumental variable results

Results shown above must be proven to be robust when controlling for endogeneity. The correlation observed in descriptive evidence and confirmed by econometric findings goes in a direction which is opposite from what reverse causality would predict. We nonetheless need to disentangle a possible direct causality nexus indicated by our findings from a potential concurring (even though weaker) reverse causality effect and from endogeneity caused by third unobserved drivers affecting both the variables of interest.

We propose an instrument drawn from the parliament political composition. Parliament political composition is expected to influence decisions on public and private expenditure but may be hardly suspected to affect directly health outcomes – insurance, persistence and recovery from the selected chronic illnesses. We expect the share of left wing party members to be significantly associated with HE given the longstanding tradition of such party in supporting HE in its political programs. In our sample, most

HE is public expenditure (around 74 percent) and political parties of the left are more likely to increase the budget on this point in order to improve wellbeing of the low income population and due to their higher sensitivity for equity concerns (Immergut, 1992, De Donder and Hindricks, 2007, Potrafke, 2010, Herwartz and Theilen, 2014).

We build our instrument by collecting government data from the national Ministries of the Interior, Parliaments and Senates datasets for the 13 selected countries in the period 1995–2014, available at their official websites. By considering the presence of some hysteresis in current HE decisions we use the following three year moving average

$$Party_t = \frac{1}{3}(p_t + 0.9p_{t-1} + 0.8p_{t-2})$$

where p_t represents the share of left wing parliament members at time t . Moreover, since we are instrumenting HE at time $t - 1$, we lag the final year of our three-year moving average by two periods considering that current parliament decisions affect the next year HE.

Empirical evidence documents that the relevance of our instrument is quite strong. Both HEgdp and HEpc are significantly and positively correlated with the share of left wing parliamentarian members. More specifically, we find in pairwise correlations that HEgdp has a correlation coefficient of 0.31 with the share of left wing members, while HEpc of 0.53. Correlation with other parliament groups is much weaker or in the opposite direction. In particular, the correlation coefficient of HEgdp (HEpc) with the share of centre-left and centre-right members is respectively 0.08 (−0.04) and −0.22 (−0.39).

The second-stage findings of the IV estimate which uses the above described instrument confirm the significance of the country health variables (Table 3, first row). In terms of economic significance what is impressive is as well the stability of the health coefficients estimated with IV, which are quite similar to those found in non instrumented estimates. More specifically, a 1 percent increase in HEgdp produces an effect of 0.138 in terms of changes in the number of chronic diseases, while US\$1,000 of HEpc have an effect of 0.19 (Table 3, first row).

IV estimates performed on subsamples indicate that the impact of HE on the change in the number of chronic diseases remains significant only on the more vulnerable groups (Table 3). We find a significant impact on the elders (0.185) on respondents aged above 65), on females (0.145), on the low educated group (0.15) and on those who do not practice physical activity. The pattern of the effects of HEpc exhibit similar variability (Table 3).

4.4 Robustness checks

To further investigate the accuracy of our results, we consider several robustness checks for the estimates on HEgdp and HEpc. First, we correct for the attrition bias that might arise because some respondents have missed some waves and we do not know whether these missing responses are related to health status (for similar approaches, see Raab et al., 2005, Nicoletti and Peracchi, 2005, and Vandecasteele and Debels, 2007).

Second, we correct for the attrition bias in our subsamples and IV estimates. Third, we wonder whether such a significance is driven by some country-level outliers. Therefore, we aggregate our data at country level by reducing drastically the number of observations by averaging our data at NUTS2.

Our results remain strongly stable after all the several robustness checks (see Appendix A).

5 Discussion

The identification of the socio-demographic factors and healthy lifestyles affecting health outcomes, as well as of its heterogeneous impact across different population groups, may be crucial to tackle the challenge of improving health outcomes without endangering government debt sustainability.

Using both individual- and regional-level data, we provide evidence that HEgdp and HEpc have a negative and significant impact on the change in the number of chronic diseases. This result is remarkably stable also in terms of economic significance for HEgdp under the different estimation approaches adopted in the paper. The average magnitude (around 10 percent) is strongly stable and not negligible for policy implications. Our findings also show that HE produces heterogeneous effects on health outcomes, being more relevant for the elders, the females, the overweight or obese, the below-median income and the less-educated subsamples vis-à-vis their complementary subsamples.

Two are the main implications of these subsample findings. First, these specific groups may be more interested in (and exert more political pressure for) higher HE. Second, active ageing policies aimed at increasing education and reducing the population exposure to excess weight may allow to save HE without adversely affecting health outcomes.

From a methodological point of view, our innovative content of our contribution hinges on the use of individual data and the change in the number of chronic diseases as a morbidity health indicator. Also, we use the political composition of the parliament as an instrument to mitigate endogeneity problems in the correlation between HE and health outcomes.

6 Conclusion

This paper aims at addressing the relation between HE and the change in the number of chronic diseases. As pointed out by the current literature, HE has a strong effect on mortality and longevity in country-level data. Therefore, the relation between HE and the change in the number of chronic diseases at individual level is a suitable candidate channel for such an effect, and this relation also allows us to exhibit a certain degree of heterogeneity across different population subsamples. Our original contribution to the literature stands as well in the combination of individual and regional-level data. We explain why such combination enriches the analysis and provides additional insights to the existing knowledge on the topic. Finally, we document that our findings are robust

when we aggregate our data at regional level, thereby documenting that our analysis can replicate and enrich the traditional aggregate country-year results provided by the related literature.

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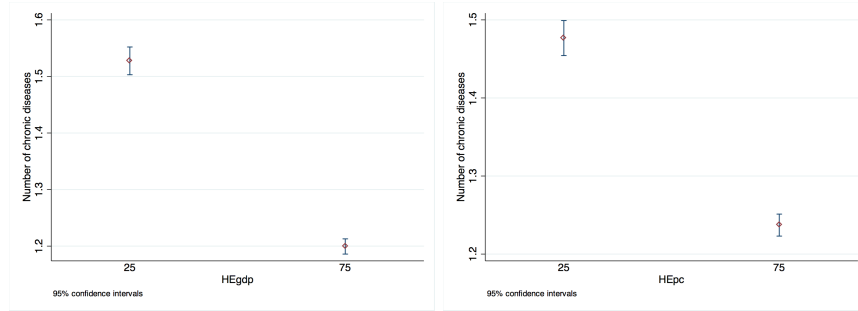
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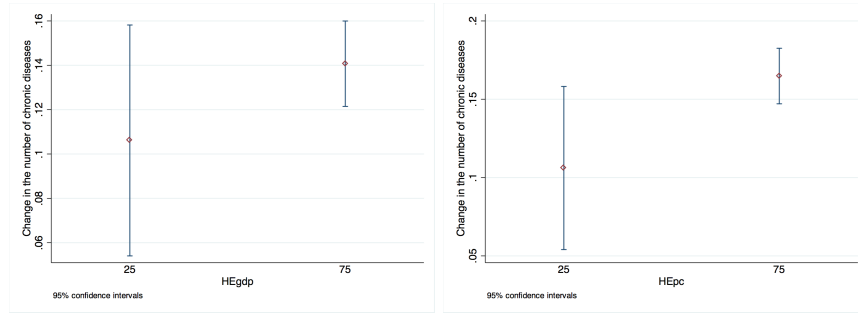
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Tables and Figures

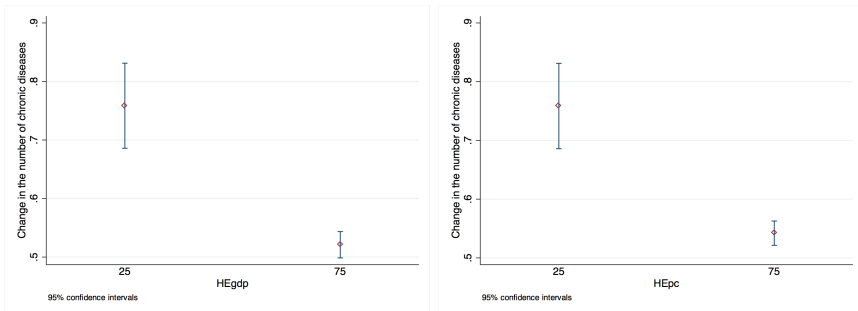
Figure 1: Levels and first differences of the number of chronic diseases for the lowest and the highest quartile of HE distribution



(a) Number of chronic diseases for the lowest and the highest quartile of HEgdp distribution (b) Number of chronic diseases for the lowest and the highest quartile of HEpc distribution



(c) Change in the number of chronic diseases for the lowest and the highest quartile of HEgdp distribution (d) Change in the number of chronic diseases for the lowest and the highest quartile of HEpc distribution



(e) Change in the number of chronic diseases for the lowest and the highest quartile of HEgdp distribution (individuals with no chronic diseases ex ante) (f) Change in the number of chronic diseases for the lowest and the highest quartile of HEpc distribution (individuals with no chronic diseases ex ante)

Table 1: The effect of HEgdp on the change in the number of chronic diseases

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HEgdp _{t-1}	-0.0599*** (0.0195)	-0.0623*** (0.0196)	-0.0499** (0.0190)	-0.0491** (0.0189)	-0.0872*** (0.0236)	-0.0931*** (0.0238)	-0.0762*** (0.0229)	-0.0774*** (0.0224)
Female	0.0269 (0.0167)	0.0314* (0.0171)	0.0332* (0.0175)	0.0310* (0.0177)	0.0247 (0.0201)	0.0345* (0.0202)	0.0355* (0.0213)	0.0392* (0.0210)
Age class _{t-1} (Ref. = 50-54)								
55-59	0.0805*** (0.0212)	0.0786*** (0.0214)	0.0771*** (0.0216)	0.0721*** (0.0214)	0.0795*** (0.0244)	0.0804*** (0.0252)	0.0774*** (0.0254)	0.0749*** (0.0257)
60-64	0.131*** (0.0271)	0.126*** (0.0287)	0.126*** (0.0267)	0.116*** (0.0269)	0.146*** (0.0353)	0.143*** (0.0367)	0.145*** (0.0344)	0.138*** (0.0344)
65-69	0.188*** (0.0340)	0.178*** (0.0348)	0.187*** (0.0342)	0.172*** (0.0354)	0.192*** (0.0474)	0.181*** (0.0463)	0.192*** (0.0475)	0.177*** (0.0470)
70-74	0.254*** (0.0418)	0.237*** (0.0422)	0.252*** (0.0429)	0.224*** (0.0436)	0.306*** (0.0449)	0.288*** (0.0451)	0.306*** (0.0469)	0.275*** (0.0477)
75-79	0.309*** (0.0501)	0.282*** (0.0493)	0.311*** (0.0513)	0.273*** (0.0518)	0.331*** (0.0652)	0.300*** (0.0639)	0.336*** (0.0671)	0.292*** (0.0673)
80+	0.283*** (0.0490)	0.261*** (0.0488)	0.272*** (0.0508)	0.235*** (0.0509)	0.280*** (0.0661)	0.257*** (0.0645)	0.287*** (0.0702)	0.242*** (0.0691)
Education _{t-1}	-0.0119*** (0.00220)	-0.0115*** (0.00217)	-0.00952*** (0.00213)	-0.00889*** (0.00206)	-0.0110*** (0.00305)	-0.0101*** (0.00295)	-0.00812*** (0.00295)	-0.00713** (0.00275)
No. Children _{t-1}	-0.0162** (0.00770)	-0.0138* (0.00799)	-0.0187** (0.00802)	-0.0165* (0.00859)	-0.0174* (0.00878)	-0.0127 (0.00878)	-0.0214** (0.00908)	-0.0169* (0.00941)
No. Grandchildren _{t-1}	0.00114 (0.00444)	0.00129 (0.00446)	0.000574 (0.00464)	0.000692 (0.00486)	0.00518 (0.00443)	0.00522 (0.00442)	0.00543 (0.00451)	0.00478 (0.00459)
Retired _{t-1}	-0.0178 (0.0459)	-0.00726 (0.0505)	-0.00758 (0.0450)	0.00756 (0.0496)	-0.0162 (0.0608)	-0.00165 (0.0653)	-0.00896 (0.0607)	0.0175 (0.0649)
Employed _{t-1}	-0.148*** (0.0367)	-0.146*** (0.0401)	-0.127*** (0.0359)	-0.121*** (0.0390)	-0.171*** (0.0435)	-0.167*** (0.0483)	-0.156*** (0.0425)	-0.140*** (0.0471)
Homemaker _{t-1}	-0.0349 (0.0460)	-0.0366 (0.0486)	-0.0302 (0.0428)	-0.0346 (0.0457)	-0.0396 (0.0540)	-0.0460 (0.0569)	-0.0403 (0.0499)	-0.0486 (0.0532)
Other Job _{t-1}	-0.473*** (0.163)	-0.336** (0.157)	-0.461*** (0.161)	-0.350** (0.162)	-0.517** (0.206)	-0.335* (0.201)	-0.493** (0.205)	-0.312 (0.204)
Married _{t-1}	0.0490 (0.0297)	0.0480 (0.0307)	0.0524 (0.0318)	0.0584* (0.0329)	0.0336 (0.0407)	0.0349 (0.0421)	0.0332 (0.0428)	0.0441 (0.0439)
Divorced _{t-1}	0.140***	0.142***	0.147***	0.154***	0.163**	0.165**	0.166**	0.174**

Separated t_{-1}	(0.0506) 0.0365 (0.0939)	(0.0507) 0.0717 (0.0911)	(0.0529) 0.0534 (0.0925)	(0.0532) 0.0592 (0.0929)	(0.0646) 0.0404 (0.115)	(0.0659) 0.0695 (0.113)	(0.0664) 0.0431 (0.113)	(0.0672) 0.0293 (0.114)
Partnership t_{-1}	-0.0116 (0.0554)	-0.00730 (0.0578)	-0.00399 (0.0567)	0.0143 (0.0583)	-0.0651 (0.0685)	-0.0574 (0.0717)	-0.0616 (0.0703)	-0.0307 (0.0704)
Widowed t_{-1}	0.128*** (0.0366)	0.126*** (0.0379)	0.127*** (0.0382)	0.129*** (0.0390)	0.136*** (0.0498)	0.134*** (0.0510)	0.126*** (0.0507)	0.128*** (0.0507)
Log(Income) t_{-1}	0.0180 (0.0157)	0.0162 (0.0153)	0.0283* (0.0163)	0.0285* (0.0156)	0.0354* (0.0197)	0.0326* (0.0191)	0.0458** (0.0200)	0.0441** (0.0190)
Δ Log(Income)	0.0140 (0.00920)	0.0150 (0.00938)	0.0163* (0.00947)	0.0170* (0.00947)	0.0265** (0.0113)	0.0268** (0.0113)	0.0274** (0.0117)	0.0271** (0.0115)
Drinking t_{-1} (Ref. = <1 a month)								
1-2 a month			-0.0276 (0.0305)	-0.0427 (0.0301)			-0.0318 (0.0425)	-0.0479 (0.0414)
1-2 a week			-0.0102 (0.0296)	-0.0295 (0.0311)			-0.00316 (0.0422)	-0.0178 (0.0435)
3-4 a week			-0.0629** (0.0257)	-0.0765*** (0.0283)			-0.0809** (0.0331)	-0.0953*** (0.0350)
5-6 a week			-0.0423 (0.0308)	-0.0538 (0.0330)			-0.0323 (0.0379)	-0.0457 (0.0390)
Almost everyday			-0.0659 (0.0505)	-0.0866* (0.0512)			-0.0274 (0.0602)	-0.0460 (0.0581)
Not at all			-0.0416 (0.0263)	-0.0513* (0.0271)			-0.0487 (0.0342)	-0.0620* (0.0336)
Sport (Ref. = >1 a week)								
1 a week			0.0353* (0.0204)	0.0774*** (0.0209)			0.0248 (0.0283)	0.0811*** (0.0263)
1-3 a month			0.0530* (0.0286)	0.108*** (0.0355)			0.0264 (0.0342)	0.111*** (0.0362)
Hardly ever/Never			0.127*** (0.0200)	0.183*** (0.0215)			0.115*** (0.0271)	0.190*** (0.0281)
Smoking t_{-1}			-0.00347 (0.0201)	-0.0131 (0.0230)			0.0124 (0.0237)	-0.000194 (0.0295)
Overweight-Obese t_{-1}			0.158*** (0.0188)	0.160*** (0.0186)			0.171*** (0.0240)	0.173*** (0.0241)
Reduce drinking								
		0.0357* (0.0195)		0.0475** (0.0196)		0.0371 (0.0272)		0.0428* (0.0252)

Improve sport	-0.0986*** (0.0222)	-0.161*** (0.0263)	-0.120*** (0.0234)	-0.188*** (0.0243)
ΔSmoking		-0.0196 (0.0326)		-0.0149 (0.0506)
ΔBMI		0.0131*** (0.00459)		0.0115** (0.00480)
Gets Separated	-0.0818 (0.222)	-0.0858 (0.239)	-0.148 (0.328)	-0.148 (0.371)
Gets Widowed	0.177*** (0.0574)	0.199*** (0.0645)	0.159** (0.0709)	0.181** (0.0768)
Gets Divorced	-0.0642 (0.106)	-0.0820 (0.115)	-0.101 (0.122)	-0.132 (0.127)
Gets Partnership	-0.262** (0.121)	-0.235 (0.150)	-0.400*** (0.151)	-0.370* (0.189)
Gets Help from outside	0.0494 (0.0311)	0.0390 (0.0318)	0.0547 (0.0344)	0.0442 (0.0361)
Gets Retired	0.0205 (0.0315)	0.0174 (0.0321)	0.0202 (0.0395)	0.0251 (0.0402)
Gets Unemployed	0.00163 (0.0740)	0.0200 (0.0731)	0.0462 (0.0950)	0.0694 (0.0927)
Gets Grandchildren	-0.0299 (0.0207)	-0.0272 (0.0211)	-0.0499** (0.0231)	-0.0484** (0.0234)
No. Chronic diseases _{t-1}	-0.398*** (0.0167)	-0.414*** (0.0172)	-0.435*** (0.0161)	-0.453*** (0.0162)
Avoidable CHF			0.000355 (0.000382)	0.000247 (0.000379)
Years (single-year variables)	Yes	Yes	Yes	Yes
Observations	15,563	15,209	10,441	10,148
R-squared	0.200	0.210	0.218	0.228
Robust standard errors in parentheses				
*** p<0.01, ** p<0.05, * p<0.1				
9,873				
0.233				

Table 2: The effect of HE on the change in the number of chronic diseases (for subsamples)

Subsample	HEgdp	St. Dev.	R-squared	HEpc	St. Dev.	R-squared	Obs.
All sample	-0.0957***	(0.0258)	0.225	-0.157***	(0.0448)	0.225	9,873
Elder 65+	-0.121***	(0.0314)	0.232	-0.200***	(0.0547)	0.232	5,355
Female	-0.0985***	(0.0305)	0.226	-0.152***	(0.0512)	0.226	5,328
No Smoking	-0.100***	(0.0278)	0.232	-0.162***	(0.0476)	0.232	8,030
Smoking	-0.0839*	(0.0424)	0.215	-0.154**	(0.0756)	0.215	1,843
Sport	-0.116***	(0.0255)	0.239	-0.191***	(0.0406)	0.239	4,875
Lack of sport	-0.0683*	(0.0396)	0.226	-0.104	(0.0724)	0.233	4,149
High income	-0.0545*	(0.0280)	0.226	-0.095*	(0.0482)	0.227	4,368
Low income	-0.125***	(0.0281)	0.233	-0.202***	(0.0499)	0.232	5,503
No overweight	-0.0750**	(0.0323)	0.221	-0.129**	(0.0603)	0.221	3,948
Overweight	-0.109***	(0.0293)	0.233	-0.175***	(0.0491)	0.233	5,925
Low education	-0.0988***	(0.0283)	0.219	-0.160***	(0.0486)	0.219	7,708
High education	-0.0907**	(0.0365)	0.278	-0.149**	(0.0674)	0.278	2,165

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The estimates displayed in HEgdp and HEpc columns correspond to specification Table 3b and Table 4b (column (8)), respectively. Elder 65+: individuals aged above 65; High income: individuals with income above country median; Low income: individuals with income below country median; Low education: individuals without graduate degree; High education: individuals with graduate degree.

Table 3: Instrumental variable estimates for subsamples

Subsample	HEgdp	St. Dev.	R-squared	HEpc	St. Dev.	R-squared	Obs.
All sample	-0.138**	(0.0674)	0.225	-0.190**	(0.0857)	0.225	9,873
Elder 65+	-0.185**	(0.0845)	0.231	-0.261**	(0.110)	0.231	5,355
Female	-0.145*	(0.0814)	0.226	-0.199*	(0.107)	0.226	5,328
Sport	-0.112*	(0.0572)	0.239	-0.150**	(0.0737)	0.239	4,875
Lack of sport	-0.163	(0.111)	0.224	-0.231	(0.150)	0.224	4,149
High income	-0.121	(0.0746)	0.225	-0.164*	(0.093)	0.226	4,368
Low income	-0.143**	(0.0708)	0.233	-0.207**	(0.098)	0.233	5,503
No overweight	-0.139	(0.0940)	0.220	-0.187	(0.118)	0.220	3,948
Overweight	-0.138**	(0.0607)	0.233	-0.193**	(0.0799)	0.233	5,925
Low education	-0.153**	(0.0716)	0.218	-0.214**	(0.0931)	0.219	7,708
High education	-0.0848	(0.0940)	0.278	-0.109	(0.120)	0.278	2,165

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1