



Health and Human Capital

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Abstract

This study examines the impact of morbidity on human capital stocks (HCS) with an application to the UK in 2014. It incorporates health status into the standard Jorgenson-Fraumeni lifetime income measure of human capital stocks through its effect on absenteeism and presenteeism (lost productivity) by modelling the impact of health on earnings and retirement behaviour. The research strategy takes account of individuals' and spouses' health as well as caring responsibilities due to adverse health of third parties. Moreover, it employs an approach, standard in the literature, of estimating individual health indices by regressing self-assessed health status on a broad range of health conditions, limitations and socio-economic characteristics in order to address reporting and errors-in-variable bias.

Results show that approximately 2% of the total employed HCS in the UK in 2014 was contributed by individuals in poor health, which is partly due to health and partly due to the fact that poor health is associated with lower qualification categories. Although this figure reflects the small share of individuals in poor health, the significance of the pure health effect is shown in the average values: average employed HCS per capita for a man is £133,089 and £371,600 if he is in poor and in good health, respectively. Female average employed HCS p.c. is £92,487 if she is in poor and £248,094 if she is in good health.

1. Introduction

Although scholars have acknowledged that physical and human capital (HC) operate complementarily and that health plays a significant role in generating human capital, existing measures of human capital stocks (HCS) do not adequately account for health status. The existing measures take account of mortality by incorporating survival rates into the model but ignore any other aspect of health and focus mainly on the contribution of education. With ageing populations, health has a profound but ambiguous impact on labour market activity and its outcomes. While generous social security systems encourage early retirement, policy makers have begun to offset this trend and address longevity by extending the age of retirement and, in some cases, removing the statutory retirement age, as in the UK in 2011. However, longevity may not necessarily be associated with good health as survival into older age is increasingly accompanied by morbidity. Therefore, the willingness to supply labour may decline, which is reflected in earlier retirement or increasing *absenteeism* from work. Against this, poor health is associated with financial commitments at an accelerating rate for the elderly due to the required medical care, which might lead to an increase in labour supply in order to compensate for these financial constraints. If poor health does not lead to absence from work or early retirement, it can still reduce on-the-job productivity and work quality, which is referred to as *presenteeism* in the occupational health literature. Existing research finds that these costs of lost productivity far exceed costs incurred through direct medical care. If these costs are further broken down, the number of productive days lost due to *presenteeism* are several times greater than the time lost caused by *absenteeism*.

Consequently, morbidity impacts on the quality of as well as the quantity supplied by labour, which affects HCS by reducing the productive capacity of the workforce. These health effects may even spill over to workers in good health because their work routine is likely to be impacted. Therefore, the relationship between health and HCS needs to be studied in depth to estimate the costs of ill-health to the economy and to evaluate cost effectiveness of interventions to improve health conditions. There is international agreement on the fact that current HCS measures need improvement¹.

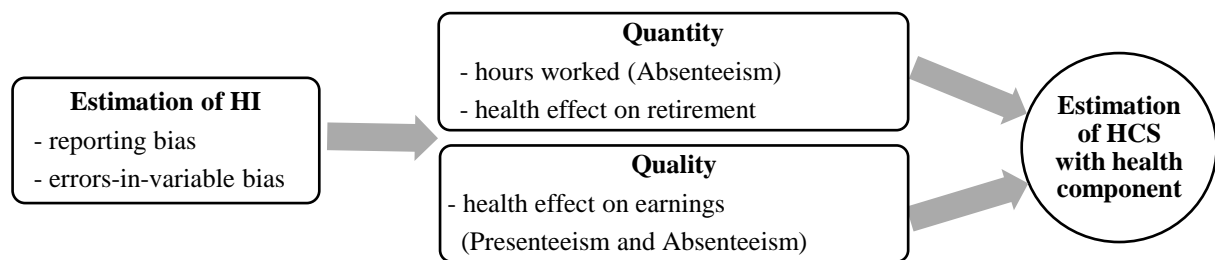
This paper addresses this gap in the literature by incorporating health status into measures of

¹ Recommendations for new measures have been developed by the Atkinson Review (Atkinson, 2005), the Commission on the Measurement of Economic Performance and Social Progress (CMEPSP, 2009) and a consortium of 15 OECD countries, Israel, Russia, Romania, Eurostat, the ILO and the ONS.

HCS by focussing on the additional impact of morbidity rather than mortality and making that effect transparent through changes in *absenteeism* and *presenteeism*. The paper applies this model to data for the UK in 2014. Thereby taking account of the ageing population in the UK and the removal of the statutory retirement age. This paper uses the Jorgenson-Fraumeni (JF) (1989, 1992) lifetime income framework to measure HCS, which sums the discounted values of all future income streams that the population is expected to earn throughout their lifetime. To make the additional impact of health transparent and quantify the effect of poor health on labour productivity and labour supply, the following strategy is implemented. Changes in labour productivity are reflected in earning differences since it is assumed that labour is paid its marginal product and workers in poor health experience increasing *presenteeism*. The impact of health on hourly wages is estimated for those who are employed and predicted wages are translated into annual earnings using the amount of hours worked. Consequently, *absenteeism* is implicitly accounted for in the annual earnings data through lower annual working hours as well as any impacts on wages. This, however, only accounts for one channel through which labour supply is affected by health. The second channel uses health adjusted employment rates for older age groups by estimating the effect of individual and spouse's health as well as caring responsibilities on the probability to retire since these three factors have been identified in the literature as drivers of early retirement.

Health is measured, standard in the literature, by a health index (HI) for each individual and their spouse by regressing a five-point categorical self-assessed health (SAH) variable on measures of diagnosed health conditions, such as Asthma, Diabetes or Cancer, a number of activities potentially limited by the current health status of the respondent and a broad range of socio-economic characteristics using standard ordered probit. The existing literature identified significant gender differences in terms of health and employment behaviour, so that, both, the HI and the effect of health on wages and retirement are estimated by sex separately using longitudinal microdata and combined with aggregate sources to estimate HCS. The different stages of this research approach are summarised in Figure 1.

Figure 1: Overview of Research Approach



The study is structured as follows. Section 2 discusses the channels through which health impacts on HC and reviews recent efforts in measuring HCS, particularly in a cross-country context. Section 3 addresses methodological issues when measuring health and explains the strategy employed to measure HCS by making health transparent through health effects on earnings and retirement probabilities – further details are available in Samek (2016 a, b). Findings are discussed in section 4 and the paper concludes with section 5.

Results show that approximately 2% of total employed HCS in the UK in 2014 was contributed by individuals in poor health when incorporating health effects on earnings only, which is partly due to health and partly due to the fact that poor health is associated with lower qualification categories. If these individuals would become healthy, total employed HCS could increase by up to 3.5%. Since this figure is a result of the low share of unhealthy individuals and the association between health and qualification levels, the true impact of health on HC through earnings and retirement behaviour only becomes apparent when average employed HCS p.c. are examined and the *qualification effect* is removed. This shows that women in good health have about 2.7 times higher HC per capita than if they are in poor health. This ratio increases to 2.8 times for men indicating that health has a slightly bigger effect on their HCS. Caring reduces average employed HCS p.c. affecting female HCS in particular due to their more extensive caring responsibilities. Therefore, the ratio between average employed HCS p.c. of healthy and unhealthy individuals is not only determined by health of the individual but also by health of others as reflected by the caring responsibility of the individual. In the UK, male HCS appears to be more affected by their own poor health, while female HCS is more affected by poor health of others as presented in their caring duties.

2. Human Capital and the Role of Health

2.1. How does Health affect HC? - Retirement, Working Hours and Wages

Longevity can imply an increase in labour supply and in productivity because, firstly, workers are potentially available for a longer time period and, secondly, healthy workers may invest in and update their skills more since their return will occur over a longer working life. However, as previously mentioned, survival into older age is increasingly accompanied by morbidity, which leads to disability, poorer quality of life, loss of mobility and out-of-pocket health expenditure at an accelerating rate for the elderly (Guralnik et al. 1996; Gijsen et al. 2001; Bayliss et al. 2003; Fortin et al. 2004; Hall, 2006; Schoenberg et al. 2007; Leopold and Engelhardt, 2013; Shaw et al. 2014).

Therefore, morbidity can lead to a reduction in labour supply through earlier retirement or increasing *absenteeism* from work. This depends on the persistence of the health shock - if individuals think they experience only a temporary health shock, they reduce their current labour participation with the anticipation to increase it after recovery. Periods of poor health may be observed by individuals first to look for significant changes before deciding about their economic activity, which implies that past information gives information on future health and, hence, changes in economic activity are related to both current and lagged health shocks (Bound et al. 1999; Disney et al. 2006). Others may retire immediately on receipt of the adverse health shock if they think it is persistent, although this is very age-dependent (Bound et al. 1999). Moreover, retirement decisions also vary by gender, although empirical work accounting for gender differences show mixed results: while early studies observe a larger negative effect on men's labour supply in terms of earlier retirement and decreasing working hours (see Disney et al., 1997; Bound and Burkhauser, 1999 and Coile, 2004). In contrast to this earlier literature, Jones et al. (2010) find women are more likely to retire early if they are in poor health than men.

The strong association between health and labour supply does not only apply to one person but it exists across relationships of people. Consequently, participation can increase to provide more income if own health is poor due to higher consumption requirements or it can increase to offset the loss in income of another ill household member (Coile, 2004; Siegel, 2006; Economou and Theodossiou, 2011). Albeit these financial constraints, related caring activities for these household members or other third parties can affect labour supply

negatively if time is taken off from work to fulfil these duties. There is evidence that the younger and especially female population compromises their career opportunities by leaving their current job or experiencing lower job performances and increasing *absenteeism* when taking care of their parents or other third parties (Horowitz, 1985b; Brody et al. 1987; Stueve and O'Donnell, 1989; Ettner, 1996; Zhang and Zhang, 2001; Bolin et al. 2008; van Houtven et al. 2013). Akintola (2008) argues that, if carers are needed, it is likely to impact more on females because they have lower attachments to the labour market as a result of their *absenteeism* from paid employment, due, for instance, to maternity leave. This leads to returns to part-time rather than full-time employment and a lower accumulation of pension entitlements. Van Houtven et al. (2013) observe a wage penalty for female rather than male carers², which supports this argument, and suggest it to result from returns to lower paying jobs with more flexibility. However, not only are women increasingly participating in the labour force and contributing to the finances of the household, the numbers of people requiring care also increases with an ageing population creating an excess demand for care (Carmichael and Charles, 2003; Bolin et al. 2008). Consequently, the involvement of men in informal care is expected to increase.

When looking closely at caring activities among couples, empirical results suggest that men supply less labour and are more likely to retire early whereas women increase their labour supply and are less likely to retire early if their spouses are in poor health (Berger, 1983; Charles, 1999; Suhrcke et al., 2005, Jimenez-Martin and Prieto, 2012). Charles (1999) argues that the traditional gender role distribution is an explanation for this observation because the care-giver takes up the work of the ill person. However, Coile (2004) only observes this pattern when taking into account other influences, such as labour markets, accessibility of health insurance and provision of benefits³. Therefore, he suggests that non-wage income of spouses in poor health plays a very important role in employment decisions of men and that workers react in predictable but offsetting ways to health shocks of spouses, creating a zero net effect. Although Jones et al. (2010) do not observe any significant effect of spouses' health on retirement decisions at all, they explain this result with the pressure to provide personal care while maintaining household income, which supports the previously reviewed arguments.

² Bolin et al. (2008) does not find any wage effect in a cross-country comparison of European countries.

³ They observed a decrease in annual working time by 813 hours and an increase in their probability to retire early by 20 per cent if their spouse received disability benefits. If disability benefits are absent, men's economic activity increases and their probability to retire decreases while women do not respond at all.

If poor health does not lead to *absenteeism* or early retirement, on-the-job productivity may decline and below-normal work quality can be experienced instead (Koopman, 2002). Evidence of *presenteeism*, which measures “the decrease in productivity for the much larger group of employees whose health problems have not necessarily led to absenteeism and the decrease in productivity for the disabled group before and after the absence period” (Burton et al. 1999), is hence, often reflected in lower wages⁴. This is either explained directly through preferences between leisure and income or indirectly through changes in individuals’ productivity and their offered wages (Becker, 1964; Grossman, 1972a, 1972b). In Grossman’s (2001) model, the rate of return to gross health investments equals the additional availability of healthy time, evaluated at the hourly wage. However, if good health increases with wages as marginal benefits of health investments increase with the wage rate⁵, reverse causality is introduced as health becomes an endogenously determined capital stock (Grossman and Benham, 1974).

Estimating the impact of health on wages, however, leads to a number of econometric issues. Contoyannis and Rice (2001), who use SAH and a measure of psychological health derived from the General Health Questionnaire (GHQ) to measure health effects on wages in the UK using the British Household Panel Survey (BHPS), employ single equation fixed effects and random effects instrumental variable estimators to address these endogeneity issues⁶. They find that decreasing psychological well-being reduces hourly wages for men while excellent SAH increases hourly wages for women. Their findings also suggest that the majority of efficiency gains from the use of the instrumental variable estimators fall on the time-invariant endogenous variable academic attainment and indicate that education and individual characteristics affecting wages are negatively correlated. However, although they control for endogeneity caused by the correlation between explanatory variables and the unobservable

⁴ Although the relationship between poor health and lower wages may also be explained by employers’ discrimination against unhealthy workers, which is referred to as the *discrimination theory* (Johnson and Lambrinos, 1985) or by the *total compensation theory*, which suggests that unhealthy workers accept lower wages in return for other work related benefits (Mullahy and Sindelar, 1995), the majority of findings do not attempt to distinguish between discrimination, compensation or productivity effects and refer to the theoretical works of Grossman (1972a, 1972b) instead.

⁵ The direction of the resulting simultaneity bias is unclear: while higher wages can cause higher quality and quantity of inputs into health production, rising returns to health increases opportunity costs of health investments and, thus, increasing individuals’ labour force participation and decreasing time put into health production (Grossman and Benham, 1974).

⁶ This procedure was first suggested by Hausman and Taylor (1981), Amemiya and MaCurdy (1986) and Breusch et al. (1989).

individual effects, their findings may suffer from simultaneity bias, which was also observed in previous cross-sectional analyses. Similar to this study and following Bound et al. (1999), Disney et al. (2006) and Jones et al. (2010), Cai (2010) uses information on specific health conditions to instrument SAH first. Then he applies this health measure to estimate a simultaneous equation model of health and wages of Australian men using the longitudinal Household, Income and Labour Dynamics in Australia (HILDA) Survey and employing a full information maximum likelihood (FIML) method. By addressing the sample selection bias, he finds that treating health exogenously underestimates its effect on wages substantially. Flores and Kalwij (2013) follow this strategy by estimating both health's direct effect on employment and its indirect effect through wages of individuals aged 50 to 64 from different European countries using SHARE. Results show that healthiness increases wages, which in turn increases incidence of employment.

2.2. Recent Efforts in Measuring HC

Although previous literature acknowledged early that physical capital and mental labour operate complementarily in order to increase output and nation's wealth (Petty, 1690; Smith, 1776; Farr, 1853; Engel, 1883), the modern approach in assessing the importance of human capital in driving economic growth and the resulting policy implications stemmed from the work of Shultz (1961), Becker (1964) and Mincer (1974). The importance of health in this context was recognised when attention moved away from the educational component of human capital towards the health aspect in the mid 1990s (Mankiw et al, 1992; Fogel, 1994; Barro, 1996; Barro and Sala-i-Martin, 2004; Lopez-Casanovas et al. 2005). However, international research on measuring HC accounts⁷ do not take account of health morbidity aspects. Since human capital is complex and defined as “the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being” (Dang et al. 2001), it is apparent why scholars struggle to capture all aspects in one model and study single aspects of human capital, especially education, instead. However, in order to measure output and assess its sustainability, all aspects of energy inputs need to be considered and as many dimensions of human capital as possible need to be combined in one single metric (Dollard and Neser, 2013).

⁷ For example: Australia (see Wei, 2004, 2008), Canada (see Gu and Wong, 2010a), China (see Li et al. 2013), New Zealand (see Le et al. 2006), Norway (see Liu and Greaker, 2009), Sweden (see Ahlroth et al. 1997), the UK (see Jones and Chiripanhura, 2010) and the US (see Christian, 2010)

One common trend in the recent literature is the application of the income-based approach in national accounts. The seminal contribution to this literature were the papers by Jorgenson and Fraumeni (1989, 1992). The JF model measures HC stocks using lifetime earnings in present discounted value that all individuals are expected to earn. This implies the assumption that labour is paid according to its marginal productivity. This is the approach recommended by the Atkinson Report (2005). JF measure total population (also see Ahlroth et al. 1997; Christian, 2010; Li et al. 2013) but it is more common to limit the data to the working-age population (see Wei, 2004, 2008; Gu and Wong, 2010a), those in employment (see Le et al. 2006; Jones and Chiripanhura, 2010) or those in the labour force (see Wei, 2004, 2008; Liu and Greaker, 2009).

Alternative measures to the income-based approach are the *cost-based approach*, which estimates investments of resources into education, or the *educational-attainment-based approach* using indicators of school enrolment and/or test scores – for a discussion see Fender (2012). In this paper we chose to employ the *income-based approach* as it allows the incorporation of health as an additional capital driver in a labour market context. By adjusting earnings and labour force participation accordingly, this approach values the productive capacity of the workforce after taking account of health status. It can be argued that health is implicitly accounted for in the JF lifetime income framework through the employment and survival rate of the employed population. The former captures labour force participation, which varies with health, while the latter measures the effect of mortality and, hence, the worst possible health status. However, these estimations fail to make the additional impact of health transparent by singling out the distinctive effect of morbidity. Moreover, this study focuses on morbidity rather than mortality by studying labour potentially available for production and how its availability changes with health.

3. Modelling the Impact of Health on Human Capital Stocks

3.1. Addressing Methodological Issues of Health

Although the literature has often relied on objective health measures, such as the incidence of chronic conditions, mental illnesses, morbidity or cardiovascular diseases (for example, Myers, 1982; Anderson and Burkhauser, 1985; Stern, 1989; Tompa, 2002; Baker et al. 2004; Suhrcke et al. 2005), they are likely to be collinear and too specific to particular health conditions, especially in surveys (Hernandez-Quevedo, 2008). Therefore, they are not

perfectly correlated with the health aspect that actually affects work capacity, and describe someone's health only partially by ignoring the severity of the disease. Both aspects introduce measurement errors (Bound et al. 1999); this is referred to as *errors-in-variable bias*.

Therefore, scholars increasingly attempted to quantify health effects using SAH (for example, Anderson and Burkhauser, 1985; Bazzoli, 1985; Stern, 1989; Bound, 1991; Kerkhofs and Lindeboom, 1995; Bound et al. 1999; Disney et al. 2006; Hagan et al. 2008; Kalwij and Vermuelen, 2007 and Jones et al. 2010). However, the subjective nature of SAH also compromises its validity by introducing *reporting bias* because different sub-groups use different reference points when answering the same health-related question. This is often referred to as *index* or *cut-point shifts*⁸ and causes a non-random measurement error biasing the estimates (Crossley and Kennedy, 2002 and Baker et al. 2004). Individuals are heterogeneous and, thus, their subjective judgment on health status varies depending on their own specific context (Bound, 1991; Deschryvere, 2004; Weil, 2013).

Since one focus of this study is on the relationship between health and retirement, a *cut-point shift* can be particularly problematic if it occurs with respect to employment status. According to the *justification hypothesis*, economically inactive people have an incentive to report a lower SAH category than their actual health status suggests because poor health is perceived as a socially acceptable and rational reason to explain absence from work (Baker et al. 2004; Jones et al. 2013). This phenomenon is linked to the *disability route* into retirement where scholars find a strong correlation between systematic overstatements of health problems and early retirement, particularly if private pension rights are absent and disability benefits, as part of the social security system, are the only option into early retirement (Kerkhofs and Lindeboom, 1995, 2009; Blundell and Johnson, 1998). SAH might also be misleading, particularly in the context of employment, where respondents may adjust their working hours or their kind of work, due to their health problems, to the extent where their ability to work is

⁸ When Lindeboom and van Doorslaer (2004) analysed reporting bias, they refer to a *cut-point shift* only if the relative position of reporting thresholds for a sub-group of the population changes, i.e. the overall distribution of SAH changes. If reporting bias is present because reporting thresholds for a sub-group of the population shift in a parallel manner, so that the distribution of SAH is unaffected, they refer to an *index shift*. However, this type of shift can be caused by reporting bias or by an actual change in the underlying true health and, generally, it is impossible to distinguish between the two. This study does not differentiate between the two as it is not of main interest in this paper.

not further reduced. The estimated effect of health on retirement behaviour would be biased towards zero (Deschryvere, 2004).

3.1.1. Identification of Health Status through the Estimated Health Index

To address the *errors-in-variable* and *reporting bias* associated with objective and subjective measures, respectively, a HI is estimated following Bound et al. (1999), Disney et al. (2006) and Jones et al. (2010) using SAH as a function of diagnosed diseases and health limitations, both presented by the vector $Z_{i,t}$, and a broad range of socio-economic characteristics, $X_{i,t}$. In the UK implementation these variables are obtained from all five waves of the Understanding Society Survey (USS) using all available observations and the model is estimated using standard pooled ordered probit⁹. This technique is analogous to using objective health measures as an instrument for the endogenous and potentially error-ridden SAH variable. The estimating equation is given by:

$$\Pr(HI_{i,t}^* = j | Z, X) = F(\alpha_j - \beta_1 Z_{i,t} - \beta_2 X_{i,t}) - F(\alpha_{j-1} - \beta_1 Z_{i,t} - \beta_2 X_{i,t}), \quad (1)$$

$$\begin{aligned} i &= 1, 2, \dots, n; \\ t &= 1, 2, \dots, T; \\ j &= 1, 2, 3, 4, 5 \end{aligned}$$

Since the underlying latent health stock can then be thought of as the propensity to identify oneself as having a better health status, the observed response categories are tied to the latent variable as shown in equations (2).

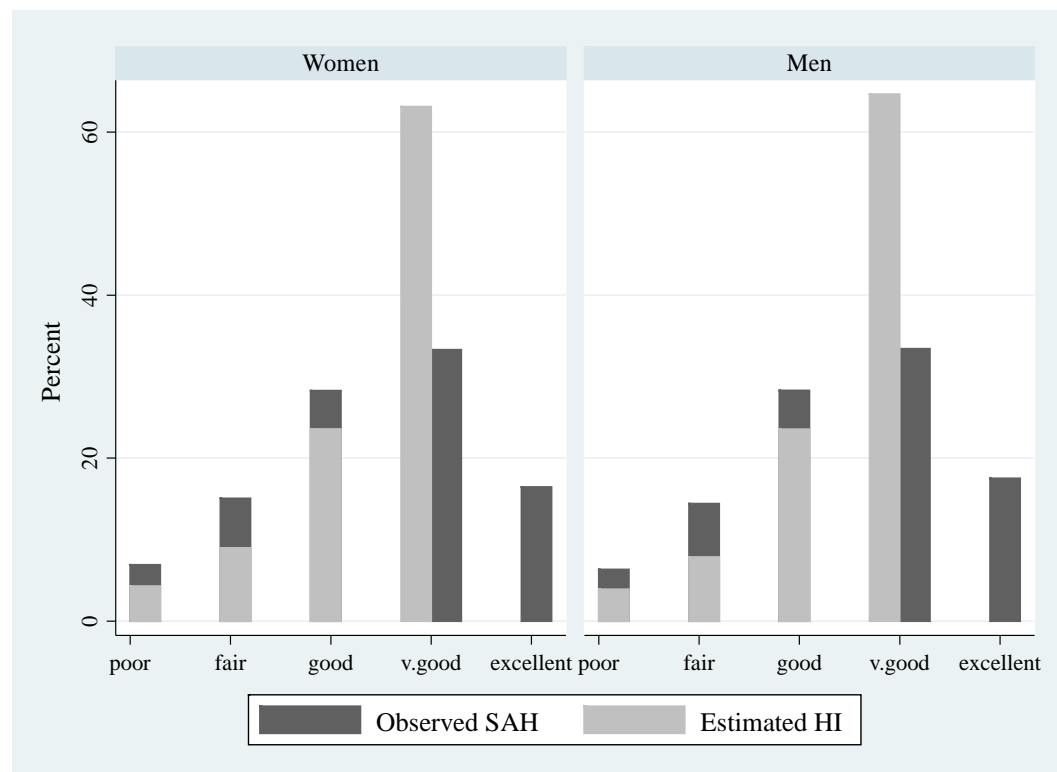
$$\begin{aligned} SAH &= 1 \text{ if } HI^* \leq \alpha_1 \\ SAH &= 2 \text{ if } \alpha_1 < HI^* \leq \alpha_2 \\ SAH &= 3 \text{ if } \alpha_2 < HI^* \leq \alpha_3 \\ SAH &= 4 \text{ if } \alpha_3 < HI^* \leq \alpha_4 \\ SAH &= 5 \text{ if } \alpha_4 < HI^* \end{aligned} \quad (2)$$

Figure 2 shows observed SAH and estimated health based on objective health conditions and socio-economic factors for men and women. Although it can be seen that individuals tend to report a worse health condition than that what the objective measures would indicate, the graph also shows the insignificance of the threshold between very good and excellent health.

⁹ Although analyses involving categorical dependent variables use ordered probit as well as ordered logit models, ordered probit is the specification, which is increasingly used and generalised to address reporting bias caused by heterogeneity in responses (Terza, 1985; Pudney and Shields, 2000; King et al. 2004).

This suggest the use of the HI rather than any SAH measure alone. For more details, see Samek (2016 a, b).

Figure 2: Comparison of SAH and HI

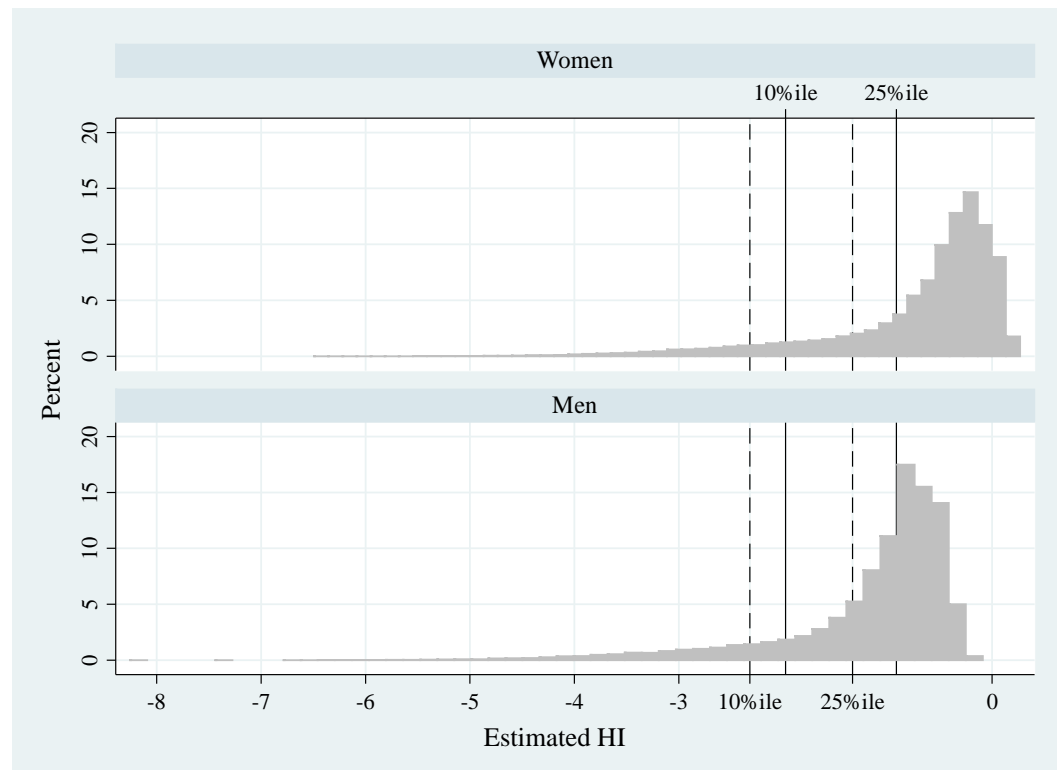


Source: University of Essex (USS) and own calculations

Since this study focuses on employed HC and individuals in very poor health are less likely to work, the sample is significantly reduced in the estimation of health effects on earnings and retirement behaviour if we use the predicted cut-off points. Instead, a self-defined cut-off point along the predicted continuous health variable rather than the predicted category is used to define poor and fair health. Figure 3 shows a histogram of the distribution of the HI from poor to excellent. It shows that most of the population are in relatively good health with a long tail on the left and points where the distributions increase sharply. These suggest self-defined cut-off points, which are set at the bottom 10 percentile and the bottom quartile of the fitted HI, respectively. The 10 percentile is in line with the amount of people, who are self-assessing their health as poor and it is still at a point on the distribution where there is no significant increase to be observed. The 25 percentile is assumed to reflect fair health best because that is the point where the distribution jumps for men and women both. However,

individuals up to the age of 20 are assumed to be in good health since the number of people in poor health in these age groups is very small.

Figure 3: Distribution of HI by gender



Source: University of Essex (USS) and own calculations

3.2. Estimation of HCS that Incorporates Health

The methodology of this paper consists of three stages (see figure 1). In order to make the effect of health on HC transparent, health has to be defined first and its effect on wages and retirement probabilities estimated at the second stage. While this paper discusses only the methodology of the last stage in greater detail, information on the first two stages are available in Samek (2016 a, b).

For the purpose of this study, the income-based approach was used, which measures HC by summing the discounted values of all future income streams that the population is expected to earn throughout their lifetime (Jorgenson and Fraumeni, 1989, 1992). The following section describes how JF's lifetime income approach is implemented and adjusted to account for and highlight the effect of health in the estimation process. This procedure is explained in two steps, of which the first one involves the construction of the database and the second one

shows the implementation of the model using the database to account for health in different ways. Firstly, it only accounts for impacts of health on earnings, later we also incorporate the health effect in the retirement probability and, thus, the employment rate. Lastly, the employment rate is further adjusted to account for different retirement probabilities depending on caring responsibilities of respondents.

3.2.1. Data for Human Capital Stocks

The database was constructed in a similar way to the approach adopted by the ONS in their national annual human capital accounts. Information was collected on the number of people aged 16 to 69 (i.e. the working age population), their annual earnings enrolment rates for schools, further education (FE) and higher education (HE) as well as employment and survival rates. Compared to the estimations provided by the ONS, we provide information beyond the age of 64 and also collect data on unemployment and retirement rates in order to incorporate the estimated health effect on labour supply in terms of changes in retirement behaviours. With the exception of the survival rate, which only varies by gender and age, all other information is cross-classified by gender, age, qualification and health status. Qualifications are classified into the following six categories, which allow the coherent use of several datasets:

- No qualification or don't know
- Other qualification
- GCSE or equivalent
- A-levels or equivalent
- Further Education
- Degree and higher or equivalent

While a brief summary of all variables is shown in table 1, detailed information on each variable is provided in appendix 1.

Table 1: Summary of Variables used in the HCS Estimation

Variable	Classification	Source
Annual earnings	Gender, age, qualification and health	LFS
Survival rate	Gender and age	ONS
Employment rate	Gender, age, qualification and health	LFS
Unemployment rate	Gender, age, qualification and health	LFS
Retirement rate	Gender, age, qualification and health	LFS
‘Others’ rate	Gender, age, qualification and health	LFS
Enrolment rate in school	Gender, age, qualification and health	Department for Education
Enrolment rate in FE	Gender, age, qualification and health	Department for Education
Enrolment rate in HE	Gender, age, qualification and health	HESA
Population	Gender, age, qualification and health	ONS and LFS

3.2.2. Estimation of HCS using Health Effect on Income

In the second step the constructed dataset together with the predicted income by health status are used to estimate HCS. By estimating the effect of health (using the previously estimated HI) on hourly wages, evidence of *presenteeism* is tested and the wage impacts of absenteeism are quantified. Therefore, hourly wages are regressed on health, $HI_{i,t,edu}^*$, and some socio-economic characteristics, $X_{i,t,edu}$ ¹⁰, using individuals in employment¹¹ from the USS in an OLS regression:

$$\ln wage_{i,t,edu} = \alpha + \beta_1 HI_{i,t,edu}^* + \beta_2 X_{i,t,edu} + u_{i,t,edu}, \quad (3)$$

$$i = 1, 2, \dots, n;$$

$$t = 1, 2, \dots, T$$

In order to address potential endogeneity, the health effect is estimated by qualification separately since it is assumed that better health increases productivity and, consequently, higher wages make better health more affordable through better treatments and nutrition. Since higher income is associated with higher qualifications, it can be argued that running regressions by qualification groups addresses endogeneity. However, in addition, we instrument the estimated HI with annual GP visits from data from the BHPS and compare both results (see Samek (2016b) for details). Because sizes and signs of the estimates are comparable, the predicted earnings from the former procedure are employed in the construction of HCS in the UK.

¹⁰ These socio-economic characteristics include information on age, education, marital status, children, job sector, type of work, part-time/full-time, firm size, caring activities, housing and region. Wave dummies are also included.

¹¹ Self-employed wages were excluded as they tend to be variable and can include returns to capital. However, the numbers of self-employed are included in the employment totals.

The predicted hourly wages by health status, using the defined cut-off points of 10 and 25 percentiles, are multiplied by the amount of hours worked per annum to arrive at annual earnings. They are then compared to average annual earnings across individuals from the LFS. Since LFS data is used for the overall HCS estimation, earnings from the LFS are weighted by the estimates from the USS data to arrive at health adjusted annual earnings. This requires some smoothing, especially for individuals in poor health and with lower qualifications.

These annual earnings are then transformed into lifetime labour income, $LLI_{s,a,e,h}$, which is calculated by gender, age, qualification and health status using backwards recursion. This implied that market income is zero beyond the age of 69 and is based on the assumption that people do not receive any earnings once they withdraw from the labour market. Therefore lifetime earnings of those aged 69 is given by:

$$LLI_{s,a=69,e,h} = EMR_{s,a=69,e} income_{s,a=69,e,h} \quad (4)$$

where EMR is the employment rate. The JF methodology assumes that an individual with a given gender, age, qualification and health status will, in year $t+1$, has the same labour income and other characteristics (employment and survival rate) as someone, in year t , who is one year older and has otherwise the same characteristics (gender, qualification and health). Therefore, if someone is aged 68, this person's LLI equals current income plus discounted future income of someone aged 69 with the same sex, qualification and health, conditional on survival, sr , equation (5). These calculations are similar for those aged 35 to 68.

$$LLI_{s,a=68,e,h} = EMR_{s,a=68,e} income_{s,a=68,e,h} + sr_{s,a=69} \frac{1+g}{1+\delta} LLI_{s,a=69,e,h}, \quad (5)$$

$$| 35 \leq a \leq 68$$

where g equals the labour productivity growth rate, which is two per cent as estimated by Lindsay (2004) and as applied by the ONS. δ represents a discount rate of 3.5 per cent, as recommended by HM Treasury's Green Book, which provides guidelines for appraisal and evaluation in central government.

For those aged between 16 and 34, LLI needs to take account of education enrolment (school, FE, HE), $ENRR$. Although the cut-off point is arbitrary here, actual enrolment rates do not show much enrolment activity beyond this age point. Therefore, equation (5) is altered to include the probability of people improving their educational attainment, which is multiplied by the income they are likely to earn given their higher qualification. At the start of each year, everyone has the choice to either work next year maintaining the same qualification level, $(1 - ENRR_{s,a,e})LLI_{s,a+1,e,h}$, or improve it and, hence, receive a different income, $ENRR_{s,a,e}LLI_{s,a+1,e+1,h}$. This is shown in equation (6).

$$LLI_{s,a,e,h} = EMR_{s,a,e}income_{s,a,e,h} + sr_{s,a+1} \frac{1+g}{1+\delta} [ENRR_{s,a,e}LLI_{s,a+1,e+1,h} + (1 - ENRR_{s,a,e})LLI_{s,a+1,e,h}] \quad (6)$$

| $16 \leq a \leq 34$

Total HCS is calculated by aggregating individual LLI of equations (4) to (6) in each age and qualification category across the population, $Pop_{e,a}$, and summing by gender and health to make the health effect transparent and comparable across men and women, equation (7).

$$HC_{s,h} = \sum_a \sum_e LLI_{a,e} Pop_{a,e} \quad (7)$$

3.2.3. Estimation of HCS using Health Effect on Income and Retirement

Since health status is not only incorporated in the earnings component but also in the retirement probabilities, the employment rate is adjusted as shown in equation (8) and then applied in equations (4) to (7) again to account for health effects on wages as well as on retirement behaviour¹². The new employment rate takes account of everyone, who is not currently unemployed or economically inactive, and applies a health adjusted retirement rate.

$$EMR_{s,a,e,h} = (1 - RETR_{s,a,e,h} - UNEMR_{s,a,e} - Other_{s,a,e}) \quad (8)$$

| $50 \leq a \leq 69$

In order to incorporate retirement probabilities by health status, retirement status is regressed on the fitted values of the estimated HI for those aged 50 and older and who are employed in the first wave of the USS to observe a potential transfer from employment into retirement. A

¹² Following this paper, health effects will also be applied on unemployment behaviour in future work to account for the role of health more extensively.

pooled probit regression is used, equation (9), which takes account of the individual's own health, $HI_{i,t}^*$, their spouses' health, $HISP_{i,t}^*$, and the respondent's informal caring responsibilities, $CAR_{i,t}$, due to adverse health of third parties, among other socio-economic characteristics, $X_{i,t}$ ¹³.

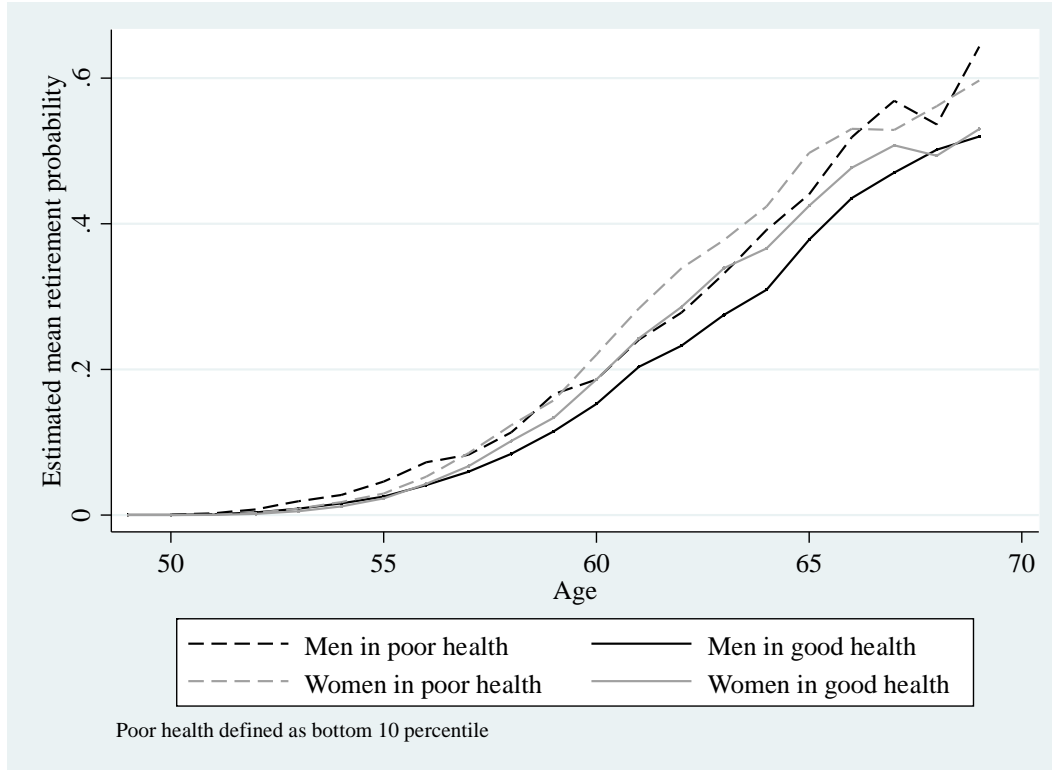
$$\begin{aligned} & \Pr(ret_{i,t} = 1 | HI^*, HISP^*, CAR, X) \\ &= \alpha + \beta_1 HI_{i,t}^* + \beta_2 HISP_{i,t}^* + \beta_3 CAR_{i,t} + \beta_4 X_{i,t} + u_{i,t}, \end{aligned} \quad (9)$$

$$\begin{aligned} i &= 1, 2, \dots, n; \\ t &= 1, 2, \dots, T \end{aligned}$$

The predicted retirement probabilities for individuals in good and in poor health, using the defined cut-off points of 10 and 25 per cent, are compared to average retirement rates across individuals from the LFS. Since LFS data is used for the overall HCS estimation, retirement rates from the LFS are weighted by the estimates from the USS data to arrive at health adjusted retirement rates. Final results are provided in figure 4, which shows that poor health increases the probability to retire. It also shows that women are more likely to retire at any given age up to the age of 66 regardless of their health status. After that age men and women in good health show a similar retirement behaviour while men in poor health have a higher probability to retire than women in poor health.

¹³ In USS, caring responsibilities are defined as the provision of “regular service or help for any sick, disabled or elderly person”, that is or is not living with the respondent (University of Essex, 2015). The socio-economic characteristics include information on age, education, marital status, children, spouses' employment, job sector, housing and region. Wave dummies are also included.

Figure 4: Estimated Retirement Probabilities by Health Status and Gender¹⁴



Source: University of Essex (USS) and own calculations

Since equation (9) accounts for the effect of caring activities on retirement and, hence, controls for the effect of third parties' health, the employment rate is further adjusted to differentiate between gender, age, health status and caring duties, $EMR_{s,a,e,h,c}$. This is shown in equation (10).

$$EMR_{s,a,e,h,c} = (1 - RETR_{s,a,e,h,c} - UNEMR_{s,a,e} - Other_{s,a,e}) \quad (10)$$

$$| 50 \leq a \leq 69$$

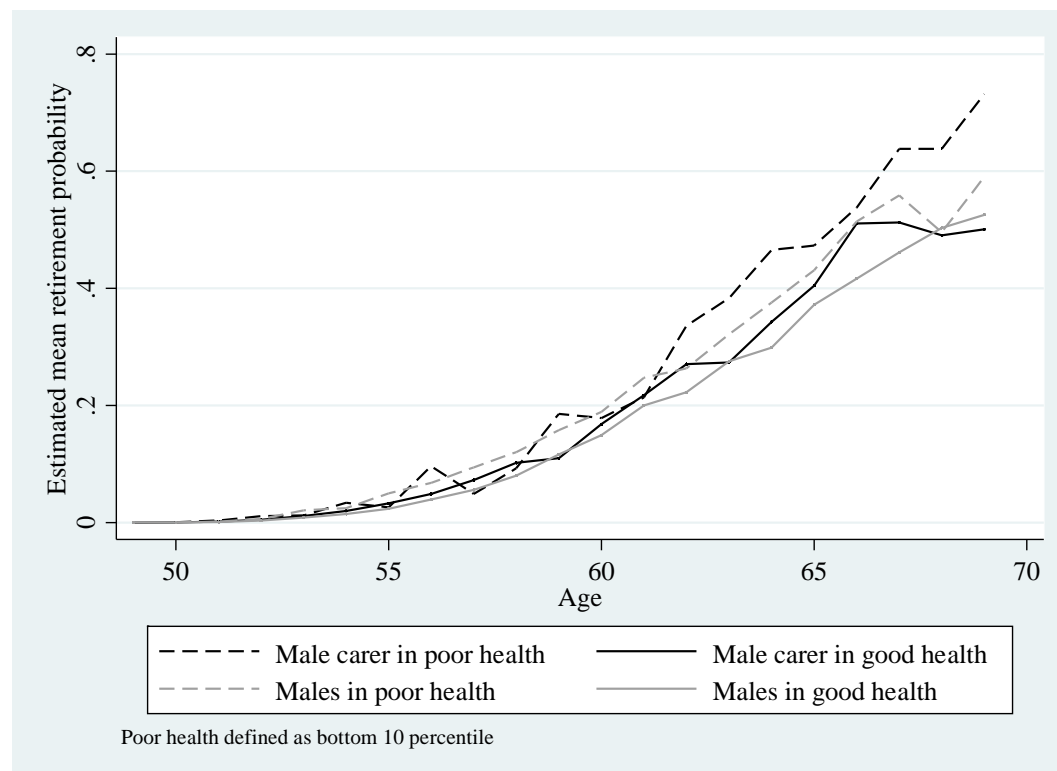
The predicted retirement probabilities for carers and non-carers in poor and in good health, using the defined cut-off points of 10 per cent¹⁵, are compared to the previously estimated average retirement rates by health status. Similar to the approach mentioned above, retirement rates from the LFS are weighted by the retirement probabilities of carers and non-carers in each health status group to arrive at health and caring adjusted retirement rates. These results are summarised in figure 5 and figure 6 for men and women, respectively. Men

¹⁴ The same figure with a cut-off point at the bottom quartile (fair health) is provided in appendix 2.

¹⁵ Retirement probabilities adjusted for caring duties are not reported for the individuals in fair health in this paper but they can be obtained upon request.

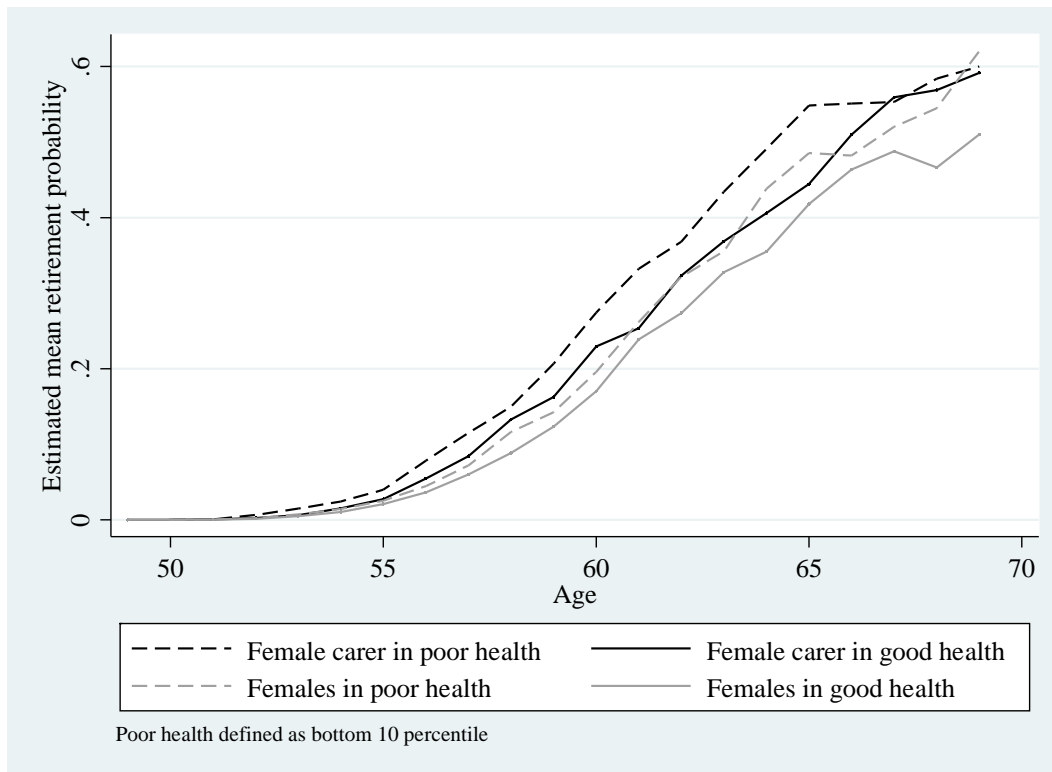
in good health as well as men in poor health have higher retirement probabilities when they are a carer. Interestingly, men, who are in good health but are a carer, show a similar retirement behaviour to men, who have no caring responsibilities but are in poor health. This suggests that poor health and caring duties together increase the likelihood to retire significantly. This trend can be observed even clearer in figure 6, which shows retirement probabilities of women. However, while the health effect of male non-carers diminishes at the age of 68 (then it picks up again) and the health effect is its largest for male carers around this age, an opposite trend can be observed amongst females. The role of health among female carers seems to diminish beyond the age of 66 while its effect on retirement probabilities of non-carers increases.

Figure 5: Estimated Retirement Probabilities of Men by Health Status and Caring Responsibility



Source: University of Essex (USS) and own calculations

Figure 6: Estimated Retirement Probabilities of Women by Health Status and Caring Responsibility



Source: University of Essex (USS) and own calculations

4. Results and Discussion

The results of combining the impacts of health on earnings and retirement with the JF HCS model are shown in Table 2. Employed HCS of men amount to approximately £7.7 trillion in 2014 when accounting for the health effect on wages only, of which only £0.165 trillion (2% of total male HCS) is contributed by men in poor health. This increases to £0.587 trillion (8% of total male HCS) when including men in fair health as well. Female employed HCS amounts to approximately £5.1 trillion in 2014, of which £0.117 trillion (2% of total male HCS) is contributed by women in poor health. This increases to £0.425 trillion (11% of total male HCS) when adding women in fair health.

When assuming that everyone in poor health moves into good health by giving each individual the average HC of a healthy person, UK's HCS would increase to approximately £8 trillion for men and £5.3 trillion for women, which reflects an increase of approximately 3.5%. These relatively small effects are explained by the low number of people in poor health. When giving not only people in poor but also individuals in fair health the estimated

average HCS of a healthy person, UK's HCS would increase to approximately £8.5 trillion for men and £5.6 trillion for women, which reflects about a 10.0% higher stock.

When presenting employed HCS as a percentage of the total by qualification, which is shown in figure 8, it becomes apparent that poor health is associated with lower qualification levels. Therefore, the largest number of people in poor health relative to people in good health have low qualifications. This proportion reflects 8% of the population without any qualification and is followed by individuals with some other qualification (4% for men and 6% for women), FE (3% for men and 4% for women), GCSE (3% for men and 2% for women), A-level (2% for both) and a degree (1% for both). These numbers show two things: firstly, the effect of health on HCS appears very small when looking at total figures, reflecting the fact that the number of people in poor health is relatively small. Secondly, since health status and qualification are clearly associated, qualification levels need to be accounted for in counterfactuals to make the health effect more transparent. Average HCS p.c. is expected to be lower for people in poor health not only because of their health status but also because they are more likely to be in a lower qualification category which both affects HCS negatively. To eliminate bias caused by the *qualification effect* and get a difference in averages solely associated with the health effect, the population in poor health needs to be redistributed across all qualification levels for the purpose of the counterfactual calculation, so that they are essentially given the qualification level shares of the healthy population.

Table 2: Employed HCS – Health Effect on Earnings

Poor health defined as lowest	Men		Women	
	25 percentile “Fair and poor”	10 percentile “Poor”	25 percentile “Fair and poor”	10 percentile “Poor”
HC (£ in trillion)				
Good health	£ 7.136	£ 7.528	£ 4.688	£ 4.986
Poor health	£ 0.587	£ 0.165	£ 0.425	£ 0.117
Poor health as a % of good health	8.23	2.19	11.03	2.3
Total (1)	£ 7.723	£ 7.694	£ 5.113	£ 5.102
Good health	£ 7.136	£ 7.528	£ 4.688	£ 4.986
Poor health → good health ^a	£ 1.399	£ 0.443	£ 0.966	£ 0.297
Poor health as a % of good health	19.6	5.9	21.2	6.0
New total (2)	£ 8.535	£ 7.971	£ 5.567	£ 5.282
Log Δ in HC (1 & 2)	10.0 %	3.5 %	10.0 %	3.5 %
Average HCS				
Good health	£ 393,407	£ 363,551	£ 262,712	£ 242,346
Poor health	£ 145,925	£ 113,891	£ 98,407	£ 73,442
Poor health – redistributed ^b	£ 176,971	£ 141,225	£ 125,069	£ 95,666
HC ratio	2.22	2.57	2.10	2.53

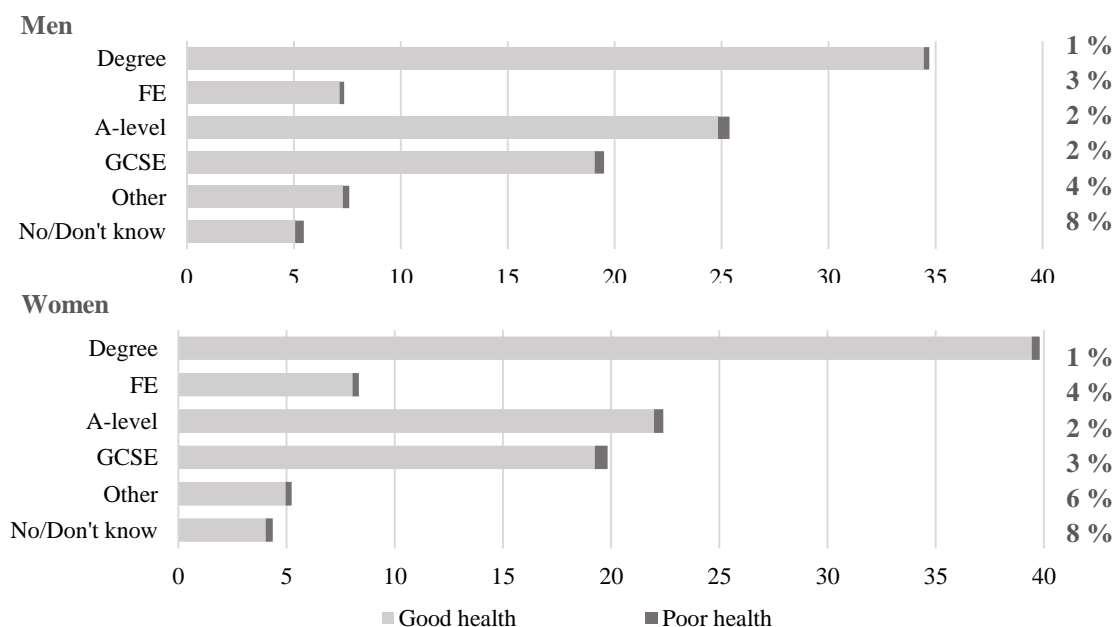
^a Average HC of individuals in good health is given to individuals in poor health

^b Population in poor health is divided across qualifications using shares from healthy population

When looking at the average figures of employed HCS in Table 2, which only account for the health effect on earnings, it becomes apparent that women in good health have an approximately 33% lower average HCS p.c. than men. While men have an average HCS p.c. of £393,407 when men in fair health are excluded and £363,551 when men in fair health are included in the good health category, women only have an average HCS p.c. of £262,712 and £242,346, respectively. This gender difference is similar across men and women in poor health. Male average HCS p.c. is £145,925 when men in fair health are excluded and £113,891 when men in fair health are included in the good health category, women only have an average HCS p.c. of £98,407 and £73,442, respectively. However, as mentioned previously these differences in average HCS across health are not solely associated with health and are biased by the *qualification effect*. If the *qualification effect* is eliminated by giving people in fair and/or poor health qualification level shares of the healthy population, average HCS p.c. for men is £176,971 and £141,225 if men in fair health are excluded and included in the good health category, respectively. This results in an average HCS of a healthy male, which is 2.22 times higher compared to a man in poor or in fair health and even

2.57 times higher compared to a man in poor health. Average HCS of a woman increases to £125,069 and £95,666 if women in fair health are excluded and included in the good health category, respectively, once controlling for the *qualification effect*. This results in an average HCS of a healthy woman, which is 2.21 times higher compared to a woman in poor or in fair health and even 2.53 times higher compared to a woman in poor health. This indicates a stronger health effect on men, which can be related to the fact that men are generally in worse health than women but also because they are more active in the labour market and have higher returns. Consequently, the effect of *absenteeism* and *presenters* has greater consequences.

Figure 8: Employed HCS by Qualification (in %) – Poor health defined as bottom (10%)¹⁶



When incorporating the health effect in earnings as well as in the employment rate through health adjusted retirement probabilities, which is shown in table 3, the effect of health on HCS becomes even more apparent. The ratio of average HCS of a healthy man to a man in poor health now increases from 2.57 to 2.79 while the ratio of a healthy woman's average HCS increases from 2.53 to 2.68.

¹⁶ Employed HCS by qualification using the bottom quartile as a cut-off point for individuals in poor health is provided in appendix 3. Although the proportion of individuals in poor health in each qualification category is much larger now, the trend is the same with the largest proportion being in lower qualification categories.

Since this paper studies the effect of own health together with third party's health to get a fuller picture of the role of health, retirement probabilities are not only adjusted by health but also by caring responsibilities. Table 3 shows that average HCS of carers is lower for both men and women and regardless of their health status. Therefore, male carers have a 3% (£377,241 vs. £ 366,597) and a 10% (£141,032 vs. £127,630) lower average HCS p.c. if they are in good and in poor health, respectively, compared to a man, who has no caring responsibilities. A female carer, in comparison has an average HCS p.c. of 5% (£254,815 vs. £242,596) and 10% (£99,671 vs. £87,017) less if they are in good and in poor health, respectively, compared to a female non-carer. This suggests that caring activities can take time away from work, which increases *absenteeism*, or decrease productivity when at work leading to *presenteeism*. Since more women are carers and take up more hours of caring duty than male carers (for more details, see Samek (2016a)), the larger effect on female average HCS is not surprising. Therefore, the ratio between average HCS p.c. of healthy and unhealthy individuals is not only determined by health of the individual but also by health of others as reflected by the caring responsibility of the individual.

Table 3: Average Employed HCS – Health Effect on Earnings and Retirement Probabilities

	Men			Women		
	All	Non-carer	Carer	All	Non-carer	Carer
Good health	£ 371,600	£ 377,241	£ 366,597	£ 248,094	£ 254,815	£ 242,596
Poor health ^a	£ 108,847	£ 115,266	£ 104,454	£ 71,200	£ 76,748	£ 66,961
Poor health redistributed ^b	– £ 133,089	£ 141,032	£ 127,630	£ 92,487	£ 99,671	£ 87,017
HC ratio	2.79	2.67	2.87	2.68	2.56	2.79

^a Poor health is referred to bottom 10 percentile of estimated HI

^b Population in poor health is divided across qualifications using shares from healthy population

5. Conclusion

This paper shows the importance of incorporating health in HCS estimations by highlighting the significant impact of health on HC through its effect on wages and retirement behaviour. The study reveals that health effects can be studied in detail with different thresholds for health statuses in mind, which allows changes in HCS to be quantified in different contexts.

When accounting for health effects on earnings, we estimated that 2% of total employed HCS was contributed by individuals in poor health in the UK in 2014. Women have an

approximately 33% lower average employed HCS p.c. than men regardless of their health status. Female and male average employed HCS p.c. is 2.68 and 2.79 times higher if they are healthy compared to when they are in poor health, respectively.

Moreover, the ratio between average HCS p.c. of healthy and unhealthy individuals is not only determined by their own health but also by health of others as reflected by the caring responsibility of the individual. Results reveal that caring for elderly, disabled or sick individuals reduces average employed HCS p.c. regardless of the carer's health status and affects female HCS in particular due to their more extensive caring responsibilities. It can be summarised that both, own health and other people's health, reduce average employed HCS p.c. However, men's HCS is more affected by their own health while women's HCS is more affected by poor health of others as presented in their caring duties.

Future improvements to this study would involve the estimation of health on unemployment probabilities in order to get an even better estimate of the health effect on HC. By adjusting the employment rate only by health dependent retirement probabilities, we are not fully taking account of the health effect on the population aged below 50. In this respect, Van Hutten et al. (2013) observed significant effects of caring duties on women (not men), which motivates a further adjustment to the study. So far we included caring activities in retirement probabilities but excluded them from the wage equation. In addition it will be useful to apply the model over time to gauge the impact of changes in health status.

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Appendices

Appendix 1: Variables used in the HCS Estimation

Population

Population numbers by gender and age are provided by the ONS for all relevant years. In order to further classify them by qualification, population numbers were tabulated from the LFS by gender, age and qualification using population weights and then compared with one another. If they varied, ONS numbers were assumed to be the correct population estimates and, thus, were used as the benchmark. Any difference in population number between both totals was divided equally across all qualification groups and added/subtracted to arrive at the total population number provided by the LFS. When aggregating LFS population numbers from three to two classifications, gender and age, and compare them to the ONS results, numbers differ by 0.5% or less and 2% or less for men and women, respectively, across all ages, except at the age of 16. In this age group, these numbers increased to 6% and 3% of men and women, respectively. These individuals were allocated giving the highest weights to the qualification categories *No qualification/don't know* and *GCSE* as these are the most age appropriate ones.

However, since the statutory retirement age increased over time and the LFS question on highest educational attainment is only asked up to that age or if the respondent is still in employment¹⁷, population numbers by qualification are only fully provided in the LFS in more recent years. Consequently, the following assumptions were made: for the years 2005 to 2007 men aged between 65 and 69, who were not employed were allocated to qualification categories based on the distribution in the years 2008 to 2014. This way the changing trend of more people getting better educated over time was taken account of. Although the same principle applied for women, more age groups are affected because of a lower labour force participation and earlier statutory retirement ages. Consequently, year 2011 to 2013 uses trend adjusted distribution shares of 2014 for the age groups 65 to 69 and year 2005 to 2007 uses trend adjusted distribution shares of 2008 to 2010 for the age groups 61 to 69. Years 2008 to 2010 have full information provided.

Annual Earnings

The wage variable relies on gross weekly earnings from the first and the second job, if respondents have one, from the LFS. To obtain an annual estimate of earnings, this number is multiplied by 52 and the log of it is regressed on age, age squared and whether the respondent is in part-time or full-time employment. No income weight was used because the LFS gives zero weight to employees exceeding weekly wages of £3,500, which was considered to be a too low cut-off point for the purpose of this study. Each regression was run separately by gender and qualification.

The health effect on wages was incorporated by using the predicted annual earnings by age, gender, qualification and health from the log hourly wage equation with the USS data as discussed earlier. Consequently, the LFS provides average annual earnings across the employed population while the USS delivers the information additionally by health. Because the LFS provides a larger sample, estimates from there are used and weighted by the wage difference given from the USS results.

Enrolment Rates

Numbers of students enrolled in schools and FE are provided by the Department for Education while student numbers enrolled in HE are provided by HESA. All information is provided by gender, age and academic year, which was transformed into enrolment rates by gender, age and calendar year by

¹⁷ This is also the reason why current HCS estimates are only provided up to the age of 69. Beyond this age point, population figures can no longer be tabulated reliable. The number of people employed becomes very small and, thus, the allocation of those by qualification is no longer representative of the population.

weighing the number of students, $ENR_{s,a,y}$, and dividing it by the total population by gender and age, $Pop_{s,a,y}$. This is shown in equation (1) below.

$$ENRR_{s,a,y=2005} = \frac{(0.75*ENR_{s,a,y=2004/05})+(0.25*ENR_{s,a,y=2005/06})}{Pop_{s,a,y=2005}} \quad (1)$$

School enrolment rates (SENR), $SENR_{s,a,y}$, are provided up to the age of 18 separately and ages 19 plus are published together. However, since the SENR for that category is almost zero, it is allocated to the age group 19 and then a SENR of zero is given to all older ages. A similar approach is applied to FE enrolment rates (FEENR) and HE enrolment rates (HEENR), where ages 16 to 29 are reported individually and ages 30 plus are summarised in one figure. This number is assumed to be true for individuals aged 30 while individuals aged 31 to 34 are given a FEENR of 0.005 and a HEENR of 0.01.

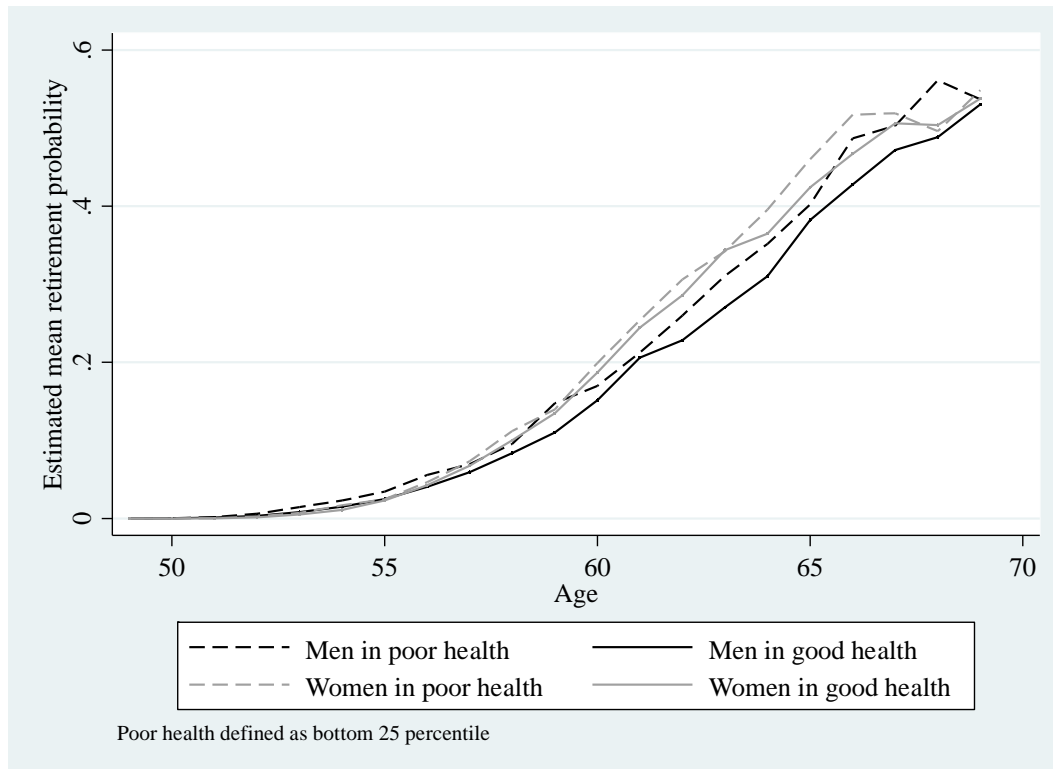
Survival Rate

The survival rate, $sr_{s,a}$, is provided annually by the ONS by gender and age.

Employment, Unemployment and Retirement Rates

All three rates are calculated using data from the LFS and then are tabulated by gender, age and qualification. Since the LFS is conducted to International Labour Organisations (ILO) definitions, the employment, $EMR_{s,a,e}$, as well as the unemployment rate, $UNEMR_{s,a,e}$, are in accordance with the official unemployment measure in Northern Ireland and the UK, which measured the proportion of the economically active who are employed or self-employed and unemployed, respectively. The retirement rate, $RETR_{s,a,e}$, is also in accordance with the ILO definition of economic inactivity and includes everyone who is not seeking for work, is retired from work and either would like or would not like to work. We allocated retirement probabilities only to individuals of the age of 50 to 69 due to the small retirement rates for individuals in other ages. We also created another rate, which refers to $Other_{s,a,e}$ in order to account for everyone else, who is economically inactive for any other reason than retirement. This can involve caring for the family or the household, long-term sickness, etc.

Appendix 2: Estimated Retirement Probabilities by Health Status and Gender Using the Bottom Quartile as a Cut-Off Point



Source: University of Essex (USS)

Appendix 3: Employed HCS by Qualification (in %) – Poor health defined as bottom (25%)

