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Health and Aging before and after Retirement

Abstract

We investigate health and aging before and after retirement for specific occupational groups. We use five waves of the Survey of Health, Aging, and Retirement in Europe (SHARE) and construct a frailty index for elderly men and women from 10 European countries. Occupational groups are classified according to low vs. high education, blue vs. white collar color, and high vs. low physical or psychosocial job burden. Controlling for individual fixed effects, we find that, regardless of the used classification, workers from the first (low status) group display more health deficits at any age and accumulate health deficits faster than workers from the second (high status) group. We instrument retirement by statutory retirement ages ("normal" and "early") and find that the health of workers in low status occupations benefits greatly from retirement, whereas retirement effects for workers in high status occupations are small and frequently insignificant. We also find that workers from low status occupations always have higher health deficits, i.e. we find evidence for an occupational health gradient that widens with increasing age, before and after retirement.

JEL-Codes: I100, I190, J130.

Keywords: health deficits, occupation, retirement, frailty index, Europe.

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1. Introduction

Some occupations exert a higher toll on human health than others. In this paper, we investigate in a unified framework how job characteristics affect health and aging before and after retirement. The related literature (discussed below) usually focuses on health status and addresses these problems separately for workers and retirees, i.e. there exists a literature on the impact of job characteristics on the health status of workers and a literature on the impact of retirement on health. Here we focus on the dynamic aspect of health, i.e. biological aging, expressed by the process of health deficit accumulation before and after retirement of individuals from different occupational groups.

Controlling for individual fixed effects and instrumenting for entry into retirement, we find that individuals in low status occupations display more health deficits at any age before and after retirement. This difference is observed for low- vs. high-skilled individuals, individuals in blue- vs. white-collar occupations, individuals in occupations of high- vs. low physical burden, and for individuals in occupations of high- vs. low psychosocial burden. We also find that retirement leads to a reduction of health deficits, which is statistically significant and large for individuals from low-status occupations and small and frequently insignificant for individuals from high-status occupations. Most importantly, we find that individuals in low-status occupations develop new health deficits faster before *and* after retirement. In other words, we find evidence for diverging aging processes across occupational groups.

These findings contribute to a better understanding of human aging and how it is shaped by occupational health burdens. Specifically, divergence of health deficits across occupational groups suggests that human aging is a self-productive process (Dragone and Vanin, 2021), which means that existing health deficits are conducive to the development of more health deficits during the next time increment (e.g. the next year). *Ceteris paribus*, unhealthy persons age faster than healthy persons. The health capital model, in contrast, predicts the opposite, namely that healthy persons (endowed with much health capital) age faster in the sense of greater loss of health capital due to depreciation during the next time increment (Grossman, 1972). If occupation exerts a level effect on health, the health capital model predicts that health differences among workers converge (Case and Deaton, 2005) and if occupation exerts a rate effect on health, the health capital model predicts that the health of workers after retirement converges (see Section 2 for details).

A widening occupational health gradient is predicted by the health deficit model, developed by Dalgaard and Strulik (2014) based on aging processes modeled in gerontology (Gavrilov and Gavrilova, 1991; Mitnitski et al., 2001, 2002, 2006, Mitnitski et al, 2017). This is so, because, according to the health-deficit model, existing health deficits are conducive to the development of further health deficits. The only case for which the health deficit model could predict convergence is if the health gains from retirement were so great that the health levels of workers in high-burden occupations returned to the levels of workers in low-burden occupations, which does not seem to be the case, empirically.

In order to measure biological aging and how it is affected by retirement, we follow Mitnitski et al. (2001, 2002) and construct a frailty index (health deficit index). The index counts the number of health deficits that a person has at a given age relative to the number of potential health deficits. Health deficits include serious disabilities as well as mild illnesses. We then use information on retirement to construct a dummy variable that indicates whether an individual is retired or not. For this purpose, we employ the Survey of Health, Aging, and Retirement in Europe (SHARE) which contains health-related information, as well as retirement and the life-history of individuals.

We follow the empirical strategy of Abeliansky and Strulik (2018a, 2018b, 2019, 2020) and use the log of the frailty index as dependent variable and age and retirement as the explanatory variables. In order to assess occupation-specific health effects that operate independently of the personal characteristics of workers, we exploit the panel dimension of the data and control for individual fixed effects. In order to account for the potential endogeneity of retirement we instrument it with two dummy variables that take the value of one if the individual has reached the early or normal statutory retirement ages, in a similar vein to Mazzona and Peracchi (2012, 2017). We first split the sample according to the educational level of the individuals (11 years of schooling as the threshold). We next consider the last job as reported in the SHARE dataset and, following Mazzona and Peracchi (2017), we classify jobs as being demanding or not in three different ways: overall job burden; physical job burden; and psychosocial burden. Finally, we classify occupations into white and blue collar jobs. We consistently observe for both men and women diverging health deficits across occupational groups and greater benefits from retirement for low-status workers. The only "anomaly" is that we also obtain large health benefits from retirement for women in white-collar occupations.

Our study is inspired by the work of Case and Deaton (2005) who also emphasize the dynamic process of aging but focus the investigation mainly on work-life. Using self-reported health from the National Health Interview Surveys (NHIS), Case and Deaton observe a health-cost especially of low-paid or manual work such that workers in these occupations have both lower health status and more rapidly deteriorating health. Case and Deaton conclude that the observation of a widening occupational health gradient as workers become older is hard to reconcile with Grossman's (1972) health capital model. In their cross-sectional study, Case and Deaton control for a host of potentially confounding variables and argue that they provide "prima facie evidence for the existence of occupational specific health effects that operate, at least in part, independently of the personal characteristics of the workers" (p. 199). We try to improve on this state of affairs by using panel data and controlling for individual fixed effects, i.e. we investigate the individual aging process of workers in specific occupational groups. We also refine the health metric by replacing the crude measure of self-reported health with the gerontologically founded frailty index.

Our study is also related to the influential work of Michael Marmot (and coauthors). Initially based on longitudinal studies of British civil servants and then extended in other directions, Marmot argues that occupational status is mainly associated with health status because of occupational stress, social position, and sense of being in control of one's life (e.g. Marmot et al., 1991, 1997, Marmot, 2005). We contribute to this line of research by investigating the impact of psychosocial job burden on health deficit accumulation and by showing that it is as large, if not larger, as the impact of physical job burden.

More recent work by Fletcher et al. (2011) constructs measures of physical demands and environmental stress of job characteristics for a sample of US households and finds negative effects on self-reported health for individuals working in jobs with high physical demands or harsh conditions, in particular for women and older workers. Gueorguieva et al. (2009) investigate self-rated health for a sample of older workers from seven waves of the Health and Retirement Survey (HRS) and find health effects of occupation on the level of health but not on the speed of aging. Kelly et al. (2014) investigate occupational effects on health behavior and find that blue collar work early in life is associated with increased probabilities of obesity and smoking, and decreased physical activity later in life. Ravesteijn et al. (2016) investigate health satisfaction in a panel of German workers. Controlling for selection by lagged health, they find level and rate effects on health of blue collar work as well as of physical strain and low job control. Morefield et al. (2011) investigate health transitions and observe that workers in physically more demanding jobs are more likely to transit from good to bad health but do not have different probabilities of health improvements. The results thus provide indirect support for the self-productive nature of health deficits, as predicted by the health deficit model. The self-productive nature of health deficit accumulation has been estimated as a Markovian process by Mitnitski et al. (2006), see Hosseini et al. (2021) for a recent refinement.

There exists a rich literature on the effects of retirement on health and many but not all studies suggest that retirement improves health. Coe and Zamarro (2011) are perhaps the first who exploit statutory retirement age as an instrument for retirement. Using data for a sample of countries from the first wave of SHARE, they find a large positive impact of retirement on self-reported health as well as on an index of objective health measures. They also find, surprisingly, that age has only a small effect on health and no evidence for a non-linear age-health relationship. A limitation of the cross-sectional study is certainly that it cannot consider the aging process of individuals and that it cannot control for individual heterogeneity by including individual fixed effects. Behncke (2012) uses data for England and a propensity score method and finds that retirement significantly increases the risk of suffering from chronic conditions such as cardiovascular diseases and cancer, as worsens self-assessed health. Insler (2014) uses panel data from the HRS and self-reported predictions of working past ages 62 and 65 as instruments. He observes a large positive impact of retirement on individual health measured by a health index comprising objective and subjective health indicators. Eibich (2015) uses a regression discontinuity design and financial incentives in the German pension system and finds that retirement improves subjective health status at the individual level, which is particularly strong for low-skilled individuals. The study also suggests several channels of health behavior by showing that retirement leads to less smoking and more sleep and physical activity.

Mazzonna and Perarchi (2017) consider the first two waves of SHARE data and merge the individuals' last occupation with indices of physical and psychosocial burden from Kroll (2011), i.e. the indices that we will also employ in our study. In first-difference regressions and instrumenting by statutory retirement age, the study finds a positive effect of retirement on a health index of male workers in physically demanding jobs but no such effect for women or individuals in jobs with low or median physical burden. Gorry et al. (2018) use panel data from the HRS, instrument several measures of social security by eligibility, and find that retirement improves self-reported health but not the number of diagnosed health conditions. Leimer (2017) uses fives waves of the SHARE data, instruments by statutory retirement age, and finds a positive impact of retirement on self-assessed health as well as on other health indicators. Workers in blue collar or in physically demanding jobs, however, are not found to benefit more from retirement in terms of self-assessed health (albeit in terms of mobility limitations and grip strength). We aim to contribute to this literature by using the frailty index as an encompassing measure of health and aging, by exploiting the panel dimension of the SHARE data, by a unified analysis of aging during the work-life and after retirement, and by addressing the question of whether the state of health converges or diverges with age across occupations, before and after retirement.

The remainder of the paper is organized as follows. In the next section we provide the theoretical background for the discussion of occupational effects on aging before and after retirement. In Section 3 we describe the data used and the empirical strategy. In Section 4 we present and discuss the results. Section 5 concludes the paper.

2. Aging Before and After Retirement: Theory

In order to theoretically identify the impact of occupations on aging it is useful to impose a *ceteris paribus* assumption and consider two individuals of the same age and state of health at the time of entry into the workforce. Suppose that the state of health depends only on the age and the physical or mental burden of the occupation. In order to derive a testable hypothesis from a theoretical background we consider stylized versions of the health capital model (Grossman, 1972) and the health deficit model (Dalgaard and Strulik, 2014). Following Case and Deaton (2005) we explore two alternative ways that explain how occupation may affect health: level effects and rate effects.

The health capital model (Grossman, 1972) conceptualizes aging as loss of health capital, which depreciates at a certain rate (δ) as individuals grow older such that $H(t+1) = (1-\delta(t))H(t)$, in which $H(t)$ is the health capital stock at age t. The depreciation rate $\delta(t)$ may be constant or increasing in age. The health deficit model captures a stylized fact from gerontology, namely that individuals accumulate health deficits as they grow older: $D(t+1) = (1+\mu)D(t)$, in which $D(t)$ are health deficits at age t, and μ is the rate of aging. In both types of health models it is additionally assumed that the evolution of health depends on behavior (health investments, consumption of unhealthy goods etc), a feature that is omitted here to isolate the direct health effects of occupation.

First suppose that the health-burden of an occupation exerts a level effect. According to the health capital model this implies that health differences across occupations are largest at young ages. This features has first been emphasized by Grand and Muurinen (1985) with respect to social classes. Intuitively, the argument is that the component of health decline that reflects biological aging (rather than occupational effects) is small for young workers and large for old workers (Case and Deaton, 2005). Formally, consider two individuals who enter the workforce at age t with health capital $\bar{H}$. Worker A experiences no health damage from work, while worker B suffers from the health burden $b > 0$ of the occupation. As a level effect, job-burden reduces health capital by factor $(1-b)$. Suppose, for simplicity that δ is constant. The difference of health capital stocks at age T is then given by $H_A(T) - H_B(T) = (1-\delta)^{T-t}\bar{H} - (1-\delta)^{T-t}\bar{H}(1-b) = (1-\delta)^{T-t}b\bar{H}$. The model predicts convergence of health status: the difference of health status is initially largest and then depreciates as both individuals grow older and suffer from "normal" aging. If health depreciation were age-dependent, the depreciation effect of a level effect would be smaller at young ages and even greater at old ages. Convergence would be faster than for an age-independent depreciation rate. Case and Deaton (2005) refute the prediction of converging health status using self-reported health for manual vs. non-manual workers.

The health deficit model, in contrast, predicts that initial health differences become larger as workers grow older. To see this, consider two workers, A and B, with health deficits $\bar{D}$ before entry into the workforce and a level effect on health deficits of size b only for worker B. Health deficits of worker B are thus shifted upwards by factor b and given by $\bar{D}(1+b)$. The difference in health deficits at age T is then computed as $D_B(T) - D_A(T) = (1+\mu)^{T-t}\bar{D}(1+b) - (1+\mu)^{T-t}\bar{D} = (1+\mu)^{T-t}b\bar{D}$, i.e. the model predicts divergence: occupational health differences increase with the age of the worker.

These distinctive features of the two models have been discussed in a general context and identified as self-depleting (health capital) and self-productive (health deficits) dynamic processes (Dragone and Vanin, 2021). Almond and Currie (2011) and Dalgaard et al. (2021) analyze level effects in the context of early-life health shocks. The self-depleting health capital model predicts that early life health shocks are depreciated away as individuals grow older while the self-productive health deficit model predicts that initial shocks are amplified as individuals grow older such that small shocks in utero or early childhood can have strong effects on late-life health. Abeliansky and Strulik (2018b, 2020) provide an empirical test of the health deficit model in the context of early-life health shocks.

Suppose now that the occupational health burden has rate effects rather than level effects. Then, naturally, both types of models predict that health differences grow during employment. Distinctive predictions, however, are obtained for life after retirement. For the health capital model suppose that the health capital depreciates at rate δ without health-burden from occupation and at rate $\delta + \delta_b$ in health-demanding occupations. Health capital at the age of retirement R can be written as $H_A(R) = (1-\delta)^{R-t}\bar{H}$ without health-burden and $H_B(R) = (1-\delta-\delta_b)^{R-t}\bar{H}$ with health burden, in which $\bar{H}$ denotes the level of initial health capital. Individuals exposed to health-burden in their occupation face a larger rate of work-related depreciation and thus exhibit less health capital at retirement.

After retirement, the job related depreciation δ_b is no longer present and the self-depleting feature of health capital depreciation means that the health differences between retirees are converging. To see this, consider the computation exercise from above. The health difference between the two individuals at age $T > R$ is $H_A(T) - H_B(T) = (1-\delta)^{T-R}H_A(R) - (1-\delta)^{T-R}H_B(R) = (1-\delta)^{T-t}(H_A(R) - H_B(R))$. The health difference is largest at retirement age and depreciates away as individuals grow older. The health capital model predicts convergence of the state of health after retirement.

For health deficit accumulation, assume analogously that the health burden from occupation increases the natural rate of aging, which is μ without burden (individual A) and $\mu + \mu_b$ with burden (individual B) and that there are no level effects. Then, health deficits at retirement are $D_A(R) = (1+\mu)^{T-t}\bar{D}$ and $D_B(R) = (1+\mu+\mu_b)^{T-t}\bar{D}$. The individual in the unhealthy occupation has accumulated more health deficits at retirement. After retirement, $\mu_b = 0$ and individuals accumulate new health deficits at the same rate. The difference in health deficits at age $T > R$ is obtained as $D_B(T) - D_A(T) = (1+\mu)^{T-R}(D_B(R) - D_A(R))$ and it becomes larger with increasing age of the individuals. The health deficit model predicts divergence of occupational health differences before *and* after retirement.

In this study, we investigate both level and rate effects in context of the health deficit model. In our baseline specification we consider level effects where health deficits at age t are given by

$$D(t) = \bar{D}\mathrm{e}^{\mu t}\mathrm{e}^{-(1_{[t \geq R]}\alpha)}, \tag{1}$$

in which $\mathbb{1}_{[j=R]}$ is an indicator function that attains a value of one for retired individuals. We thus identify the occupational health burden α as a downward shift of health deficits at the age of retirement. In the level specification, we allow the rate of aging μ to differ across occupational classes but not within classes before and after retirement. In line with most of the related literature the model assumes that retirement leads to a shift in health deficits due to the now absent effect of occupation on health.

Alternatively, health could be conceptualized as a slowly moving state variable, which does not change spontaneously with entry in retirement. Instead, retirement affects the rate at which health deficits are accumulated. This view is captured by the rate-model:

$$D(t) = \bar{D}\mathrm{e}^{\mu t}\mathrm{e}^{\gamma(t-R)1_{[t \geq R]}}, \tag{2}$$

in which $\mu + \gamma$ is the rate of health deficit accumulation after retirement. The problem with this specification is that positive health effects from retirement are not necessarily visible as $\gamma < 0$. The reason is that health deficits could accumulate at a speed faster than exponentially (and there is supporting evidence for this feature from non-linear growth regressions; see Mitnitski et al., 2002, and Abeliansky and Strulik, 2018a). Faster than exponential aging would be reflected in $\gamma > 0$ regardless of whether individuals retire at age R or not. If retirement is beneficial to health, the only conclusion that we can draw is that post-retirement health deficits will accumulate more slowly after retirement age R than if people had not retired at age R. The latter, however, is an unobservable counterfactual. Nevertheless, we can use the rate model to make inferences across occupational groups. Specifically, we would expect that individuals in occupations with high health toll age faster before retirement (larger μ) and more slowly after retirement (lower γ). These features are captured by a model with double interaction effects:

$$D(t) = \bar{D}\mathrm{e}^{(\mu+\beta 1_G)t}\mathrm{e}^{(\gamma+\delta 1_G)(t-R)1_{[t \geq R]}}, \tag{3}$$

where $\mathbb{1}_G = 1$ is an indicator variable for the occupational group, which assumes the value of 1 if an individual belongs to the group of blue collar workers, low education, or high physical or psychosocial job burden.

We do not explicitly test the health capital model. Nevertheless, inferences about the health capital model are feasible if there is a monotonous negative association of health capital and health deficits. In contrast to health deficits, there exists no standardized metric for health capital but empirical attempts to measure health capital are frequently based on the absence of health deficits (e.g. Wagstaff, 1993) or on self-evaluated health (e.g. Grossman, 2000). In the latter case, we need to assume that individuals with less health deficits evaluate their health better, which seems to be a plausible assumption. Under these restrictions, empirical support of the health deficit model in terms of divergence of health deficits during or after retirement implies a refutation of the health capital. This is so because, in the terminology of Dragone and Vanin (2021), the process of human aging can only be either self-depleting or self-productive, but not both at the same time.

3. Empirical Method and Data

3.1. **Data.** In order to study aging before and after retirement, we use the Survey of Health, Aging, and Retirement in Europe (SHARE dataset release 7.0.0) and the Job Episodes Panel (release 7.0.0).[1] We use five waves from SHARE that provide health-related information (wave 1, 2, 4, 5 and 6); for methodological details, see Börsch-Supan et al. (2013) and Brugiavini et al. (2019). Wave 1 took place in the year 2004, wave 2 in 2006/7, wave 4 in 2011 (in 2012 for Germany) wave 5 in 2013, and wave 6 in 2015.[2] We considered adults aged 50 and above in 10 countries that participated in the survey: Austria, Belgium, Switzerland, Germany, Denmark, Spain, France, Italy, Netherlands and Sweden. We focused on these countries because their relevant statutory retirement ages do not depend on individual characteristics (other than age) as in other countries like, for example, the Czech Republic where the number of children is also decisive for the statutory retirement age. We also omit Israel and Greece because they participated in the survey less often than the other countries. We only used observations of individuals

[1]DOIs: 10.6103/SHARE.w1.700, 10.6103/SHARE.w2.700, 10.6103/SHARE.w4.700, 10.6103/SHARE.w5.700, 10.6103/SHARE.w6.700, and 10.6103/SHARE.jep.700)

[2]Wave 3 was not included given that it does not report health-related variables (it is a retrospective wave). Wave 7, although available, lacks the whole module on mental health for those who have been surveyed in the past so it could not be included in the analysis.

aged 85 and below because several very old people show “super healthy” characteristics (likely because of selection effects).

For each observation of each surveyed individual we constructed a frailty index following Mitnitski et al. (2002) and Searle et al. (2006). We took into consideration 38 symptoms, signs, and disease classifications, which can be found in Table A.1 in the Appendix. We followed Mitnitski et al. (2002) and coded multilevel deficits using a mapping to the Likert scale within the interval 0-1. Details on the construction of each variable are available in Table A.2 in the Appendix. We then obtained the frailty index as an individual’s ratio of deficits. If information on specific deficits was not there for an individual, we instead calculated the index based on the information which was available about potential deficits (i.e. if data was not available for x potential health deficits, the observed health deficits were divided by $38-x$). From the surveyed people, we retained only those with information on at least 30 health deficits for at least 2 waves and also removed individuals younger than 50 since this was not the targeted population of the survey (and this group very likely represented partners of the actual targeted people). We further removed a few individuals with a frailty index of zero (1.3% of the sample) because we use the logarithm of health deficits. We arrived at a sample of 83,659 observations, which corresponds to 28,664 individuals.[3]

We first split the sample by educational level. We took 11 years of schooling as the threshold for high-and low-educational levels since this was the mean value of years of education (across countries and waves). Next we split the sample according to the level of job burden (high/low) that each individual had in their last job. Each person was asked in wave 1 which was their last job, and the answer was coded following the ISCO-88 classification. Since this information is only available for wave 1, the sample for this analysis only includes individuals that were present in wave 1 (and onwards). The ISCO-88 code on the last job is used to match it with the classification from Kroll (2011). Kroll (2011) classified the jobs according to their overall intensity, which is comprised of physical and mental strain, and assigned a value from 1 to 10 to each job in the ISCO-88 classification. Mazzonna and Peracchi (2017, p.135) define a physical burdensome job as one with high environmental pollution and ergonomic stress and a psychosocially burdensome job as one with high level of “mental stress, social stress, and temporal loads”. We follow Mazzona and Peracchi (2017) and use the interval [1,5] to classify

[3] In related work have shown that results are very similar when zeroes are kept and the log is replaced with the inverse hyperbolic sine (Abeliansky and Strulik, 2019).

an individual whose last job is/was low in intensity, while all whose index is above 5 as strenuous ("high intensity"). Finally, we also use the reported last job with its ISCO-88 classification and assign it the category of "blue" or "white collar" using the classification of Eurofund (2020). While we are unable to control for selection into educational level or professions, we provide alternative reinforcing evidence. We divide the sample according to the number of books at home at age 10, retrieved from the wave 3 of the SHARE dataset, which collects retrospective information of individuals. As a proxy for low education we put into one category those who had "none or very few (0-10 books)" and in the other category the rest.[4][5] While this is an imperfect measure of educational level of individuals, it cannot be argued that our estimates suffer from selection.

We recorded individuals as "retired" when they replied "retired" to the question "In general, how would you describe your current situation?". Following the literature, we omitted those individuals who answered "Permanently sick or disabled" since this group could benefit from early retirement benefits due to disability and because their aging process could be different. Moreover, we erased those individuals who refused to provide an answer. We also complimented the retirement information with that of the Job Episode Panel, provided by SHARE in another dataset. Facing the problems of endogeneity of retirement and of reverse causality, we use an instrumental variable approach. We take the "normal" and "early" statutory retirement ages as external instruments, since individuals do not choose these themselves and have no power to change these. The SHARE dataset provides the "normal" statutory retirement age for most individuals but the "early" statutory retirement age is reported only for a severely reduced group of individuals. Because relying on the "early" information from SHARE would reduce our sample size considerably, we have complemented it with information on early retirement provided in Leimer (2017). In the robustness analysis we only kept individuals who are retired, employed or unemployed (in a similar vein to Heller-Sahlgren, 2017), which reduces our sample by about a quarter of the observations. We perform this exercise to observe whether retirement has a particular effect on those who are in the job market (either working or actively looking for work).

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[4] Those classified as "few" have "none or very few (0-10 books)", while those classified as "several" include those who have answered "enough to fill one shelf (11-25 books)", "enough to fill one bookcase (26-100)", "enough to fill two bookcases (101-200)", or "enough to fill two or more bookcases".

[5] If we would put the second category into the first group, results would be fairly unchanged.

Table 1. Summary Statistics

	Females		Males		Females		Males	
Variables	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
	High Education				Low Education			
Frailty index	0.130	0.097	0.097	0.086	0.185	0.132	0.130	0.110
Age	63.154	8.306	64.237	8.405	67.364	8.837	67.536	8.729
Retired	0.504	0.500	0.585	0.493	0.600	0.490	0.758	0.428
Statutory retirement age	63.755	2.083	64.463	1.610	63.167	2.382	64.499	1.574
(Early) Statutory retirement age	60.135	1.940	60.749	2.096	59.940	1.903	60.709	2.175
	Overall Job Burden: Low Burden				Overall Job Burden: High Burden			
Frailty index	0.168	0.114	0.127	0.105	0.201	0.128	0.155	0.123
Age	69.541	7.849	71.385	7.149	69.592	7.826	71.315	7.139
Retired	0.849	0.358	0.967	0.178	0.787	0.410	0.967	0.179
Statutory retirement age	63.185	2.276	64.282	1.733	63.075	2.361	64.514	1.499
(Early) Statutory retirement age	59.565	2.005	60.216	2.175	59.629	1.924	60.248	2.056
	Physical Job Burden: Low Burden				Physical Job Burden: High Burden			
Frailty index	0.170	0.115	0.130	0.108	0.199	0.127	0.154	0.121
Age	69.766	7.788	71.502	7.076	69.382	7.881	71.187	7.213
Retired	0.865	0.342	0.971	0.167	0.774	0.418	0.963	0.190
Statutory retirement age	63.185	2.263	64.297	1.715	63.072	2.372	64.514	1.505
(Early) Statutory retirement age	59.543	2.032	60.253	2.171	59.644	1.901	60.211	2.051
	Psychosocial Job Burden: Low Burden				Psychosocial Job Burden: High Burden			
Frailty index	0.168	0.111	0.139	0.114	0.197	0.128	0.144	0.116
Age	69.307	7.976	71.477	7.008	69.739	7.739	71.211	7.287
Retired	0.824	0.381	0.966	0.181	0.811	0.392	0.968	0.176
Statutory retirement age	63.232	2.273	64.346	1.679	63.058	2.350	64.459	1.558
(Early) Statutory retirement age	59.592	2.048	60.220	2.162	59.603	1.906	60.246	2.064
	White Collar				Blue Collar			
Frailty index	0.169	0.116	0.123	0.104	0.218	0.142	0.159	0.127
Age	69.748	7.647	71.435	7.104	70.005	8.109	71.677	7.246
Retired	0.872	0.334	0.970	0.170	0.751	0.433	0.961	0.193
Statutory retirement age	63.336	2.246	64.282	1.734	62.818	2.449	64.531	1.489
(Early) Statutory retirement age	59.659	1.939	60.271	2.142	59.549	1.852	60.198	2.025

Table 1 shows the summary statistics of the samples used for the educational split, job intensity splits as well as for the collar split. Females have, on average, more health deficits than men. This observation is line with Abeliansky and Strulik (2018a, 2018b, 2019, 2020). We also observe that individuals with higher educational levels have, on average, less deficits (as previously shown by Harttgen et al, 2013). The mean age of females and males is similar; while individuals are, on average, 3 to 4 years younger in the high education group. In line with this observation, the percentage of observations of retired individuals is somewhat lower among the highly educated. As expected, the mean early statutory retirement age is lower than the statutory retirement age. With respect to the sample splits according to the job burden, we observe that within burden-classes men are, on average, about 1.5 years older than women. Across burden classes there are only small age differences. Men and women in high burden occupations display on average more health deficits. This difference is most pronounced for men in occupations of high physical burden who display about 20 percent more health deficits than their counterparts in low-burden occupations. Occupational differences are greatest across collar groups. Men and women in blue collar occupations display on average almost 30% more health deficits than their counterparts in white collar occupations.

3.2. **Model Specification.** As our baseline specification, we log-linearize equation (1) and estimate the following relationship between the frailty index, age, and retirement:

$$\log D_{iw} = \mu \cdot age_{iw} + \alpha \cdot retirement_{iw} + \lambda_i + \epsilon_{iw}, \tag{4}$$

where D is the frailty index, i represents the individual, w the wave, *age* represents the age at the interview, *retirement* is a dummy variable that takes the value of one if the individual is retired, λ_i are individual fixed effects and ϵ is the error term. Standard errors are clustered at the year-of-birth level.[6] Equation (4) implies that health deficits grow exponentially with age akin to the Gompertz law of mortality. When individuals retire, there is a shift in the health-deficit accumulation curve.

We estimate (4) separately for men and women since previous studies have shown that males and females accumulate health deficits at different rates and levels (e.g. Mitnitski et al., 2002; Abeliansky and Strulik, 2018a, 2019). Most importantly, we estimate (4) for different occupational groups, i.e. we consider sample splits according to education, different characteristics of job burden, and collar-color in order to obtain occupational differences of aging before and after retirement. In instrumental variable (IV) regressions for (4) we control for the potential endogeneity of individual retirement status by instrumenting it with the statutory retirement age.

Alternatively, we consider that occupational factors affect the rate of aging when working and in retirement. After log-linearizing (3), we estimate the following model:

$$\begin{aligned} \log D_{ij} = {} & \mu \cdot age_{ij} + \beta \cdot age_{ij} \cdot group_{ij} + \gamma \cdot years\,in\,retirement_{ij} \\ & + \delta \cdot years\,in\,retirement_{ij} \cdot group_{ij} + \epsilon_{ij}. \end{aligned} \tag{5}$$

In order to cope with the statistically more demanding task, we aggregate the data by age (as in Mitnitski et al., 2002, and Abeliansky and Strulik, 2018a) and along occupational groups. While

[6]We have also conducted the analysis using two-way clustering at the country and year-of-birth level. We refrained from reporting these results since the command *xtivreg*2 would not report the Hansen test due to few observations in some clusters (in the IV regressions). The conclusions derived from using these alternative standard errors are the same. Results are available upon request.

we lose individual-level information, we are able to investigate whether there are regularities with respect to human aging along occupational group. Index i denotes the age group and not the individual as in equation 4. Since the binning prevents the use of information about the individual retirement age, we consider a retirement age of 65, which is between the mean retirement age between both groups (high/low). Therefore, we consider individuals retired when 65 and calculate the years in retirement as the years between 65 and above. We estimate (5) separately for the five different occupation classifications and the indicator variable $group_{ij}$ is equal to 1 if an individual from age group i belongs to the group j defined alternatively as the group of low education, blue collar, high job burden, high physical burden, or high psychosocial burden. Aside from the regressions for educational groups, we also refrain from the gender analysis in order to smooth out individual heterogeneity (given the small sample size) and get closer to population averages.

4. Results

Table 2 shows the results of estimating equation (4) for men and women, according to their educational level. On average, individuals develop about 2 percent more health deficits from one birthday to the next. We see that elderly women start from a higher level of initial health deficits than men (larger constant) and that men, as they age, accumulate health deficits at a greater speed than women, in line with past literature (i.e. Mitnitski et al., 2002; Abeliansky and Strulik, 2018). Columns (1), (4), (7) and (10) show the baseline results when the retirement dummy is not included. We see that within-gender groups, individuals with low education age faster. While this result is, in principle known from the literature (e.g. Harttgen et al., 2013), we here show that it holds true when controlling for time-invariant individual characteristics by including individual fixed effects in the regression.

In columns (2), (5), (8), and (11) we include the retirement dummy in the fixed effects regressions. We observe a statistically significant effect of retirement only for women with low education and for men with high education. The results, however, are likely driven by endogeneity-bias. This view is confirmed when we consider the results from IV regressions in columns (3), (6), (9), and (12). The first stage results are shown in Table E.1 in the Appendix. The instruments are sufficiently strong in predicting retirement according to the Kleinbergen Paap Wald F-statistic (above the threshold of 10) and in most of the cases the Hansen statistic fails to reject the null hypothesis that the over-identifying restrictions are valid. We now observe that retirement has a significant effect on health deficits. For all four gender-occupation groups, the entry into retirement shifts the age-deficit trajectory downwards. Among women, the point estimate is only marginally higher (in absolute value) for women with low education. Among men, we observe that men with low education age more rapidly and benefit more from retirement than those with higher education. As a further robustness check, we verify that similar conclusions are obtained when we use the 45-item frailty index from Börsch-Supan et al. (2021), see Appendix Table C.1.

Since education is a choice, as well as the type of job, and since we are unable to control for selection, we show in Appendix Table D.1 the results for a different sample split that avoids the selection problem, namely by the number of books at home when the respondents were children. Those who had no or very few books at home belong to one group, while the rest belongs to the other group. The sample split resembles that of the low vs. high education but it is now difficult to argue that individuals have selected themselves into these groups of households. The availability of books is a decision made by parents, not by the individuals. While the number of books at home is an imperfect measure, it serves as a robustness check to our results. We observe from the results shown in Appendix Table D.1 that the estimated coefficients are similar with respect to sign, size, and statistical significance to those of the education split from Table 2.

The precise effects of education on health deficit accumulation before and after retirement are difficult to assess from the estimated coefficients. In particular, the issue of convergence

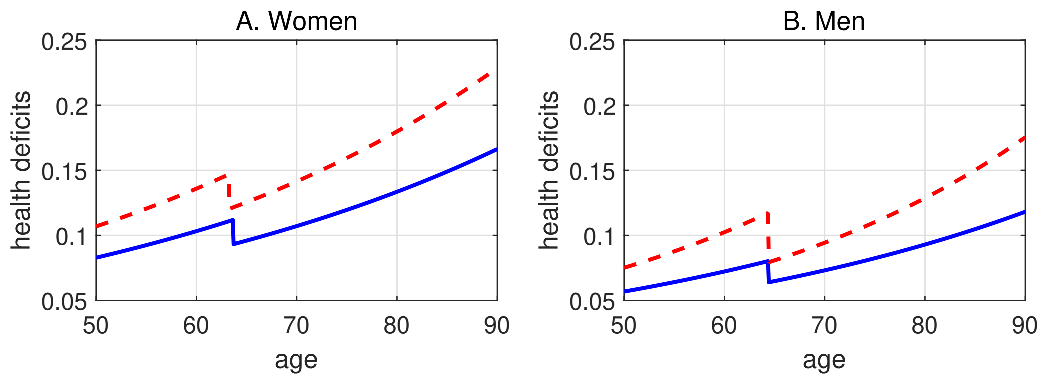
Table 2. Health Deficits and Retirement - Education Split

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Age	0.015***	0.016***	0.022***	0.019***	0.020***	0.024***	0.016***	0.019***	0.024***	0.021***	0.022***	0.031***
	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.005)	(0.003)	(0.003)	(0.003)
Retired		-0.029	-0.183***		-0.037*	-0.200***		-0.071***	-0.228**		-0.056	-0.392***
		(0.025)	(0.058)		(0.020)	(0.065)		(0.023)	(0.093)		(0.033)	(0.077)
Constant	-3.256***	-3.310***	-3.591***	-3.231***	-3.269***	-3.436***	-3.683***	-3.803***	-4.068***	-3.758***	-3.812***	-4.139***
	(0.139)	(0.153)	(0.185)	(0.135)	(0.132)	(0.130)	(0.188)	(0.194)	(0.257)	(0.196)	(0.195)	(0.179)
Obs.	19,583	19,583	19,583	25,485	25,485	25,485	19,232	19,232	19,232	19,359	19,359	19,359
Ind.	6,750	6,750	6,750	8,601	8,601	8,601	6,707	6,707	6,707	6,606	6,606	6,606
Educ.	High	High	High	Low	Low	Low	High	High	High	Low	Low	Low
Gender	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male
Method	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV
F-test	-	-	282.64	-	-	206.44	-	-	117.12	-	-	181.87
H-Test	-	-	0.088	-	-	0.707	-	-	0.260	-	-	0.480

Notes: standard errors are clustered at the year-of-birth level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. The dependent variable is the log of the frailty index. FE stands for fixed effects and IV for instrumental variables regression, Obs. for observations, Ind. for individuals, Educ. for education, F-test is the Kleinbergen Paap Wald F-statistic and H-test for Hansen test (p-value).

or divergence motivated in the theory section is hard to resolve by inspection of Table 2. To simplify inferences, we thus use the point estimates from the IV regressions for a graphical representation of biological aging of men and women distinguished by educational class. These results are shown in Figure 1. We took the gender-specific average retirement age as the shift point. Women are represented in panel A and men are represented in panel B of Figure 1. Health deficits by age are represented by blue (solid) lines for individuals with high education and by red (dashed) lines for individuals with low education.

Figure 1: Health Deficits by Age: High vs. Low Education



Predictions for estimates from IV-regression, columns (3),(6), (9), and (12) from Table 2. Retirement at the average gender-specific retirement age. Blue (solid) lines: high education; red (dashed) lines: low education.

The results from Figure 1 show that individuals with low education have at any age accumulated more health deficits and that the distance between health deficits by skill-group gets larger with increasing age, before and after retirement. Thus there is divergence of health deficits as predicted by the health deficit model (and in disagreement with the health capital model). Divergence after retirement follows from the feature that health deficit accumulation is a self-productive process (cf. theory section) together with the result that the age-coefficient is larger for low-educated individuals at all ages.

While it is reasonable that part of the effect of education on aging works through occupation, it is well known that education affects health also through other pathways than occupation (e.g. Grossman, 2006; Strulik, 2018; Galama and Van Kippersluis, 2019). With our next sample split we thus focus on the physical and psychosocial burden of occupation, classified to be either high or low (as explained in Section 3). By including individual fixed effects in the regression, we control for education as a selection device since it can be reasonably argued that education is finished at the age of 50 (the youngest age in our sample). A shortcoming of these regressions is that the job burden refers to the current job or the last job that retired individuals had. If individuals, as they age, move from health-demanding occupations to less health-demanding occupations, we do not capture the job burden of the whole work-life correctly and the regressions tend to overestimate the health toll of low-burden jobs, i.e. to underestimate the occupational differences of aging and retirement.

Table 3 shows the results for the aggregate job burden split, as well as separated by physical burden and psychosocial burden. Focusing on the IV regressions, we observe a statistically significant impact of retirement only for men and women in high burden occupations. For both men and women the age coefficient is similar across burden levels but the constant is significantly larger in high burden occupations. Retirement causes a particularly large reduction of health deficits for men in high-burden occupations, regardless of the dimension of burden.

Finally, Table 4 shows the results using a different categorization: whether the last job was classified either as "white" or "blue" collar. In the case of men we observe the familiar pattern: the health of men with blue collar jobs benefits more from retirement. For women, we observe a new and perhaps surprising pattern: women in white collar jobs benefit more in terms of health deficit reduction from retirement than those in blue collar jobs. The point estimates, however, are quite close and the occupational differences in the benefit from retirement are no longer statistically significant when we remove home-makers and individuals having reported "other" as their last occupation (Table F.5 in the Appendix).

The first stages of the instrumental variable regressions are available in the Appendix, Tables E.1, E.2 and E.3. Moreover, in the Appendix-Tables F.1 – F.5 we replicate the above regressions for a reduced sample in which we kept only individuals who are employed, unemployed, or retired. The estimated coefficients are of similar size and significance as in the benchmark regressions. As another robustness test we merged the burden indicator at the two-digit ISCO-level. The benefit of this approach is that we gain in sample size, but given the high aggregation level we lose the difference between the general burden index and the physical burden index. Overall, the aging pattern for high burden individuals remains the same in terms of statistical significance and similar in size (see Tables G.1 and G.2 in the Appendix). A robust result of all performed tests is that individuals who are or were in high burden occupations benefit from retirement in terms of health deficit reduction. In some specifications also individuals with low burden benefit from retirement.

Table 3. A. Health Deficits and Retirement - Overall Job Burden Split

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Age	0.024***	0.024***	0.024***	0.023***	0.024***	0.029***	0.032***	0.032***	0.034***	0.030***	0.031***	0.035***
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)
Retired		0.004	0.024		-0.053	-0.413**		0.014	-0.453		-0.229**	-0.967***
		(0.071)	(0.126)		(0.044)	(0.171)		(0.132)	(0.376)		(0.108)	(0.335)
Constant	-3.696***	-3.696***	-3.695***	-3.418***	-3.428***	-3.498***	-4.644***	-4.653***	-4.341***	-4.318***	-4.176***	-3.719***
	(0.182)	(0.182)	(0.185)	(0.202)	(0.196)	(0.171)	(0.251)	(0.258)	(0.380)	(0.297)	(0.303)	(0.325)
Obs.	3,501	3,501	3,501	3,885	3,885	3,885	3,270	3,270	3,270	3,361	3,361	3,361
Ind.	958	958	958	1,079	1,079	1,079	940	940	940	931	931	931
Burden	Low	Low	Low	High	High	High	Low	Low	Low	High	High	High
Gender	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male
Method	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV
F-test	-	-	60.56	-	-	52.00	-	-	11.21	-	-	12.23
H-Test	-	-	0.294	-	-	0.047	-	-	0.729	-	-	0.964

B. Health Deficits and Retirement - Physical Job Burden Split

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Age	0.026***	0.025***	0.027***	0.022***	0.023***	0.026***	0.033***	0.033***	0.035***	0.029***	0.030***	0.034***
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Retired		0.050	-0.117		-0.078*	-0.321**		0.033	-0.405		-0.240**	-0.971***
		(0.075)	(0.162)		(0.044)	(0.145)		(0.139)	(0.370)		(0.090)	(0.351)
Constant	-3.791***	-3.792***	-3.789***	-3.342***	-3.360***	-3.418***	-4.709***	-4.732***	-4.428***	-4.234***	-4.091***	-3.660***
	(0.234)	(0.238)	(0.229)	(0.174)	(0.170)	(0.149)	(0.293)	(0.302)	(0.380)	(0.265)	(0.267)	(0.329)
Obs.	3,439	3,439	3,439	3,961	3,961	3,961	3,463	3,463	3,463	3,182	3,182	3,182
Ind.	949	949	949	1,091	1,091	1,091	994	994	994	882	882	882
Burden	Low	Low	Low	High	High	High	Low	Low	Low	High	High	High
Gender	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male
Method	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV
F-test	-	-	43.45	-	-	64.36	-	-	9.84	-	-	16.27
H-Test	-	-	0.442	-	-	0.058	-	-	0.488	-	-	0.605

C. Health Deficits and Retirement - Psychosocial Job Burden Split

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Age	0.023***	0.023***	0.025***	0.024***	0.024***	0.028***	0.032***	0.032***	0.034***	0.030***	0.031***	0.035***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)
Retired		-0.023	-0.093		-0.034	-0.375*		-0.021	-0.307		-0.240***	-1.342***
		(0.072)	(0.106)		(0.050)	(0.193)		(0.126)	(0.325)		(0.063)	(0.448)
Constant	-3.603***	-3.609***	-3.626***	-3.513***	-3.515***	-3.529***	-4.592***	-4.579***	-4.402***	-4.352***	-4.190***	-3.449***
	(0.140)	(0.135)	(0.142)	(0.216)	(0.213)	(0.202)	(0.266)	(0.271)	(0.309)	(0.297)	(0.285)	(0.425)
Obs.	2,925	2,925	2,925	4,461	4,461	4,461	3,460	3,460	3,460	3,171	3,171	3,171
Ind.	801	801	801	1,236	1,236	1,236	976	976	976	895	895	895
Burden	Low	Low	Low	High	High	High	Low	Low	Low	High	High	High
Gender	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male
Method	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV
F-test	-	-	60.56	-	-	52.00	-	-	11.21	-	-	12.23
H-Test	-	-	0.294	-	-	0.049	-	-	0.729	-	-	0.964

Notes: standard errors are clustered at the year-of-birth level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. The dependent variable is the log of the frailty index. FE stands for fixed effects and IV for instrumental variables regression, Obs. for observations, Ind. for individuals, F-test is the Kleinbergen Paap Wald F statistic and H-test for Hansen test (p-value).

Due to the interaction of the age coefficient, the constant, and the retirement coefficient it is not always easily inferred from the estimated numbers whether the difference of health deficits between occupational groups increases or declines with advancing age, i.e. whether the results reject the health capital model or the health deficit model. In order to assess this issue in a convenient and condensed way we used the point estimates of the IV regressions from Table 2 to 4 and the average gender-specific retirement age and computed the predicted health deficits by

Table 4. Health Deficits and Retirement - White/Blue Collar Split

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Age	0.026***	0.026***	0.030***	0.023***	0.025***	0.027***	0.036***	0.036***	0.039***	0.034***	0.035***	0.039***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)
Retired		-0.007	-0.414***		-0.116***	-0.271**		0.047	-0.678*		-0.195***	-1.068***
		(0.079)	(0.147)		(0.040)	(0.134)		(0.163)	(0.372)		(0.051)	(0.294)
Constant	-3.829***	-3.828***	-3.743***	-3.369***	-3.397***	-3.436***	-4.996***	-5.028***	-4.527***	-4.553***	-4.438***	-3.922***
	(0.199)	(0.198)	(0.166)	(0.175)	(0.175)	(0.179)	(0.225)	(0.259)	(0.345)	(0.272)	(0.254)	(0.298)
Observations	3,442	3,442	3,442	3,864	3,864	3,864	4,174	4,174	4,174	4,379	4,379	4,379
Individuals	955	955	955	1,104	1,104	1,104	1,235	1,235	1,235	1,240	1,240	1,240
Collar	White	White	White	Blue	Blue	Blue	White	White	White	Blue	Blue	Blue
Gender	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male
Method	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV
F-test	-	-	45.68	-	-	100.55	-	-	13.83	-	-	56.82
H-Test	-	-	0.213	-	-	0.786	-	-	0.381	-	-	0.589

Notes: standard errors are clustered at the year-of-birth level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. The dependent variable is the log of the frailty index. FE stands for fixed effects and IV for instrumental variables regression, Obs. for observations, Ind. for individuals, F-test is the Kleinbergen Paap Wald F statistic and H-test for Hansen test (p-value).

age for the average individual from the occupational groups. We then computed the predicted difference of health deficits between occupational groups. Results are shown in Figure 2. A downward shift of the curve indicates that individuals from low status group benefit more in terms of health from retirement than individuals from high status groups. A curve remaining in the positive quadrant indicates non-convergence. An upward sloping curve indicates divergence of health deficits between low and high status groups.

Panels A and B shows results for the educational split, which is just another representation of the information shown in Figure 1. For example, the line in Panel A shows the difference between the blue and red line of Panel A in Figure 1. We observe that health differences between educational groups increase with increasing age for men and women before and after retirement while retirement as such reduces educational differences. The interpretation is that retirement leads to a reduction of acute job-related health deficits (e.g. acute back pain) but does not level all job-related health deficits. Some job-related deficits remain (e.g. chronic back pain) and are conducive to the development of further health deficits in retirement, as predicted by gerontological models (Gavrilov and Gavrilova, 1991; Mitnitski et al., 2006; Rutenberg, 2018) and the health deficit model in economics (Dalgaard and Strulik, 2014).

Panels C-D show results for the sample split by physical job burden. The occupational difference of health deficits is particularly large and steeply increasing with age during working age. Retirement is associated with a large reduction in health deficits, which are however not fully equalized across occupational groups. After retirement, health deficits diverge again albeit at a slower pace than during working age. Panels E-F show results for the sample split according

Figure 2: Health Deficits Difference by Age: Low vs. High Status Groups

Health differences by age between occupational groups. A-B: low vs. high eduction; C-D: high vs. low physical job burden; E-F: high vs. low psychosocial job burden; G-H: blue vs. white collar occupation. Predictions for estimates from IV-regression, columns (3),(6), (9), and (12) from Table 2, 3, and 4. Retirement at the average gender- and occupation specific retirement age.

to psychosocial job burden. While health deficits diverge before retirement for both genders, health differences for men are basically flat after retirement. For women, we observe again divergence. Finally, panels G-H show results for groups identified by collar color. For men, we observe that health deficits of blue collar workers rise at a higher rate before and after retirement. The health difference between blue and white collar women stays basically constant before retirement and increases after retirement. Interestingly, we observe that the health of white collar women benefits more from retirement, i.e. we observe a rare case where retirement increases health deficits between low and high status workers. The overall conclusion is that we never observe convergence of health deficits with increasing age. The results contradict the predictions of the health capital model and are supportive of the predictions of the health deficit model.

We next turn to the analysis of rate effects of retirement by estimating specification (5). Results are summarized in Table 5. We observe the following regularities. Individuals from low status groups (low education, blue collar, high physical or psychosocial job burden) age significantly faster when working (larger age coefficient). After retirement, the pace of aging slows down for the low status groups, reflected by the negative coefficient for age-retirement interaction. The slowdown, however, is statistically significant only for the education split (and there only for men).

Table 5. Health Deficits and Retirement - Rate Effects

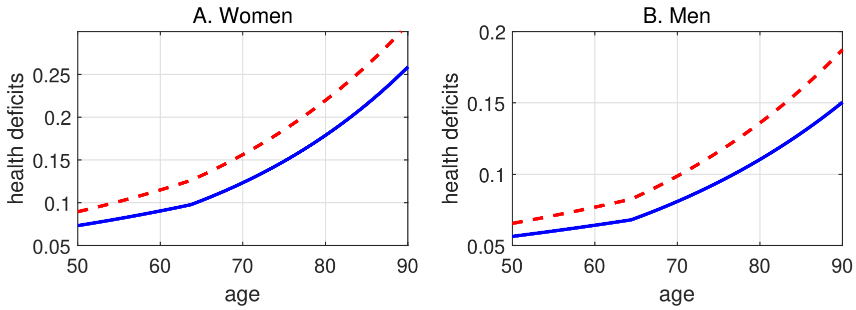
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Age	0.021***	0.013***	0.016***	0.008*	0.008**	0.009*	0.003
	(0.001)	(0.001)	(0.001)	(0.004)	(0.004)	(0.005)	(0.005)
Low Educ. × Age	0.004***	0.003***	0.004***				
	(0.000)	(0.000)	(0.000)				
Years in Ret.	0.016***	0.018***	0.016***	0.016***	0.017***	0.013*	0.023***
	(0.002)	(0.003)	(0.001)	(0.006)	(0.006)	(0.007)	(0.006)
Low Educ.× Years in Ret.	-0.007***	-0.002	-0.003**				
	(0.001)	(0.002)	(0.001)				
Overall High × Age				0.004***			
				(0.000)			
Overall High × Years in Ret.				-0.004			
				(0.003)			
Phys. High × Age					0.004***		
					(0.000)		
Phys. High × Years in Ret.					-0.005		
					(0.003)		
Psych. High × Age						0.002***	
						(0.001)	
Psych. High × Years in Ret.						-0.000	
						(0.004)	
Blue Collar × Age							0.004***
							(0.001)
Blue Collar × Years in Ret.							-0.003
							(0.003)
Constant	-3.663***	-3.525***	-3.524***	-2.876***	-2.875***	-2.918***	-2.623***
	(0.042)	(0.063)	(0.045)	(0.260)	(0.244)	(0.309)	(0.294)
Observations	72	72	72	72	72	72	72
R-squared	0.994	0.982	0.994	0.891	0.902	0.849	0.898
Sample	All	All	All	All	All	All	All
Gender	Female	Male	All	All	All	All	All

Notes: Robust standard errors in parenthesis. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. The dependent variable is the log of the frailty index. Educ. stands for education, Phys. for physical, and Psych. for psychosocial (these are the job-burden indices).

A slower speed of aging after retirement for low status groups, however, does not necessarily mean that health deficits converge. The slowdown needs to be sufficiently strong. Inspection of (5) shows that, formally, $\beta+\delta < 0$ is a necessary and sufficient condition for *eventual* convergence of health deficits. But even then, convergence may be so slow that it is not discernable during the lifetime of individuals. We next explore the convergence or divergence of health deficits when the point estimates of Table 5 are taken at face value.

Figure 3 shows the predicted accumulation of health deficits for men and women from the two educational groups using the estimates from column (2) and (3) of Table 5. According to the rate-model there is, by design, no drop of health deficits upon retirement. The rate of aging slows down for individuals from low status groups but not sufficiently strongly to provide convergence of health deficits after retirement. Instead we observe divergence of health deficits across educational groups before and after retirement, which is best visible in men.

Figure 3: Health Deficits by Age: High vs. Low Education (Rate Effects)



Predictions for estimates from columns (1) and (2) of Table 5. Retirement at the average statutory retirement age from Table 1. Blue (solid) lines: high education; red (dashed) lines: low education.

In Panel A of Figure 4 we consider the sample split by overall job burden. In this case the point estimates of the interaction terms provide convergence ($\beta + \delta = 0.004 - 0.005 < 0$). Mathematically, the model predicts an equalization of health deficits across groups at age 320. The convergence after retirement remains invisible, however, during the lifetime of individuals. The impression is rather that health deficits do not converge after retirement whereas the divergence of health deficits before retirement is clearly visible. Finally, Panel B visualizes the divergence of health deficits of white and blue collar workers before and after retirement. Summarizing, the rate-model leads to similar conclusions as the level model. The health of workers from low-status groups benefits more from retirement than that of workers from high-status groups, but not so much to offset the health effects of faster working-age aging. Differences in health deficits between occupational groups diverge before retirement and do not converge after retirement.

Figure 4: Health Deficits by Age: Low vs. High Status Groups (Rate Effects)

Panel A: Blue (solid) lines: low job burden; red (dashed) lines: high job burden. Panel B: Blue (solid) lines: white collar workers; red (dashed) lines: blue collar workers. Predictions for estimates from columns (7) and (7) of Table 5. Retirement at the average retirement age.

5. Conclusion

In this study we provide evidence for occupational health effects before and after retirement using the frailty index, an encompassing measure of health and aging developed in gerontology, and panel data for 10 European countries. We find that, controlling for individual fixed effects, individuals with low education, in blue collar jobs, and in physically or psychosocially demanding occupations develop new health deficits faster than individuals in the corresponding higher status groups. We instrument for retirement by statutory retirement ages and find that retirement provides a strong relief from health deficit accumulation for individuals in low status occupations but does not lead to a complete reset of health deficits to the corresponding level in high status occupations. Consequently, individuals in low status occupations develop health deficits faster before and after retirement. Public policy should take these features into consideration and adjust statutory retirement according to the health burden of occupations. This conclusion becomes particulary compelling when one considers that health deficits are are strong predictor of mortality (e.g. Mitnitski et al., 2002), implying that members of groups with low status will experience a shorter life span in retirement if the retirement age is not adjusted by the health burden of the occupations (Grossmann et al., 2021).

Overall, we observe a widening occupational health gradient not only during the work-life but also in retirement, which is particularly large for men. Diverging states of health refute the predictions of the convergence-generating health capital model. They are supportive of the self-productive nature of health deficit accumulation according to the health deficit model.

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Appendix A. Data construction

Table A.1. Items of the Health Deficit Index

Arthritis	Difficulties concentrating
Stroke	Difficulties shopping
Parkinson	Difficulties lifting 5kg
Diabetes	Difficulties pulling/pushing object
Cholesterol	Less enjoyment
Asthma	Difficulties managing money
Depressed	Difficulties joining activities
High blood pressure	Difficulties bathing
Cataracts	Difficulties dressing
Pain	Difficulties doing housework
Difficulties seeing arm length	Difficulties walking across house
Difficulties seeing across street	Difficulties eating
Difficulties sitting long	Difficulties getting out of bed
Difficulties walking 100mt	Difficulties using the toilet
Difficulties getting out chair	Difficulties using map
Difficulties climbing stairs	Walking speed (only in wave 1 and 2)
Difficulties kneeing	BMI
Difficulties picking an object	Grip strength
Difficulties extending arms	Mobility

Table A.2. Variables from the SHARE data.

Dimension	Variable	Coding in SHARE dataset
Arthritis	ph006d8	yes=1, no=0
Stroke	ph006d4	yes=1, no=0
Parkinson	ph006d12	yes=1, no=0
Diabetes	ph006d5	yes=1, no=0
Cholesterol	ph006d3	yes=1, no=0
Asthma	ph006d7	yes=1, no=0
Depressed	mh002_	yes=1, no=1
High blood pressure	ph006d2	yes=1, no=0
Cataracts	ph006d13	yes=1, no=0
Pain	ph010d1	yes=1, no=0
Difficulties seeing arm length	ph044_	none=0, mild=0.25, moderate=0.5, bad=0.75, very bad=1
Difficulties seeing across street	ph043_	none=0, mild=0.25, moderate=0.5, bad=0.75, very bad=1
Difficulties sitting long	ph048d2	yes=1, no=0
Difficulties walking 100mt	ph048d1	yes=1, no=0
Difficulties getting out chair	ph048d3	yes=1, no=0
Difficulties climbing stairs	ph048d5	yes=1, no=0
Difficulties kneeing	ph048d6	yes=1, no=0
Difficulties picking an object	ph048d10	yes=1, no=0
Difficulties extending arms	ph048d7	yes=1, no=0
Difficulties concentrating	mh014_	yes=1, no=0
Difficulties shopping	ph049d9	yes=1, no=0
Difficulties lifting 5kg	ph048d9	yes=1, no=0
Difficulties pulling/pushing object	ph048d8	yes=1, no=0
Less enjoyment	mh016_	yes=1, no=0
Difficulties managing money	ph049d13	yes=1, no=0
Difficulties joining activities (because of health)	ph005_	not limited=0, limited, not severely=0.5, severely limited=1
Difficulties bathing	ph049d3	yes=1, no=0
Difficulties dressing	ph049d1	yes=1, no=0
Difficulties doing housework	ph049d12	yes=1, no=0
Difficulties walking across the house	ph049d2	yes=1, no=0
Difficulties eating	ph049d4	yes=1, no=0
Difficulties getting out of bed	ph049d5	yes=1, no=0
Difficulties using the toilet	ph049d6	yes=1, no=0
Difficulties using map	ph049d7	yes=1, no=0
Walking Speed	wspeed and wspeed2	no problem if: aged<75 (by construction);(wspeed>=0.4 or wspeed2==0);
(only available wave 1 and wave 2)		problem if: wspeed<=0.4 or wspeed2==1
BMI	bmi	(bmi<=18.5 or bmi>=30) =1; (bmi>=25 and bmi<30)=0.5; bmi>18.5 and bmi<25)=0
Grip strength	maxgrip and bmi	it is recorded as frail for women if (maxgrip<=29 & bmi<=24); (maxgrip<=30 & (bmi>=24.1 & bmi<=28));
		(maxgrip<=32 & bmi>28); for men if : (maxgrip<=29 & bmi<=24);
		(maxgrip<=30 & (bmi>=24.1 & bmi<=28)); (maxgrip<=32 & bmi>28)
Mobility	mobility	(mobility>=3)=1; (1>=mobility<3)=0.5 and mobility=0

Appendix B. Frailty at age 65

Table B.1. Mean frailty index at age 65

Sample	Gender	Mean Frailty	Sample	Gender	Mean Frailty
High Education	Females	0.126	Low Education	Females	0.165
	Males	0.095		Males	0.114
White Collar	Females	0.143	Blue Collar	Females	0.188
	Males	0.106		Males	0.133
OJI: Low	Females	0.148	OJI: High	Females	0.176
	Males	0.112		Males	0.128
OPI: Low	Females	0.147	OPI: High	Females	0.175
	Males	0.113		Males	0.129
OSI: Low	Females	0.146	OSI: High	Females	0.173
	Males	0.118		Males	0.122

Notes: OJI stands for overall job burden index, OPI for overall physical job burden index and OSI for overall psychosocial job burden index.

Appendix C. MEA 45 Index

Table C.1. Health Deficits and Retirement - Education Split (MEA 45 Index)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Age	0.028***	0.030***	0.036***	0.027***	0.028***	0.033***	0.032***	0.034***	0.038***	0.032***	0.033***	0.040***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)
Retired		-0.045*	-0.215***		-0.029	-0.227***		-0.060***	-0.176**		-0.050*	-0.314***
		(0.023)	(0.045)		(0.018)	(0.053)		(0.021)	(0.074)		(0.029)	(0.073)
Constant	-4.167***	-4.250***	-4.560***	-3.901***	-3.931***	-4.134***	-4.749***	-4.851***	-5.049***	-4.601***	-4.650***	-4.908***
	(0.134)	(0.146)	(0.141)	(0.122)	(0.119)	(0.108)	(0.170)	(0.174)	(0.226)	(0.171)	(0.172)	(0.167)
Obs.	19,680	19,680	19,680	25,508	25,508	25,508	19,369	19,369	19,369	19,424	19,424	19,424
Ind.	6,765	6,765	6,765	8,603	8,603	8,603	6,719	6,719	6,719	6,609	6,609	6,609
Educ.	High	High	High	Low	Low	Low	High	High	High	Low	Low	Low
Gender	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male
Method	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV
F-test	-	-	202.44	-	-	291.02	-	-	116.76	-	-	182.72
H-Test	-	-	0.219	-	-	0.032	-	-	0.030	-	-	0.323

Notes: standard errors are clustered at the year-of-birth level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. The dependent variable is the log of the frailty index. FE stands for fixed effects and IV for instrumental variables regression, Obs. for observations, Ind. for individuals, Educ. for education, F-test is the Kleinbergen Paap Wald F-statistic and H-test for Hansen test (p-value).

Appendix D. Books at Home by Age 10

Table D.1. Books at Home by Age 10: Health Deficits and Retirement

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Age	0.020***	0.024***	0.023***	0.029***	0.018***	0.024***	0.030***	0.040***
	(0.002)	(0.003)	(0.002)	(0.002)	(0.004)	(0.004)	(0.003)	(0.003)
Retired	-0.065**	-0.170**	-0.058**	-0.289***	-0.064*	-0.241***	-0.094***	-0.440***
	(0.032)	(0.069)	(0.022)	(0.060)	(0.035)	(0.083)	(0.030)	(0.076)
Constant	-3.498***	-3.691***	-3.436***	-3.708***	-3.746***	-4.038***	-4.353***	-4.728***
	(0.148)	(0.146)	(0.132)	(0.127)	(0.222)	(0.252)	(0.192)	(0.189)
Obs.	9,395	9,395	15,798	15,798	7,765	7,765	13,620	13,620
Ind.	2,693	2,693	4,512	4,512	2,239	2,239	3,952	3,952
Books	Several	Several	Few	Few	Several	Several	Few	Few
Gender	Female	Female	Female	Female	Male	Male	Male	Male
Method	FE	FE-IV	FE	FE-IV	FE	FE-IV	FE	FE-IV
F-test	-	316	-	265	-	578	-	170
H-test	-	0.12	-	0.61	-	0.06	-	0.75

Notes: standard errors are clustered at the year-of-birth level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. The dependent variable is the log of the frailty index. FE stands for fixed effects and IV for instrumental variables regression, Obs. for observations, Ind. for individuals, Educ. for education, F-test is the Kleinbergen Paap Wald F-statistic and H-test for Hansen test (p-value). Those classified as "few" have "none or very few (0-10 books)", while those classified as "Several" include those who have answered "enough to fill one shelf (11-25 book)", "enough to fill one bookcase (26-100)", "enough to fill two bookcases (101-200)", or "enough to fill two or more bookcases".

Appendix E. First Stages

Table E.1. Education Split

	(1)	(2)	(3)	(4)
Age	0.014***	0.008***	0.015***	0.009***
	(0.002)	(0.001)	(0.003)	(0.003)
Ret. Age	0.295***	0.272***	0.220***	0.192***
	(0.016)	(0.014)	(0.019)	(0.015)
Early Ret. Age	0.198***	0.162***	0.229***	0.239***
	(0.028)	(0.015)	(0.028)	(0.019)
Constant	-0.646***	-0.281***	-0.624***	-0.186
	(0.139)	(0.081)	(0.168)	(0.159)
Obs.	19,583	25,485	19,232	19,359
Ind.	6,750	8,601	6,707	6,606
Education	Low	High	Low	High
Gender	Female	Female	Male	Male

Notes: standard errors are clustered at the year-of-birth level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. The dependent variable is the log of the health deficit index. FE stands for fixed effects and IV for instrumental variables regression, Obs. for observations and Ind. for individuals. Ret. Age is a dummy variable that takes the value of one if the person has the same or is older than the statutory retirement age, zero otherwise; and Early Ret. Age takes the value of one if the person has the same or is older than the statutory early retirement age, zero otherwise.

Table E.2. Job Intensity Split

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Age	0.004***	0.003***	-0.000	0.000	0.003***	0.004***	0.000	0.000	0.004***	0.002***	0.000	0.000
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
Ret. Age	0.150***	0.234***	0.050***	0.061**	0.165***	0.221***	0.039***	0.070**	0.217***	0.183***	0.062***	0.048**
	(0.024)	(0.036)	(0.015)	(0.025)	(0.027)	(0.029)	(0.013)	(0.027)	(0.036)	(0.027)	(0.018)	(0.019)
Early Ret. Age	0.194***	0.162***	0.157***	0.138***	0.188***	0.166***	0.157***	0.139***	0.169***	0.179***	0.182***	0.115***
	(0.031)	(0.019)	(0.037)	(0.028)	(0.039)	(0.020)	(0.037)	(0.025)	(0.036)	(0.026)	(0.048)	(0.016)
Constant	0.309***	0.261***	0.787***	0.758***	0.378***	0.206***	0.787***	0.757***	0.202**	0.333***	0.741***	0.798***
	(0.071)	(0.062)	(0.035)	(0.035)	(0.067)	(0.063)	(0.034)	(0.032)	(0.077)	(0.062)	(0.047)	(0.030)
Obs.	3,501	3,885	3,270	3,361	3,439	3,961	3,463	3,182	2,925	4,461	3,460	3,171
Ind.	958	1,079	940	931	949	1,091	994	882	801	1,236	976	895
Burden	OJI	OJI	OJI	OJI	OPI	OPI	OPI	OPI	OSI	OSI	OSI	OSI
Level	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Gender	Female	Female	Male	Male	Female	Female	Male	Male	Female	Female	Male	Male

Notes: standard errors are clustered at the year-of-birth level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. The dependent variable is the log of the health deficit index. FE stands for fixed effects and IV for instrumental variables regression, Obs. for observations and Ind. for individuals. Ret. Age is a dummy variable that takes the value of one if the person has the same or is older than the statutory retirement age, zero otherwise; and Early Ret. Age takes the value of one if the person has the same or is older than the statutory early retirement age, zero otherwise.

Table E.3. Collar Split

	(1)	(2)	(3)	(4)
Age	0.002**	0.004***	0.000	0.000
	(0.001)	(0.001)	(0.000)	(0.000)
Ret. Age	0.144***	0.265***	0.036***	0.073***
	(0.021)	(0.039)	(0.011)	(0.026)
Early Ret. Age	0.156***	0.139***	0.164***	0.153***
	(0.044)	(0.038)	(0.035)	(0.021)
Constant	0.492***	0.162*	0.760***	0.744***
	(0.065)	(0.080)	(0.037)	(0.028)
Obs.	3,442	3,864	4,174	4,379
Ind.	955	1,104	1,235	1,240
Sample	White Collar	Blue Collar	White Collar	Blue Collar
Gender	Female	Female	Male	Male

Notes: standard errors are clustered at the year-of-birth level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. The dependent variable is the log of the health deficit index. FE stands for fixed effects and IV for instrumental variables regression, Obs. for observations and Ind. for individuals. Ret. Age is a dummy variable that takes the value of one if the person has the same or is older than the statutory retirement age, zero otherwise; and Early Ret. Age takes the value of one if the person has the same or is older than the statutory early retirement age, zero otherwise.

Appendix F. Reduced Sample - Sample Split

Table F.1. Health Deficits and Retirement - Education Split

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Age	0.013***	0.014***	0.019***	0.019***	0.020***	0.023***	0.016***	0.019***	0.024***	0.021***	0.022***	0.030***
	(0.002)	(0.003)	(0.004)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.005)	(0.003)	(0.003)	(0.003)
Retired		-0.023	-0.163**		-0.066**	-0.190***		-0.083***	-0.253***		-0.056*	-0.389***
		(0.029)	(0.072)		(0.026)	(0.056)		(0.023)	(0.091)		(0.033)	(0.078)
Constant	-3.174***	-3.215***	-3.469***	-3.255***	-3.318***	-3.436***	-3.655***	-3.790***	-4.066***	-3.748***	-3.801***	-4.111***
	(0.155)	(0.169)	(0.201)	(0.146)	(0.143)	(0.136)	(0.199)	(0.204)	(0.261)	(0.196)	(0.196)	(0.179)
Obs.	15,761	15,761	15,761	15,244	15,244	15,244	18,449	18,449	18,449	18,780	18,780	18,780
Ind.	5,473	5,473	5,473	5,227	5,227	5,227	6,466	6,466	6,466	6,416	6,416	6,416
Educ.	High	High	High	Low	Low	Low	High	High	High	Low	Low	Low
Gender	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male
Method	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV
F-test	-	-	163.97	-	-	354.48	-	-	141.80	-	-	176.69
H-Test	-	-	0.091	-	-	0.212	-	-	0.173	-	-	0.530

Notes: standard errors are clustered at the year-of-birth level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. The dependent variable is the log of the health deficit index. FE stands for fixed effects and IV for instrumental variables regression, Obs. for observations, Ind. for individuals, Educ. for education, F-test is the Kleinbergen Paap rk Wald F statistic and H-test for Hansen test (P-value).

Table F.2. Health Deficits and Retirement - Overall Job Burden Split

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Age	0.025***	0.025***	0.025***	0.024***	0.025***	0.027***	0.033***	0.033***	0.035***	0.031***	0.032***	0.035***
	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)
Retired		-0.078	-0.129		-0.131	-0.628***		0.086	-0.708		-0.246	-1.015**
		(0.083)	(0.229)		(0.100)	(0.233)		(0.136)	(0.708)		(0.151)	(0.407)
Constant	-3.702***	-3.661***	-3.634***	-3.542***	-3.461***	-3.154***	-4.728***	-4.795***	-4.175***	-4.371***	-4.203***	-3.677***
	(0.240)	(0.237)	(0.249)	(0.248)	(0.242)	(0.291)	(0.271)	(0.291)	(0.674)	(0.303)	(0.324)	(0.380)
Observations	2,450	2,450	2,450	2,323	2,323	2,323	3,092	3,092	3,092	3,259	3,259	3,259
Individuals	667	667	667	642	642	642	893	893	893	903	903	903
Burden	Low	Low	Low	High	High	High	Low	Low	Low	High	High	High
Gender	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male
Method	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV
F-test	-	-	41.24	-	-	25.23	-	-	4.14	-	-	7.42
H-Test	-	-	0.209	-	-	0.520	-	-	0.849	-	-	0.746

Notes: standard errors are clustered at the year-of-birth level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. The dependent variable is the log of the health deficit index. FE stands for fixed effects and IV for instrumental variables regression, Obs. for observations, Ind. for individuals, E. for education, F-test is the Kleinbergen Paap rk Wald F statistic and H-test for Hansen test (P-value).

Table F.3. Health Deficits and Retirement - Physical Job Burden Split

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Age	0.026***	0.027***	0.028***	0.023***	0.023***	0.025***	0.034***	0.034***	0.036***	0.030***	0.031***	0.034***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)
Retired		-0.087	-0.261		-0.118	-0.479**		0.065	-0.640		-0.237*	-1.039**
		(0.094)	(0.234)		(0.098)	(0.204)		(0.145)	(0.691)		(0.132)	(0.426)
Constant	-3.816***	-3.768***	-3.672***	-3.415***	-3.346***	-3.132***	-4.799***	-4.851***	-4.292***	-4.278***	-4.121***	-3.586***
	(0.267)	(0.260)	(0.270)	(0.200)	(0.198)	(0.244)	(0.312)	(0.332)	(0.646)	(0.272)	(0.295)	(0.396)
Obs.	2,493	2,493	2,493	2,294	2,294	2,294	3,290	3,290	3,290	3,075	3,075	3,075
Ind.	682	682	682	630	630	630	947	947	947	854	854	854
Burden	Low	Low	Low	High	High	High	Low	Low	Low	High	High	High
Gender	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male
Method	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV
F-test	-	-	28.91	-	-	25.41	-	-	3.88	-	-	9.90
H-Test	-	-	0.133	-	-	0.863	-	-	0.615	-	-	0.875

Notes: standard errors are clustered at the year-of-birth level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. The dependent variable is the log of the health deficit index. FE stands for fixed effects and IV for instrumental variables regression, Obs. for observations, Ind. for individuals, E. for education, F-test is the Kleinbergen Paap rk Wald F statistic and H-test for Hansen test (P-value).

Table F.4. Health Deficits and Retirement - Psychosocial Job Burden Split

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Age	0.024***	0.024***	0.026***	0.025***	0.025***	0.027***	0.033***	0.033***	0.034***	0.031***	0.032***	0.037***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)
Retired		-0.079	-0.264		-0.124	-0.446		-0.013	-0.399		-0.288**	-1.989***
		(0.092)	(0.195)		(0.087)	(0.275)		(0.123)	(0.401)		(0.114)	(0.707)
Constant	-3.646***	-3.610***	-3.526***	-3.608***	-3.528***	-3.320***	-4.621***	-4.612***	-4.350***	-4.456***	-4.230***	-2.894***
	(0.182)	(0.190)	(0.209)	(0.260)	(0.265)	(0.299)	(0.278)	(0.290)	(0.370)	(0.313)	(0.303)	(0.620)
Obs.	1,930	1,930	1,930	2,843	2,843	2,843	3,325	3,325	3,325	3,026	3,026	3,026
Ind.	528	528	528	781	781	781	939	939	939	857	857	857
Burden	Low	Low	Low	High	High	High	Low	Low	Low	High	High	High
Gender	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male
Method	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV
F-test	-	-	38.86	-	-	52.89	-	-	6.77	-	-	7.66
H-Test	-	-	0.233	-	-	0.393	-	-	0.347	-	-	0.423

Notes: standard errors are clustered at the year-of-birth level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. The dependent variable is the log of the health deficit index. FE stands for fixed effects and IV for instrumental variables regression, Obs. for observations, Ind. for individuals, F-test is the Kleinbergen Paap rk Wald F statistic and H-test for Hansen test (P-value).

Table F.5. Health Deficits and Retirement - White/Blue Collar Split

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Age	0.027***	0.027***	0.028***	0.027***	0.028***	0.028***	0.037***	0.037***	0.040***	0.034***	0.035***	0.040***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
Retired		-0.022	-0.469		-0.266***	-0.243		-0.002	-1.076*		-0.187**	-1.236***
		(0.110)	(0.438)		(0.080)	(0.191)		(0.142)	(0.569)		(0.073)	(0.380)
Constant	-3.873***	-3.856***	-3.519***	-3.666***	-3.516***	-3.528***	-5.044***	-5.042***	-4.186***	-4.599***	-4.476***	-3.783***
	(0.230)	(0.224)	(0.412)	(0.244)	(0.244)	(0.236)	(0.240)	(0.268)	(0.513)	(0.275)	(0.267)	(0.372)
Obs.	2,606	2,606	2,606	2,028	2,028	2,028	3,972	3,972	3,972	4,219	4,219	4,219
Ind.	706	706	706	586	586	586	1,175	1,175	1,175	1,195	1,195	1,195
Collar	White	White	White	Blue	Blue	Blue	White	White	White	Blue	Blue	Blue
Gender	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male
Method	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV
F-test	-	-	4.37	-	-	16.39	-	-	6.15	-	-	16.85
H-Test	-	-	0.011	-	-	0.030	-	-	0.552	-	-	0.560

Notes: standard errors are clustered at the year-of-birth level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. The dependent variable is the log of the health deficit index. FE stands for fixed effects and IV for instrumental variables regression, Obs. for observations, Ind. for individuals, F-test is the Kleinbergen Paap rk Wald F statistic and H-test for Hansen test (P-value).

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Table G.1. Health Deficits and Retirement - Overall Job Burden Split

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Age	0.025***	0.025***	0.027***	0.022***	0.023***	0.027***	0.035***	0.035***	0.037***	0.033***	0.034***	0.038***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Retired		0.006	-0.102		-0.077**	-0.346***		0.004	-0.612		-0.184***	-1.118***
		(0.063)	(0.143)		(0.033)	(0.116)		(0.154)	(0.400)		(0.051)	(0.333)
Constant	-3.795***	-3.795***	-3.787***	-3.324***	-3.340***	-3.398***	-4.893***	-4.896***	-4.462***	-4.514***	-4.401***	-3.825***
	(0.192)	(0.193)	(0.186)	(0.151)	(0.146)	(0.140)	(0.222)	(0.260)	(0.376)	(0.249)	(0.231)	(0.309)
Obs.	4,530	4,530	4,530	6,214	6,214	6,214	4,640	4,640	4,640	4,933	4,933	4,933
Ind.	1,276	1,276	1,276	1,770	1,770	1,770	1,372	1,372	1,372	1,385	1,385	1,385
Sample	Low Burden	Low Burden	Low Burden	High Burden	High Burden	High Burden	Low Burden	Low Burden	Low Burden	High Burden	High Burden	High Burden
Gender	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male
Method	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV	FE	FE	FE-IV
F-test	-	-	36.86	-	-	128.24	-	-	11.90	-	-	58.76
H-Test	-	-	0.764	-	-	0.360	-	-	0.720-	-	0.428	

Notes: standard errors are clustered at the year-of-birth level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. The dependent variable is the log of the health deficit index. FE stands for fixed effects and IV for instrumental variables regression, Obs. for observations, Ind. for individuals, F-test is the Kleinbergen Paap rk Wald F statistic and H-test for Hansen test (P-value).

Table G.2. Health Deficits and Retirement - Psychosocial Job Burden Split

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Age	0.025***	0.025***	0.025***	0.022***	0.023***	0.028***	0.037***	0.038***	0.041***	0.030***	0.030***	0.034***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)
Retired		-0.038	0.024		-0.058	-0.427***		-0.203	-0.734***		0.026	-1.026***
		(0.047)	(0.101)		(0.046)	(0.131)		(0.131)	(0.260)		(0.056)	(0.355)
Constant	-3.691***	-3.694***	-3.690***	-3.419***	-3.425***	-3.464***	-4.959***	-4.827***	-4.480***	-4.379***	-4.396***	-3.697***
	(0.142)	(0.143)	(0.144)	(0.178)	(0.173)	(0.161)	(0.222)	(0.242)	(0.231)	(0.266)	(0.253)	(0.327)
Obs.	4,006	4,006	4,006	6,738	6,738	6,738	5,299	5,299	5,299	4,274	4,274	4,274
Ind.	1,113	1,113	1,113	1,933	1,933	1,933	1,546	1,546	1,546	1,211	1,211	1,211
Sample	Low Burden	Low Burden	Low Burden	High Burden	High Burden	High Burden	Low Burden	Low Burden	Low Burden	High Burden	High Burden	High Burden
Gender	Female	Female	Female	Female	Female	Female	Male	Male	Male	Male	Male	Male
F-test	-	-	55.29	-	-	76.70	-	-	16.69	-	-	32.44
H-Test	-	-	0.617	-	-	0.327	-	-	0.897	-	-	0.653

Notes: standard errors are clustered at the year-of-birth level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. The dependent variable is the log of the health deficit index. FE stands for fixed effects and IV for instrumental variables regression, Obs. for observations, Ind. for individuals, F-test is the Kleinbergen Paap rk Wald F statistic and H-test for Hansen test (P-value).