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Lifetime job demands and later life disability

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ABSTRACT

Occupational characteristics may improve or harm health later in life. Previous research, largely based on limited exposure periods, reached mixed conclusions. We use Health and Retirement Study data linked to the Department of Labor's O*Net job classification system to examine the relationship between lifetime exposure to occupational demands and disability later in life. We consistently find an association between non-routine cognitive demands and lower rates of Social Security Disability Insurance (SSDI) receipt and work-limiting health conditions. Routine manual demands are associated with moderately worse health and increased SSDI receipt in most lifetime specifications. These results are robust to various specifications of occupational demand measures and controlling for transitions between jobs of different levels of occupational intensity. We show that failure to account for job characteristic exposure early in a worker's tenure obscures the relationship between physical job demands and disability later in life. While characteristics of jobs worked at ages 30 and 55 are both predictive of later-life health outcomes, early-life job characteristics frequently dominate in models containing early and late exposures.

Introduction

Work accounts for a significant portion of Americans' daily lives and is increasingly recognized as a determinant of health status. Research dating to the Whitehall study results of the 1970s has shown a relationship between occupation and long-term health outcomes including mortality, diabetes and cardiovascular disease that cannot be explained by differences in income, education, health behaviors or access to health insurance (Marmot et al., 1978). Several studies have found that older workers retire from physically demanding jobs more rapidly than from other types of jobs (i.e. Case and Deaton, 2005; Filer and Petri, 1988; Hayward et al., 1989; Mitchell et al., 1988) but have focused on characteristics of current jobs, which are likely jointly determined with health and labor force status. A growing literature in economics and medicine has found lasting health effects of adverse early life health exposures, including the earliest events experienced in utero (Almond and Currie, 2011; Almond, 2006; Smith, 2009), suggesting that exposure to job demands throughout the life course may influence work capacity and health later in life.

In this paper, we examine the relationship between lifetime occupational exposures which may harm or hurt health, including physical and cognitive job demands, on subjective and objective measures of whether health limits work capacity later in life including application for and receipt of Social Security Disability Insurance (SSDI) benefits and self-reported work limitations at age 62. We use lifetime jobs reported by older adult respondents in the Health and Retirement Study (HRS), covering an average of 37.5 years of employment, which enables us to assess the intensity and duration of a worker's exposure to physical and cognitive job demands during both early and late career jobs. Our study extends prior research by using a much longer work history, accounting for exposure by age 30 and at various points over the life-course, in contrast to starting at age 50 and or relying on short exposure periods as most studies of job characteristics and later life health have done; including women, who have traditionally been excluded from many studies in this literature; using a more comprehensive and accurate classification system for job characteristics; and focusing on both subjective and objective measures of later-life disability including SSDI benefit receipt and self-assessed work limitations.

We find that greater exposure to physically demanding jobs over a worker's career is associated with a higher probability of receiving SSDI benefits and of having a work-limiting health condition at age 62. In contrast, exposure to high levels of non-routine cognitive interpersonal job demands, and to a lesser extent routine cognitive demands, is associated with lower probabilities of SSDI application and receipt and health limitations. Our results are relatively large in magnitude and are robust to different specifications and sample selections. Our data allow

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us to study the potential for health-related selection out of demanding jobs to bias estimates of the relationship between job demands and health early in workers' careers, advantageous given that half of workers who transition out of jobs with high levels of routine manual or routine cognitive demands do so prior to age 45. Routine physical and cognitive demands of the job worked at age 30 are predictive of later-life health limitations and SSDI claiming, while non-routine cognitive interpersonal demands measured later in life are more informative for these outcomes than early life measures.

Our job histories also allow us to describe transitions over the course of a career. We show that many major changes in exposure to job demands occur prior to age 50, leaving little within-person variation to inform panel data models examining the health effects of contemporaneous job characteristics on older workers. For example, only 10% of workers experience a job transition with a large (one standard deviation or greater) change in their level of non-routine cognitive demands, 3% routine cognitive, and 6% routine manual demands between ages 50 and 65. While characteristics of jobs worked at ages 30 and 55 are both predictive of later-life health outcomes, early-life job characteristics frequently dominate in models containing early and late exposures.

Background

Related literature

Motivation for this paper comes from two primary literatures: work in economics demonstrating the relationships between health status and workforce exits due to disability or early retirement, and an extensive epidemiological and occupational health literature finding relationships between various job characteristics and worker health outcomes. Physically demanding jobs can help health through on-the-job exercise, or harm health through stressors such as repetitive motion, lifting or pushing heavy objects, and accidents. Workers in low-skill occupations requiring manual labor report worse self-rated health and higher disease burden than other workers in cross-sectional data (Case and Deaton, 2005). Health problems induced or exacerbated by job demands can promote workforce exit and reliance on Disability Insurance.

Long-term epidemiological data support the premise that high physical demands are harmful to later-life health, particularly to musculoskeletal capacity (Costa, 2005). The decrease in physical disability rates among older people occurred in conjunction with a shift in the occupation mix towards less manual labor. Assuming a causal effect, the consequences of occupation for health are potentially large: Costa (2000) estimated that 29 percent of the decline in chronic illness among older men from 1900 to 1980 was driven by shifts to less physically demanding occupations. Differences in occupational composition are also a strong determinant of the average age of retirement across countries, explaining up to 40 percent of the cross-country variation in retirement age (Saure and Zoabi, 2012). The absence of physical activity at work can also harm health; extended sitting and computer use have been linked to back pain, obesity, and elevated cholesterol (Owen et al., 2010).

Aside from the direct effect of physical demands on health, the link between physical demands and disability or early retirement may be confounded by pre-existing poor health, which could make jobs entailing strenuous physical work more difficult to perform. Several cohort studies found that self-reported health was a predictor of early retirement, including among Finnish men (Karpansalo et al., 2004) and British civil servants (Mein et al., 2000). Other studies found an explicit link between high physical job demands and disability retirement (Chirikos and Nestel, 1991; Krause et al., 1997; Blekesaune and Solem, 2005). However, these studies have tended to focus on particular occupations, thus limiting the generalizability of their findings and limiting the variation in job demands within their samples.

Recent papers linking job characteristics to national surveys including the Health and Retirement Study, the National Health Interview Study and the National Health and Nutrition Examination Survey found mixed evidence of a contemporaneous association between physically demanding work, hazardous work exposures, and several measures of health and disease (Fletcher et al., 2011; Lakdawalla and Philipson, 2007; Schmitz, 2016). However, these results are likely biased by less healthy workers selecting out of demanding jobs as their health declines. Moreover, the few papers that estimate causal effects of physically demanding occupations have focused on a limited number of health outcomes among workers who are largely still employed (Fletcher et al., 2011; Lakdawalla and Philipson, 2007).

Fletcher et al. (2011) used data from the Panel Study of Income Dynamics to study the longer-term effect of job characteristics on health. Their design and findings are particularly relevant to our study. While the papers discussed previously rely on the demands of jobs that workers still hold at ages 50 and above, Fletcher and colleagues assessed the cumulative effect of jobs held over the past 5 years in a sample of working-aged adults with a mean age of 42. They found that cumulative exposure to physical demands is associated with non-trivial declines in self-rated health for older (but not younger) men as well as older and younger women. Their results indicate that a 1 standard deviation increase in job physical demands deteriorates health at a magnitude comparable to a 1–2 year decrease in years of education. However, Fletcher et al. did not examine the effects of cognitive demands, nor did they consider the effect of job characteristics on retirement and disability.

Job demands can also impact health through the psychological impacts on wellbeing (Karasek, 1979). Those with less control over their jobs and limited ability to control the demands on their time may also experience worse health outcomes due to years of stress response (North et al., 1996). Carr et al. (2016) used longitudinal data from the English Longitudinal Study of Aging (ELSA) and found that physical and psychological job demands were not associated with the probability of work exit, but psychosocial demands were predictive of preferences for shorter time until retirement.

Theory and empirical evidence suggest that work has important long and short-term implications for cognitive functioning. The disuse theory of cognitive function posits that intellectual activity during different stages of life, such as during one's career or in post-retirement, impact cognitive functioning (Salthouse, 2000). Consequently, disuse of cognitive resources is thought to result in a decline in cognitive processes and skills. Several studies report lower rates of Alzheimer's disease among people who worked in cognitively stimulating jobs (Andel et al., 2005; Potter et al., 2007).

Disability insurance

The Social Security Administration established the Social Security Disability Insurance program in 1956 to provide income support for workers whose health precludes substantial gainful activity. Workers can apply for benefits if they have suffered from a medical condition limiting their ability to work for a year or more and worked for five of the ten years prior to the disability onset. Applicants cannot be working at the time of application, and payments can start at the beginning of the sixth month of disability. The average applicant receives their benefits decision after 4.3 months, with approximately 35 percent receiving benefits at the first stage; though more than half of rejected applicants appeal, only 10 percent of appeals are successful (Autor, 2011). Although SSDI recipients can participate in trial work periods and simultaneously receive employment income and benefits for up to 36 months, fewer than 3% of beneficiaries also work (Social Security Administration, 2016).

Approximately 8.7 million Americans received benefits in 2017. SSDI receipt has increased from just over 2 percent of workers ages 25–64 in 1985 to more than 4.5 percent in 2009, with total transfers of

Table 1
Descriptive statistics of HRS respondents.

	All Respondents	At least 75% Known Job Tenure and Known Working at 30	At least 75% Known Job Tenure and Known Occupation at 30, no AHEAD
Ever Apply SSDI	0.14	0.13	0.15
Ever Receive SSDI	0.09	0.09	0.10
Health limits work at 62	0.28	0.23	0.24
Job Characteristics			
Total NR Cognitive Interpersonal	6.73	12.28	15.37
Total Routine Cognitive	2.43	3.88	5.24
Total Routine Manual	1.19	2.01	0.74
Missing Job Demands	0.49	0.44	0.50
Low NR Cognitive Interpersonal for 5 + years	0.57	0.79	0.78
Low Routine Cognitive for 5 + years	0.69	0.96	0.97
Low Routine Manual for 5 + years	0.63	0.88	0.88
High NR Cognitive Interpersonal for 5 + years	0.23	0.37	0.40
High Routine Cognitive for 5 + years	0.04	0.07	0.07
High Routine Manual for 5 + years	0.12	0.19	0.22
NR Cognitive Interpersonal (age 30)	0.27	0.26	0.26
Routine Cognitive (age 30)	0.14	0.14	0.15
Routine Manual (age 30)	0.02	0.03	0.02
NR Cognitive Interpersonal (age 55)	0.21	0.27	0.30
Routine Cognitive (age 55)	0.09	0.08	0.11
Routine Manual (age 55)	−0.08	0.09	0.04
Total years worked with job codes observed	20.36	31.23	36.16
Total years worked	28.72	39.26	37.51
Total number of jobs worked	1.98	2.54	2.25
Total number of jobs with occupation codes	1.61	2.30	2.20
Demographic characteristics			
Age last reported	68.80	64.59	63.41
Black	0.18	0.17	0.19
Missing race	0.05	0.04	0.04
Hispanic	0.11	0.08	0.08
Missing ethnicity	0.00	0.00	0.00
Lower than high school	0.27	0.17	0.16
High school	0.34	0.34	0.36
College and above	0.40	0.49	0.48
Female	0.56	0.44	0.41
Family SES poor	0.28	0.27	0.27
Family SES varied	0.01	0.01	0.01
Family SES average	0.54	0.59	0.59
Missing family SES	0.11	0.06	0.07
Health coverage/characteristics			
Ever had ESI coverage	0.48	0.67	0.71
Ever had pension plan from job	0.52	0.76	0.81
Ever received pension income	0.32	0.34	0.37
Very good health as a child	0.24	0.25	0.25
Good health as a child	0.15	0.13	0.13
Fair or poor health as child	0.06	0.05	0.05
Missing health as child	0.11	0.06	0.08
Whether Current Smoker	0.19	0.20	0.20
Vigorous Physical Exercise	0.16	0.19	0.20
Whether Overweight or Obese	0.67	0.72	0.73
Observations	36,983	17,056	9452

Notes: The “All Respondents” sample contains all individuals who responded to at least one HRS interview between 1992 and 2010. The other two samples are restricted to the respondents who linked jobs characteristics data for at least 75% of total years worked. The “Known Working at 30” sample is limited to those reporting working at age 30. The “Known Job at 30” sample is limited to those with a known occupation in the job held at age 30.

$124 billion in 2010. Applications for SSDI have increased steadily since the 1980s, when Congress expanded benefits access to those suffering from mental illness and reduced the burden of medical proof placed on applicants (Autor, 2011). The rise in applications has also been attributed to increased female labor force participation, which has increased the number of qualifying workers; growing wage replacement rates which make SSDI benefits attractive alternatives to unemployment benefits; and improved health among older Americans, more of whom now survive for longer with previously fatal health conditions (Autor, 2011; Duggan & Imberman, 2009).

Compared to non-recipients, SSDI recipients are older, less likely to be married or college-educated, and have lower incomes (Duggan and Imberman, 2009; Coe et al., 2011; Kreider, 1999; Benítez-Silva et al., 1999). They are more likely to be smokers and to have health conditions including diabetes, arthritis, and lung disease (Coe et al., 2011; Benítez-Silva et al., 1999), and more often work non-managerial, physically demanding jobs such as those in agriculture or construction (Bound et al., 1995; Coe et al., 2013; Turner et al., 2000).

Data and methods

Health and retirement study

We use survey data from the Health and Retirement Study (HRS), a nationally representative, longitudinal study of more than 30,000 older Americans age 51 and above and their spouses (Juster and Suzman, 1995; Sonnega et al., 2014). HRS respondents provide detailed information about current and previous occupations, health, and

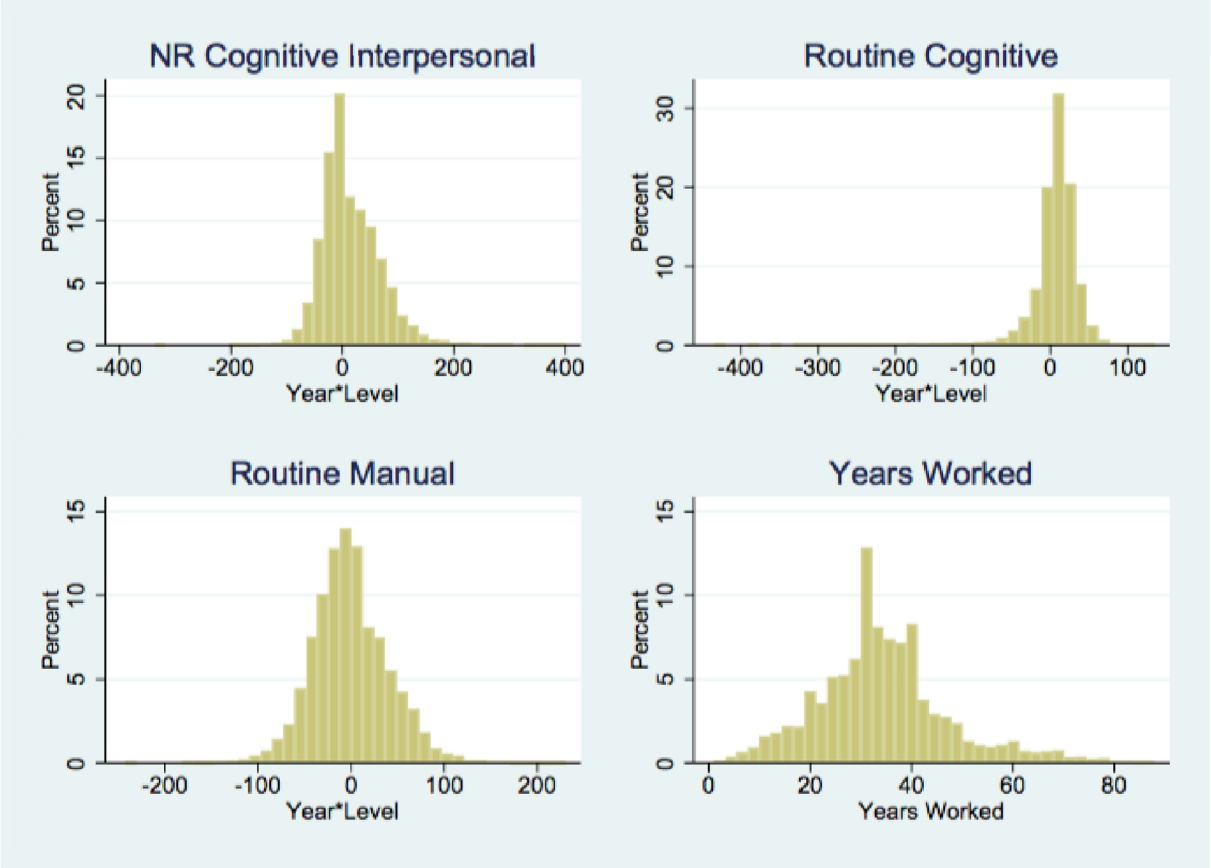

Fig. 1. Distribution of Exposure to Job Demands and Total Years Worked. *Notes:* Exposure refers to cumulative score of Acemoğlu and Autor (2011) exposure to job demands across all lifetime jobs. HRS Respondents with 75 + % of job tenure with a known occupation at age 30, excluding those in AHEAD sample, linked to O*Net job characteristics. Total exposure calculated as sum of exposures in each known occupation.

Table 2
Transitions across levels of job demands.

	Mean
Transitioned to Jobs of Much Lower Exposure	
Lower NR Cognitive Interpersonal	0.16
Lower NR Cognitive Interpersonal, Early	0.05
Lower NR Cognitive Interpersonal, Late	0.11
Lower Routine Cognitive	0.04
Lower Routine Cognitive, Early	0.02
Lower Routine Cognitive, Late	0.02
Lower Routine Manual	0.10
Lower Routine Manual, Early	0.05
Lower Routine Manual, Late	0.05
Transitioned to Jobs of Much Higher Exposure	
Higher NR Cognitive Interpersonal	0.14
Higher NR Cognitive Interpersonal, Early	0.07
Higher NR Cognitive Interpersonal, Late	0.07
Higher Routine Cognitive	0.03
Higher Routine Cognitive, Early	0.02
Higher Routine Cognitive, Late	0.02
Higher Routine Manual	0.07
Higher Routine Manual, Early	0.03
Higher Routine Manual, Late	0.04
Observations	9452

Notes: Proportion of workers who underwent a large transition (+ or − at least 0.5 standard deviations) in their level of exposure to job demands.
Exposure calculated as standardized score of Acemoğlu and Autor (2011) exposure to job demands in each occupation. Transitions were considered early if they occurred at age 45 or younger, and considered late if they occurred older than 45.

socioeconomic status, and childhood demographic, health, and family characteristics. The first cohort of HRS respondents consisted of individuals between the ages of 51 and 61 in the first baseline year of the study in 1992, and an older cohort aged 70 and above entered in 1993. Additional cohorts aged 51–61 and 68–74 entered in 1998. Since then, younger cohorts aged 51–56 have entered every six years, including 2004 and 2010. Spouses of sample members can enter the study at any age.

Some HRS respondents are observed during their working years and others enter after retirement. At the first interview, the HRS asks comprehensive questions about the respondents' current or most recent job and up to 3 previous positions held for five years or more. However, occupation and industry codes are collected only for the current or most recent job as well as the most recent of the 3 previous positions. Those who are working in subsequent interviews are asked about current jobs and any held since the previous interview, and occupation/industry information is collected for these jobs. We use these reports to compile job histories for the 92% of respondents interviewed between 1992 and 2010 who report at least one job during an HRS interview (see Data Appendix).

In addition to the job history data that are key to our study design, HRS respondents provide information about SSDI benefit application and receipt and work-limiting health problems later in life, our measures of later-life work capacity. Childhood health and socioeconomic status measures allow us to control for frequently unobserved factors that may influence both job choices and later life health. The earliest waves of the HRS were conducted as two separate studies, the Health and Retirement Study, including respondents age 51–61, and the Study of Aging and Health Dynamics, including those 70 and above. The AHEAD collected very little job history information until 1998, so we

Table 3
Cumulative job demand scores and later life disability and health.

VARIABLES	(1) Ever Applied for SSDI	(2) Ever applied for SSDI	(3) Ever received SSDI	(4) Ever received SSDI	(5) Health limiting work at 62	(6) Health limiting work at 62
Total Score						
NR Cognitive Interpersonal	−0.00040***	−0.00035***	−0.00027***	−0.00024***	−0.00037***	−0.00028***
	(0.000076)	(0.000075)	(0.000064)	(0.000065)	(0.000094)	(0.000092)
Routine Cognitive	−0.00038***	−0.00024**	−0.00028***	−0.00019**	−0.00028**	−0.00013
	(0.000095)	(0.000095)	(0.000078)	(0.000080)	(0.00012)	(0.00012)
Routine Manual	0.00036***	0.00035***	0.00026***	0.00026***	0.00049***	0.00045***
	(0.000098)	(0.000098)	(0.000082)	(0.000084)	(0.00013)	(0.00012)
Extended Controls	No	Yes	No	Yes	No	Yes
Observations	9452	9452	9452	9452	9307	9307

Notes: Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Coefficients are average marginal effects of variable on application for SSDI, receipt of SSDI, or reporting of health limitations at 62. HRS Respondents with 75+% of job tenure with a known occupation at age 30, excluding those in AHEAD sample, linked to O*Net job characteristics. "Total Score" refers to cumulative score of Acemoğlu and Autor (2011) exposure to job demands across all lifetime jobs. All regressions control for age, sex, race, ethnicity, educational attainment, and the number of job years with missing characteristics. Extended controls include health as a child, family socioeconomic status, ever having ESI coverage, pension status, and health characteristics (smoking, being overweight/obese, vigorously exercising). Standard errors are clustered by household. NR = non-routine, ESI = employer-sponsored health insurance. See Appendix Table 1 for full Table 3 with controls.

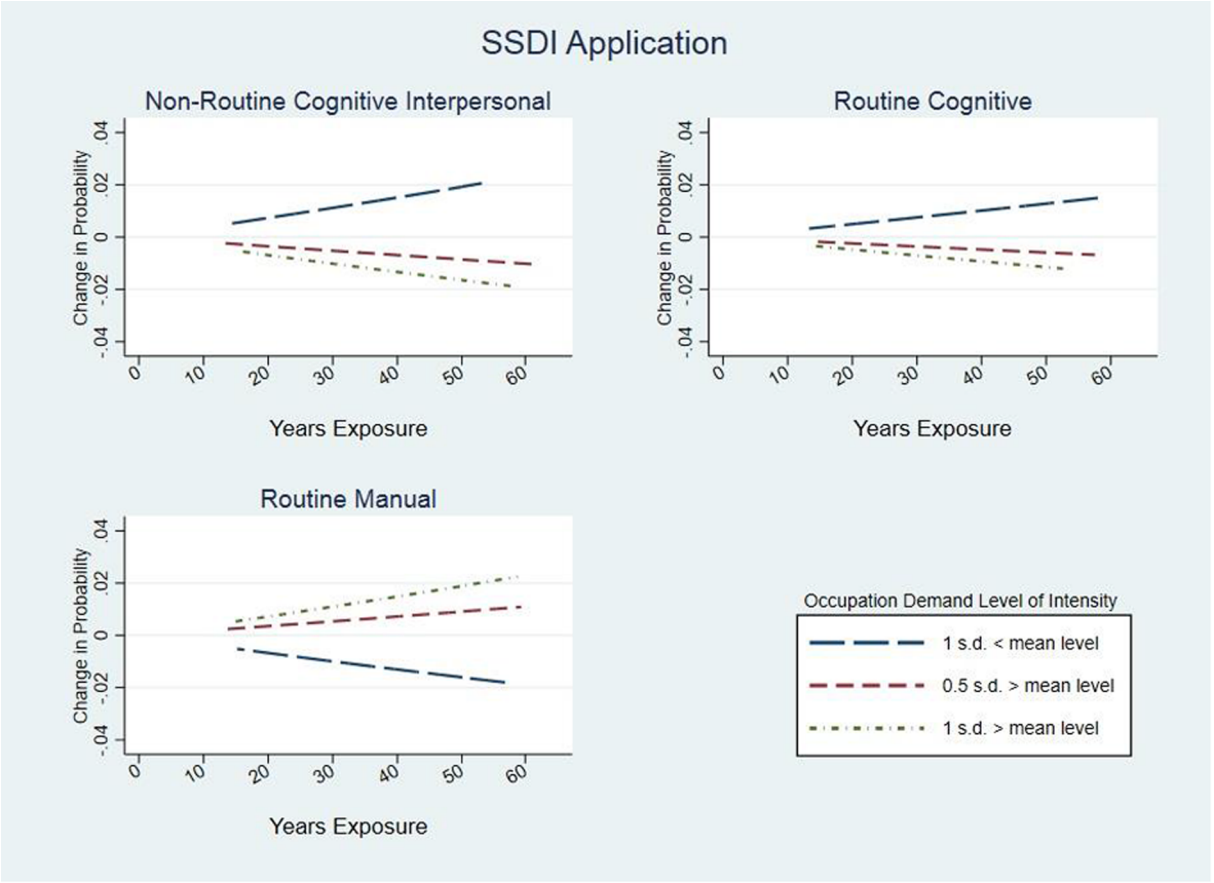

Fig. 2. Cumulative exposure to occupational demands and disability insurance applications. *Notes*: Change in probability of applying for SSDI for each year in a job with occupation demands 1 s.d. below, 0.5 s.d. above, and 1 s.d. above mean exposure, for workers within ± 1.5 s.d. of mean tenure among workers at specified exposure levels. HRS Respondents with 75+% of job tenure with a known occupation at age 30, excluding those in AHEAD sample, linked to O*Net job characteristics. Marginal effects calculated with probit regressions reported in Table.

exclude AHEAD respondents in our primary sample.

*Occupational information network (O*Net)*

Although HRS respondents provide some information about the physical and cognitive demands of current jobs held during the survey, no information is collected about demands in earlier jobs. By the time workers are age-eligible for the HRS, considerable selection out of health-influencing jobs may have already occurred. If workers move into jobs that have different demands later in life, studies using current job characteristics may attribute the benefits or harms of a previous job to the current position. We recover characteristics from previous jobs and standardize our reporting of current job demands using O*Net data.

O*Net was developed by the Department of Labor to replace the Dictionary of Occupational Titles as a primary source of job characteristics (Crouter et al., 2006). These data report standardized job

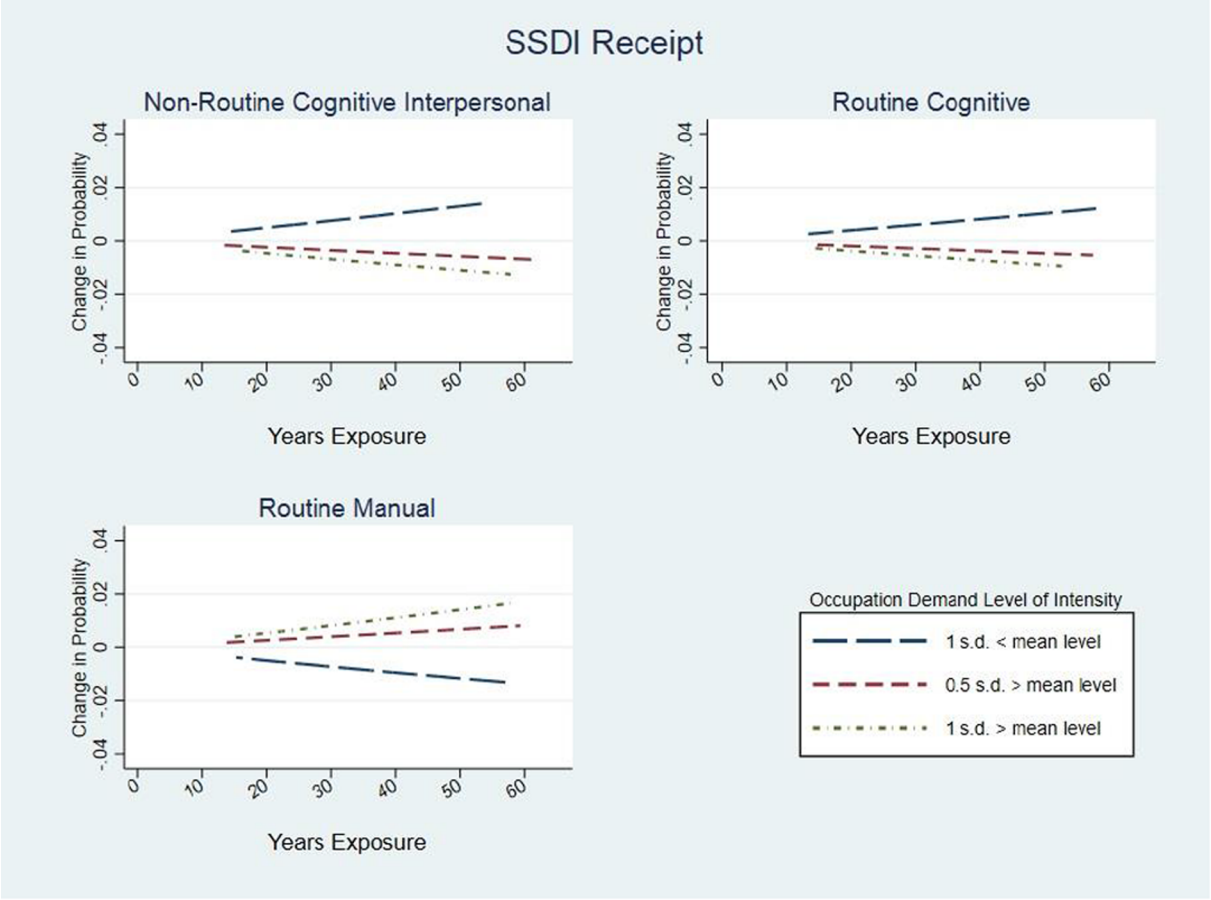

Fig. 3. Cumulative exposure to occupational demands and disability insurance receipt. *Notes*: Change in probability of receiving SSDI for each year in a job with occupation demands 1 s.d. below, 0.5 s.d. above, and 1 s.d. above mean exposure, for workers within +/- ± 1.5 s.d. of mean tenure among workers at specified exposure levels. HRS Respondents with 75+% of job tenure with a known occupation at age 30, excluding those in AHEAD sample, linked to O*Net job characteristics. Marginal effects calculated with probit regressions reported in Table.

characteristics for 974 different occupations covering the skills and abilities necessary to perform each job as well as characteristics of the occupational environment including generalized work activities, work context and tasks. Most of the economics studies discussed above used the DOT measures of occupation rather than the more comprehensive (and recent) O*Net. Though some critics charge that the O*Net data understate physical job demands and are more representative of modern desk jobs, a National Academies Panel found that DOT job characteristics were largely incomplete for positions other than manufacturing jobs, and would inaccurately classify more than 80% of jobs reported in the HRS (Tippins and Hilton, 2010).

Prior to linking the O*Net to HRS respondents' jobs, we use information about the importance and frequency of a variety of tasks and exposure to working conditions to construct three scales classifying job demands developed by Acemoğlu and Autor (2011):

- *Non-Routine Cognitive Interpersonal Tasks:* Develop relationships, guide and coach others, interact with others in multiple ways; examples include office supervisors, medical and health services managers, and clergy members.
- *Routine Cognitive Tasks:* Repetitive physical or mental activities, importance of accuracy, structured job; examples include accountants and auditors, bank tellers, and payroll clerks.
- *Routine Manual Tasks:* Job pace determined by machinery, includes operating machines other than vehicles or computers, frequent repetitive motions necessary; examples include sanitation workers, dishwashers, and factory machine operators.[1]

Following Acemoğlu and Autor (2011), we take the full set of O*Net jobs in the US economy and create standardized measures of intensity level for each of the three characteristics. Each of the standardized

[1] The original paper by Acemoglu and Autor developed 6 scales. In addition to the three we use in this paper, they classify jobs along the following measures: Non-Routine Cognitive Analytical, which characterizes demands such as analyzing data, creative thinking, and interpreting information; Non-Routine Manual, which refers to maneuvering/driving vehicles or equipment, using hands, manual dexterity, and spatial orientation; and Offshorability, which includes demands such as not working directly with the public, not caring for others, absence of face-to-face discussions, not inspecting, maintaining, or repairing equipment, structures, or material. However, these scores are highly correlated for a given job, suggesting that fewer measures are sufficient to describe the job demands. In particular, the two non-routine cognitive scores have a correlation of about 0.7, the two measures of manual work have a correlation of about 0.8, while Offshorability is highly inversely correlated with non-routine cognitive demands. Factor analysis also suggested that there are only three underlying job demand factors, which we can loosely define as: managerial (loading heavily on the Non-Routine Cognitive scores); administrative (loading partially on Non-Routine Analytical and Routine Cognitive scores); and physical (loading highly on the manual scores). We were unable to identify meaningful statistical differences between the multiple Non-Routine Cognitive demands or the two physical job demands when we included all scales in regression models, thus we selected these three to proxy for the larger set of correlated job demands.

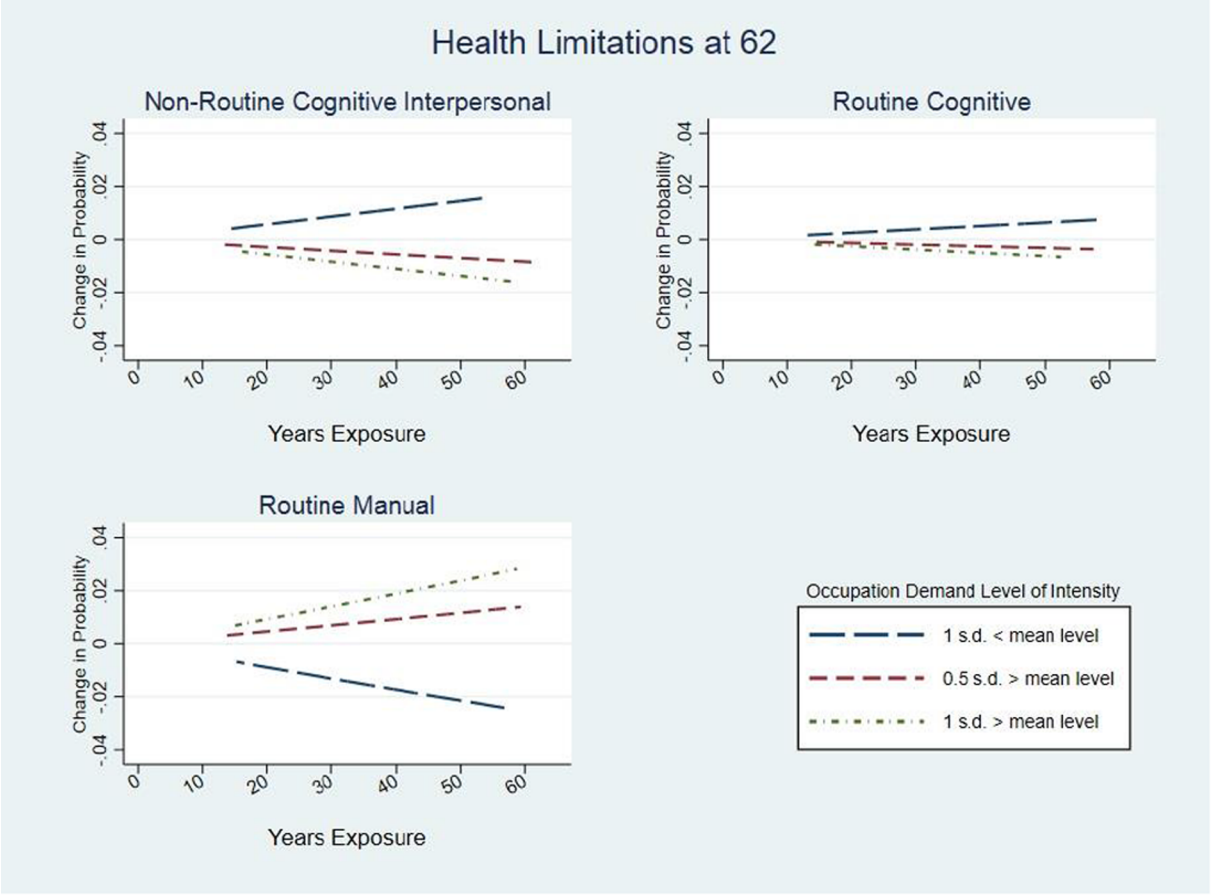

Fig. 4. Cumulative exposure to occupational demands and health limitations at age 62. *Notes*: Change in probability of reporting health limitations at age 62 for each year in a job with occupation demands 1 s.d. below, 0.5 s.d. above, and 1 s.d. above mean exposure, for workers within ± 1.5 s.d. of mean tenure among workers at specified exposure levels. HRS Respondents with 75 + % of job tenure with a known occupation at age 30, excluding those in AHEAD sample, linked to O*Net job characteristics. Marginal effects calculated with probit regressions reported in Table 3.

Table 4
Average exposure to job demands and later life disability and health.

VARIABLES	(1) Ever applied for SSDI	(2) Ever applied for SSDI	(3) Ever received SSDI	(4) Ever received SSDI	(5) Health limiting work at 62	(6) Health limiting work at 62
Average Score						
NR Cognitive Interpersonal	−0.0069**	−0.0067**	−0.0043*	−0.0041	−0.0057	−0.0046
	(0.0030)	(0.0029)	(0.0026)	(0.0025)	(0.0037)	(0.0036)
Routine Cognitive	−0.013***	−0.0098***	−0.0098***	−0.0080***	−0.0092**	−0.0057
	(0.0036)	(0.0035)	(0.0031)	(0.0031)	(0.0046)	(0.0045)
Routine Manual	0.022***	0.020***	0.016***	0.014***	0.028***	0.024***
	(0.0038)	(0.0037)	(0.0033)	(0.0033)	(0.0049)	(0.0048)
Total Years Worked	−0.0096***	−0.0074***	−0.0068***	−0.0054***	−0.012***	−0.0087***
	(0.00040)	(0.00040)	(0.00035)	(0.00035)	(0.00051)	(0.00052)
Extended Controls	No	Yes	No	Yes	No	Yes
Observations	9452	9452	9452	9452	9307	9307

Notes: Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Coefficients are average marginal effects of variable on application for SSDI, receipt of SSDI, or reporting of health limitations at 62. HRS Respondents with 75 + % of job tenure with a known occupation at age 30, excluding those in AHEAD sample, linked to O*Net job characteristics. "Average Score" refers to the Acemoğlu and Autor (2011) exposure to job demands, averaged across years worked. All regressions control for age, sex, race, ethnicity, educational attainment, and the number of job years with missing characteristics. Extended controls include health as a child, family socioeconomic status, ever having ESI coverage, pension status, and health characteristics (smoking, being overweight/obese, vigorously exercising). Standard errors are clustered by household. NR = non-routine. See Appendix Table 2 for full Table 4 with controls.

measures, *J,* by construction has a mean of 0 and standard deviation of 1 in the full distribution of O*Net jobs. We match these variables to each job reported by HRS respondents to construct cumulative exposure metrics to each job demand, *J*, multiplied by tenure at that particular job, *T*: $\sum J_{ij} * T_{ij}$ for individual *i* in job *j*. We also identify the level of exposure of jobs held at particular ages (i.e. J_i at age 30), and the average level of job exposures over the course of a career (cumulative exposure/total tenure).

Dependent variables: later-life work capacity

We focus on objective and subjective measures of work capacity

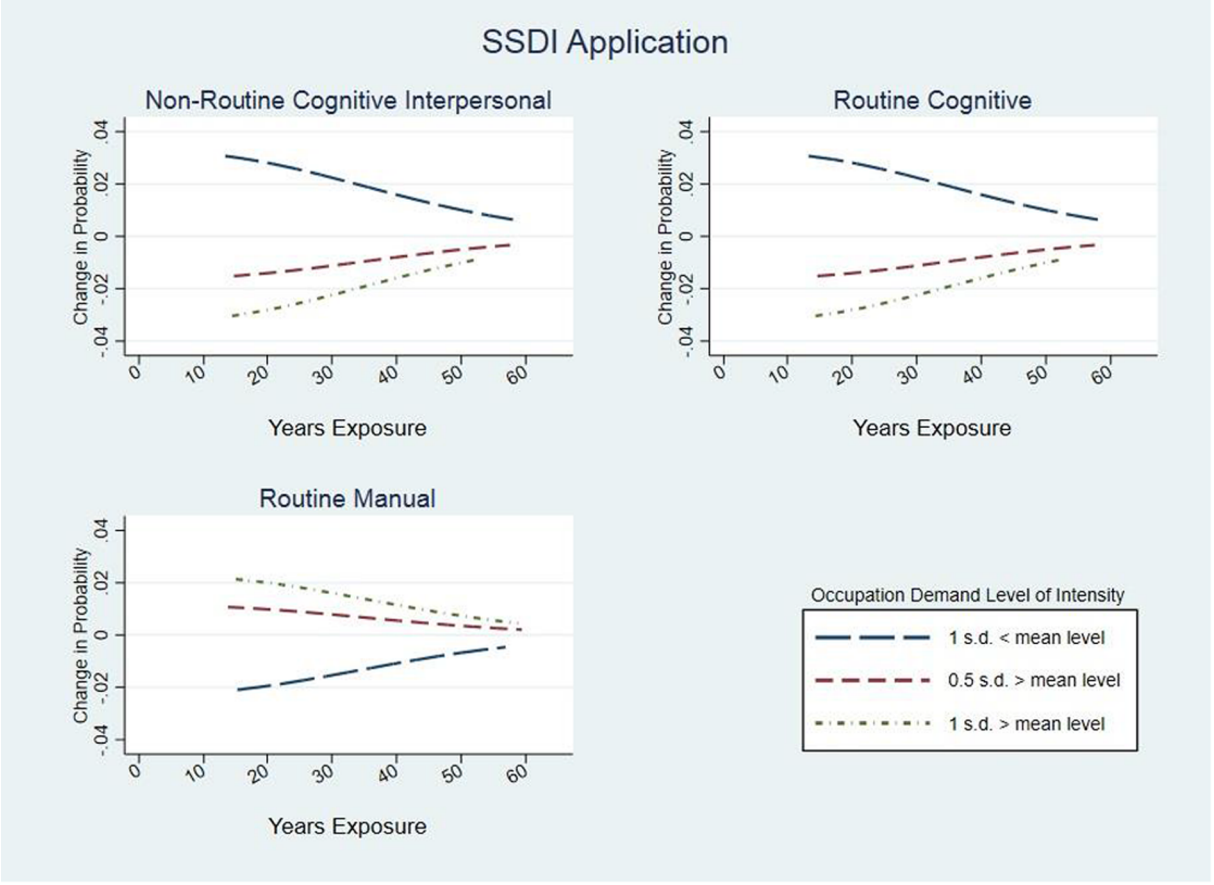

Fig. 5. Average exposure to job demands, tenure and disability insurance application. *Notes*: Change in probability of applying for SSDI given total years worked and average occupation demands 1 s.d. below, 0.5 s.d. above, and 1 s.d. above mean exposure across all years worked, for workers within ± 1.5 s.d. of mean tenure among workers at specified exposure levels. Marginal effects calculated with probit regressions reported in Table 4.

later in life in our dependent variables, including indicators of whether a respondent ever applied for or received SSDI (including through Supplemental Security Income) and their self-rated physical capacity for work at age 62, assessed by reports that they have a health condition that limits their ability to work. SSDI receipt provides a more objective measure of disability, since the medical limitation must be verified during the application process. However, obtaining accurate reports of disability status in survey data can be challenging and the self-reported measure is likely a noisy measure of SSDI status, biasing us towards the null (Burkhauser et al., 2012).

Whether health limits work is a subjective assessment that may be biased by a respondent's current employment situation. To test this, we followed Bound (1991) and constructed an objective measure of health limitations, which is the predicted probability that health limits work after regressing the self-reported measure on self-rated health, indicators of whether a respondent has ever been diagnosed with arthritis, cancer, diabetes, heart disease, lung disease, or stroke, and a count of fine motor limitations (difficulties picking up a dime, dressing, or eating). This measure was highly correlated with the self-reported measure ($\rho = 0.60$) and yielded similar regression results, so we focus on the self-rated measure in our analysis.

Analytical samples

36,983 respondents completed at least one HRS interview between 1992 and 2010. We are able to match at least one job to its O*Net characteristics for 26,048 respondents representing a total of 55,456 jobs. We exclude 2953 respondents who report job tenures that are longer than the oldest age that they are observed in the HRS minus six years plus years of education reported, and 87 respondents reporting jobs with negative tenure, resulting in a sample of 23,008 respondents with plausible occupational tenure. Although HRS does not collect detailed information about all jobs worked by respondents, total years worked and total number of jobs are available. On average, HRS respondents report 2.1 jobs during their lifetime, ranging from 0 to 11. We have occupational codes for 1.77 of these jobs. Total tenure averages 29.8 years, and we observe job characteristics for jobs worked in 22.1 of these years.

In order to increase our confidence that the job characteristics available are representative of the respondents' total job tenure, we conduct our main analyses in the subsample of 9452 respondents who have linked data for at least 75% of their total years worked and have a known occupation at age 30. Years worked in this analytical subsample averages 37.5 years, accumulated over the course of a mean 2.21 total jobs. We have occupational codes for more than 99 percent of these reported jobs. This sample allows us to track respondents in jobs started early in their careers; 60 percent are observed in jobs started before age 25 and 100 percent in jobs started by 30. In contrast, 24 percent of those in the full linked dataset are observed in a job started by age 25 and another 28 percent are observed working between age 25 and 35.

Table 1 describes the full HRS linkage, respondents known to be working at age 30 with matched job characteristics for 75 percent of their tenure, and our main analytical sample, for whom we know the characteristics at the age 30 job and observe jobs for at least 75 percent of total years worked. The three groups are similar in terms of rates of SSDI application and receipt (0.15 and 0.10 in the analytic sample and 0.14 and 0.09 in the full sample), while the full sample is slightly more likely to report that health limits work at age 62 (0.28 vs. 0.24). We

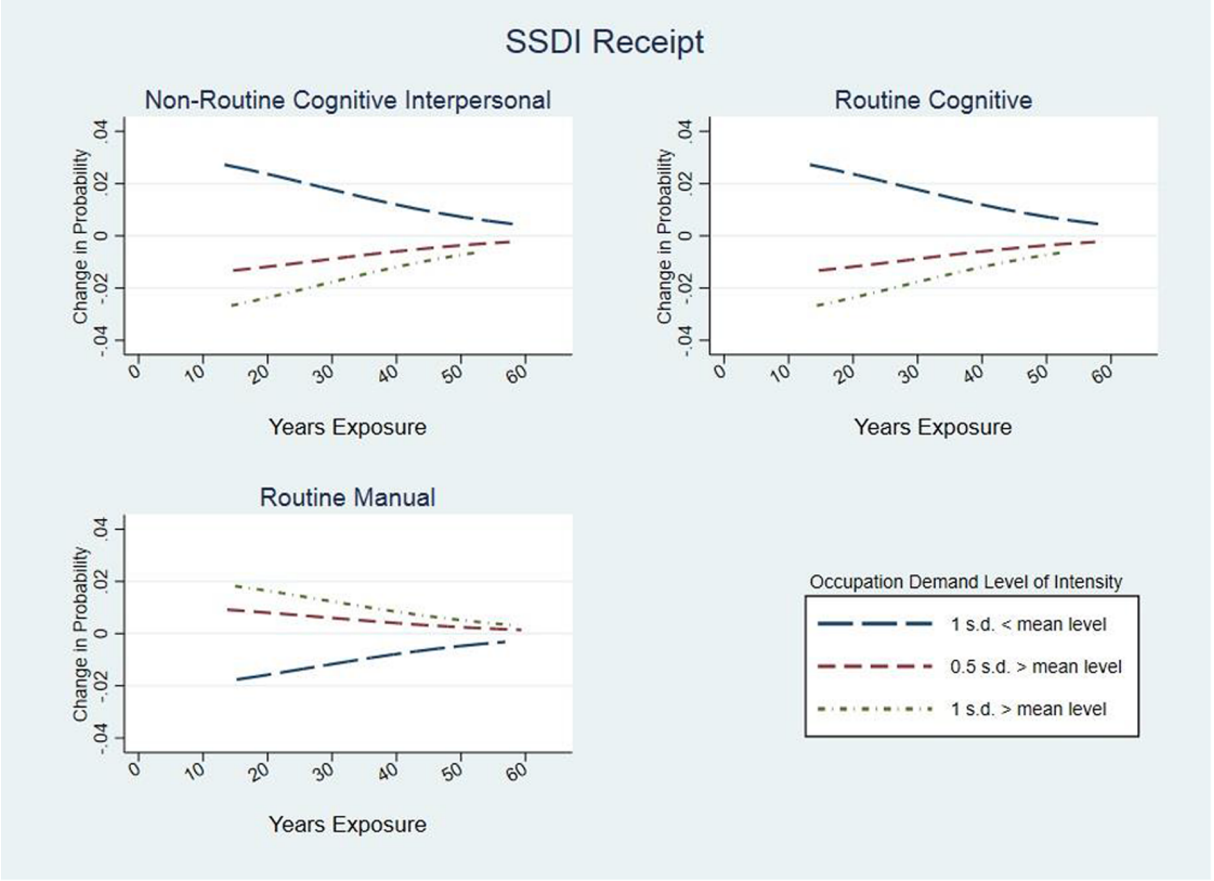

Fig. 6. Average exposure to job demands, tenure and disability insurance receipt. *Notes*: Change in probability of receiving SSDI given total years worked and average occupation demands 1 s.d. below, 0.5 s.d. above, and 1 s.d. above mean exposure across all years worked, for workers within ± 1.5 1.5 s.d. of mean tenure among workers at specified exposure levels. Marginal effects calculated with probit regressions reported in Table 4.

observe significantly more years of work and a larger number of jobs in the restricted samples, though these respondents are younger and more likely to be male than the full HRS population. Using HRS sample weights, we estimate that the analytic sample contains 31 percent of the total years worked by respondents in the 1992 HRS and 27 percent of the 2010 HRS.

The average worker in the analytic sample experienced occupational demand scores (intensity level*time) of 15.37 for non-routine cognitive interpersonal skills over their career, routine cognitive exposure score of 5.24, and a routine manual exposure score of 0.74. Population averages are close to zero because the Acemoglu and Autor intensity levels are normalized to a mean 0. There is significant heterogeneity in exposure to jobs with above versus below mean exposure (Fig. 1). While workers typically stay in jobs that are either consistently above or consistently below mean levels during their careers, there is non-trivial movement across jobs; 30 percent of workers change levels of non-routine cognitive interpersonal exposure, 7 percent of workers transition between jobs of different routine cognitive exposure levels, and 17 percent transition between jobs with high and low exposure to routine manual tasks (Table 2). Job changes with increases or decreases in exposure level of at least 0.5 standard deviations are equally likely to happen early or late in a respondent's career (before versus after age 45), with the exception of moves to lower non-routine cognitive demands, which typically happen later in life. Thus, analyses starting with later-life work histories miss a number of key changes in occupational demands.

Estimation strategy

Our empirical approach is similar to those of Filer and Petri (1988) and Fletcher et al. (2011), but applied to lifetime job exposure rather than the relatively brief periods of exposure captured in previous studies. We first consider the relationship between cumulative exposure to job characteristics and measures of health and disability later in life, Y_i. Because all of our outcomes are dichotomous and the relationships between variables may not be linear, especially at high levels of job tenure or occupational exposure, we use probit regression models to estimate the relationships between later-life disability and cumulative job exposure:

$$\text{Probit}(Y_i) = \alpha \left[\sum_{j=1}^{n_i} J_j * T_j \right]_i + \beta X_i + \epsilon_i \quad (1)$$

where J_j is a vector of job characteristics for each job j of n_i jobs reported by each respondent; T_j is a respondent's tenure at each reported job; X_i is a vector of respondent characteristics including sex, race, age last interviewed in the sample, and educational attainment; and ε_i is an idiosyncratic error term. We estimate of Eq. (1) with and without an expanded set of controls including childhood health and family socioeconomic status, since early life conditions may constrain educational or occupational choices and directly contribute to later life health outcomes and a vector of potentially endogenous characteristics that capture some of the pathways through which occupational characteristics can influence long-term health outcomes, including whether jobs worked provided benefits such as employer-sponsored health insurance and pensions and health behaviors including smoking, drinking, exercise, and obesity. Because we lack instruments to address the

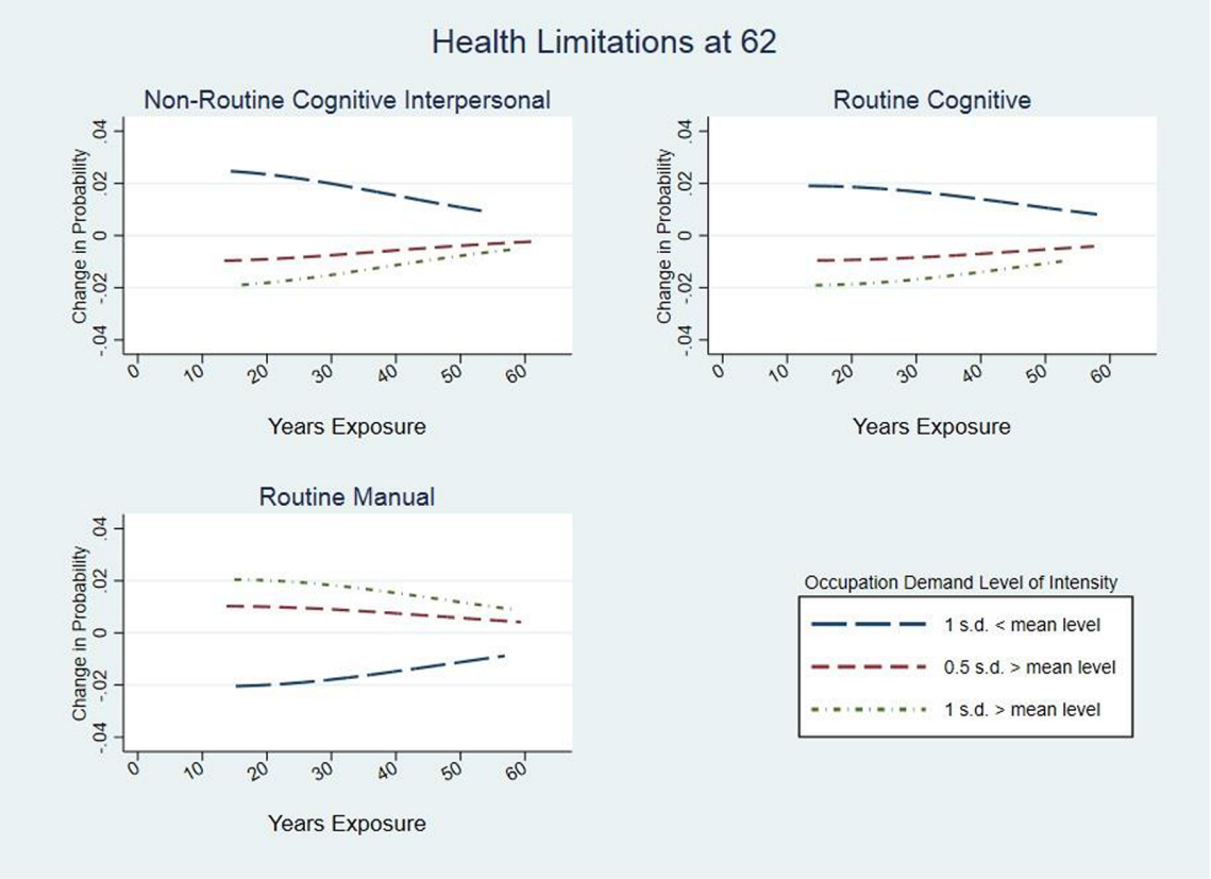

Fig. 7. Average exposure to job demands, tenure and health limitations at age 62. *Notes*: Change in probability of reporting health limitations at age 62 given total years worked and average occupation demands 1 s.d. below, 0.5 s.d. above, and 1 s.d. above mean exposure across all years worked, for workers within ± 1.5 s.d. of mean tenure among workers at specified exposure levels. Marginal effects calculated with probit regressions reported in Table 4.

potential endogeneity of the choice of job attributes, we prefer the second specification given its inclusion of a number of factors likely correlated with these choices. Standard errors for all regressions are clustered at the household level to account for correlations across spousal pairs.

Since workers can accumulate high levels of cumulative exposure to job demands through many years of exposure to weak demands or fewer years of exposure to high levels of demand, we consider a second set of models that replaces cumulative exposure with average lifetime exposure and total tenure:

$$\text{Probit}(Y_i) = \alpha\bar{J}_i + \gamma T_i + \beta X_i + \epsilon_i \quad (2)$$

Lifetime exposures versus later-life exposures

While age-30 and age-55 job demands are highly correlated, the correlation is far from perfect. 66.7 percent of workers with jobs 1 standard deviation above mean non-routine cognitive interpersonal demands at age 55 faced similar demands at age 30, along with 47.4 percent of those with high levels of routine cognitive demands and 71.3 percent with routine manual demands. In many settings, lifetime job characteristics are not available, and many studies have focused on the effect of exposure after age 50. However, there are a number of reasons why the relationship between the demands of jobs that a worker is still able to hold later in life and his later life health may understate the relationship between lifetime job demands and later life health. To understand the potential benefits of accounting for earlier life job exposures, we replace the cumulative exposure measures in Eq. (1) with the levels of exposure at respondent's job held at age 30 (J_{30}), the job held at age 55 (J_{55}), and both of these demands.[2]

Many studies of the relationship between job characteristics and later-life health outcomes estimate panel data models using data from older workers. We contrast the results of our probit models with fixed effect regressions, where changes in job exposure over time within individuals identify the relationships between job exposure and later-life disability. Fixed effect models allow us to control for time-invariant respondent characteristics that may be related to disability outcomes and job selection beyond the childhood and educational factors included in the probit models. We implement our models using all available observations from age 50 to 65 (regardless of whether we observe work at age 30 or the majority of total years worked) and use contemporaneous measures of dependent and independent variables assessed at each HRS wave instead of the cumulative measures. Thus, each wave's outcome is a measure of whether the respondent has applied for or received SSDI up to this point or currently has a health condition that impedes work. While the panel data models allow us to control for unobserved respondent factors, they exclude all changes in job demands experienced prior to HRS entry. Variation in the outcome variables comes from those with changes in status during their HRS participation up to age 65.

Robustness

Endogeneity in transitions across jobs over the life course are an important potential source of bias in this analysis. Although we are unable to instrument for each of the job tenures and exposure levels

[2] We thank an anonymous referee for this suggestion.

Table 5
Job demands at age 30 & 55 and later life disability and health.

VARIABLES	(1) Ever Applied for SSDI	(2) Ever applied for SSDI	(3) Ever received SSDI	(4) Ever received SSDI	(5) Health limiting work at 62	(6) Health limiting work at 62
Exposure in Job at Age 30						
NR Cognitive Interpersonal	−0.013***	−0.012***	−0.0083***	−0.0071**	−0.013***	−0.010**
	(0.0035)	(0.0034)	(0.0030)	(0.0030)	(0.0044)	(0.0042)
Routine Cognitive	−0.017***	−0.012***	−0.012***	−0.0089**	−0.0091*	−0.0043
	(0.0042)	(0.0041)	(0.0036)	(0.0035)	(0.0054)	(0.0052)
Routine Manual	0.029***	0.024***	0.019***	0.016***	0.030***	0.024***
	(0.0046)	(0.0044)	(0.0039)	(0.0038)	(0.0057)	(0.0056)
Endogenous Controls	No	Yes	No	Yes	No	Yes
Observations	9421	9421	9421	9421	9276	9276
Exposure in Job at Age 55						
NR Cognitive Interpersonal	−0.015***	−0.012***	−0.0080***	−0.0059**	−0.015***	−0.011**
	(0.0036)	(0.0034)	(0.0031)	(0.0030)	(0.0044)	(0.0042)
Routine Cognitive	−0.015***	−0.010**	−0.0076**	−0.0050	−0.0052	−0.00049
	(0.0042)	(0.0042)	(0.0036)	(0.0036)	(0.0054)	(0.0053)
Routine Manual	0.021***	0.018***	0.018***	0.016***	0.024***	0.021***
	(0.0048)	(0.0046)	(0.0040)	(0.0040)	(0.0060)	(0.0058)
Endogenous Controls	No	Yes	No	Yes	No	Yes
Observations	9160	9160	9160	9160	9022	9022
Exposure in Job at Age 30 & Age 55						
NR Cognitive Interpersonal (age 30)	−0.0063	−0.0071	−0.0050	−0.0055	−0.0035	−0.0042
	(0.0046)	(0.0045)	(0.0040)	(0.0040)	(0.0057)	(0.0055)
Routine Cognitive (age 30)	−0.012**	−0.0100*	−0.011**	−0.011**	−0.0097	−0.0081
	(0.0055)	(0.0052)	(0.0044)	(0.0044)	(0.0069)	(0.0067)
Routine Manual (age 30)	0.024***	0.020***	0.0092*	0.0063	0.022***	0.016**
	(0.0065)	(0.0061)	(0.0055)	(0.0053)	(0.0080)	(0.0076)
NR Cognitive Interpersonal (age 55)	−0.011**	−0.0072	−0.0048	−0.0023	−0.013**	−0.0080
	(0.0047)	(0.0045)	(0.0041)	(0.0040)	(0.0057)	(0.0054)
Routine Cognitive (age 55)	−0.0071	−0.0042	−0.00021	0.0018	0.0011	0.0048
	(0.0055)	(0.0054)	(0.0045)	(0.0045)	(0.0069)	(0.0068)
Routine Manual (age 55)	0.0040	0.0041	0.011**	0.012**	0.0081	0.0093
	(0.0068)	(0.0064)	(0.0057)	(0.0055)	(0.0082)	(0.0078)
Endogenous Controls	No	Yes	No	Yes	No	Yes
Observations	9135	9135	9135	9135	8997	8997

Notes: Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Coefficients are average marginal effects of variable on application for SSDI, receipt of SSDI, or reporting of health limitations at 62. HRS Respondents with 75+% of job tenure with a known occupation at age 30, excluding those in AHEAD sample, linked to O*Net job characteristics. "Job at 30/Job at 55" refers to the Acemoğlu and Autor (2011) exposure to job demands for the job held at age 30/55. All regressions control for age, sex, race, ethnicity, educational attainment, and the number of job years with missing characteristics. Extended controls include health as a child, family socioeconomic status, ever having ESI coverage, pension status, and health characteristics (smoking, being overweight/obese, vigorously exercising). Standard errors are clustered by household. NR = non-routine, ESI = employer-sponsored health insurance.

Table 6
Exposure to job characteristics and disability, age 50–65.

VARIABLES	(1) Ever applied for SSDI	(2) Ever applied for SSDI	(3) Ever received SSDI	(4) Ever received SSDI	(5) Health limits work	(6) Health limits work
Total Score						
NR Cognitive Interpersonal	0.00048	0.00089	0.00047	0.00048	−0.0035	−0.00078
	(0.0014)	(0.0014)	(0.0014)	(0.0014)	(0.0026)	(0.0026)
Routine Cognitive	0.00071	0.00024	0.00021	0.00022	−0.0021	0.0011
	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0029)	(0.0029)
Routine Manual	0.0016	0.0021	0.003	0.003	−0.0094***	0.0057
	(0.0020)	(0.0020)	(0.0020)	(0.0020)	(0.0036)	(0.0036)
Extended Controls	No	Yes	No	Yes	No	Yes
Respondents (N)	17,922	17,922	17,922	17,922	17,922	17,922
Observations (N * t)	69,512	69,512	69,512	69,512	69,512	69,512

Notes: Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. OLS regression models with respondent fixed effects. HRS respondents aged 50–65, where each observation represents the total exposure for a respondent in a given wave. Extended controls include ESI coverage, pension status, and health behaviors (smoking, being overweight/obese, vigorous exercising). Standard errors are clustered by household. NR = non-routine, ESI = employer-sponsored health insurance.

experienced over a career, we are able to identify potentially endogenous job switches. We report the results from a separate set of regression analyses in which we control for indicators of whether respondents had transitions from low- to high-intensity and high- to low-intensity job demands.

Results

Effects of cumulative exposure measures

For our regression results, we first consider the cumulative effect of exposure to physical and cognitive job demands. Table 3 reports probit average marginal effects from Eq. (1) with and without the expanded controls, which typically modestly attenuate the magnitudes of the job demand coefficients. In these specifications, the $\sum J * T$ exposure score can be large because of either a high level of job demand over a relatively short time or sustained exposure to a moderate demand. The probit average marginal effects present one-unit changes in exposure. It is instructive to think about these results at representative values. For example, results from the extended controls model imply that in comparison to workers exposed to mean levels of each of the 3 exposure variables over their careers, a worker with average tenure (37.5 years) at a job with a one standard deviation above the mean level of non-routine cognitive interpersonal demands would be 1.3 percentage points less likely to apply for and 0.9 percentage points less likely to receive SSDI and 1 percentage point less likely to report that health limits work.

Point estimates are slightly smaller for a 1 standard deviation above the mean level of routine cognitive demands (−0.9 pp SSDI application, −0.70 pp SSDI receipt, and −0.50 pp health limits work). A worker with a job one standard deviation above the mean level of routine manual demands faces increased probability of SSDI application (1.4 pp), receipt (1.0 pp), and health limiting work (1.1 pp). These relationships are statistically and substantively significant—the magnitudes discussed above are roughly one-third the size of the coefficient on high school education relative to college and correspond to between 4 percent (health limits work) and 10 percent (SSDI receipt) of dependent variable means.[3] Figs. 2–4 plot the marginal effects at various points in the cumulative exposure distribution from Eq. (1) assuming that various levels of exposure are constant in a career for illustrative purposes over a range of tenure times. These figures imply that the effects of exposure increases with greater time on the job.

Exposure intensity and duration

The results reported above give equal weight to exposure time and exposure intensity in constructing the cumulative measures and interpreting marginal effects. However, these two factors may be endogenous, as evidenced by the differing lengths of tenure across exposure levels. Thus, 20 years at 0.5 standard deviations above mean routine manual exposure may not have equivalent implications for later life disability as 10 years at 1 standard deviation above the mean, though each would generate cumulative exposures of 10. In Table 4 and Figs. 5–7, we consider average exposure and total tenure as separate terms.[4] The average marginal effects for the average level of exposure variables are generally similar in direction to the cumulative measures (the cognitive exposures are associated with lower rates of SSDI application and receipt and routine manual demands are positively related to both SSDI outcomes and health limiting work), but the total tenure term becomes negative, capturing the positive selection that occurs over time.

The joint effects of exposure intensity and tenure are shown in Figs. 5–7, which plot marginal effects at representative values of average exposure and tenure. In these figures, the lengths of the curves again vary to reflect the differences in total tenures worked by those at different levels of average tenure. In contrast to the increasing magnitudes associated with exposure over time from Figs. 2–4, we now see that the contributions of job characteristics are diminished at lengthy work tenures. For example, exposure to a one standard deviation above mean routine manual demand is more likely to be associated with health limiting work at age 62 for a worker who works 20 years in that job versus 30. While this process is somewhat mechanical, we cannot observe a worker in any job for 40 years if he was disabled by the job after 20 years. These figures highlight the challenges with studying the relationship between contemporaneous job characteristics and health and point to both the importance and the challenges of accounting for exposure intensity and duration.

Exposure to job demands over a career

To gain a better understanding of the contributions of early and later-life job exposure, we consider specifications including early exposure, proxied by the job worked at age 30; late exposure, proxied by the job worked at 55; and measures of both early and late exposure. Table 5 presents these results. Holding a job with an exposure level one standard deviation above the mean at age 30 generally has a similar effect on late life outcomes as the career measures described previously (i.e. a 1.0 pp decrease in health limits work for non-routine cognitive and a 2.4 pp increase for routine manual). Results are similar when we use exposure at age 55, though routine cognitive demands are no longer related to health limits work in either specification. When both early and late exposures are added simultaneously, early-career routine cognitive and manual demands appear to drive the observed relationships, while later-career non-routine cognitive interpersonal demands are significantly related to SSDI application and health limitations at 62 in the parsimonious controls models only.

When earlier life job histories are not observed, the missing exposures can be controlled for in fixed effect regressions which essentially difference out these earlier exposures along with other time-invariant characteristics among older workers. We estimate fixed effect regressions among workers 50–65 to contrast with our cumulative exposure models. These models indicate no contemporaneous relationships between any of our job characteristics and SSDI application and receipt (Table 6). We find a significant negative relationship between routine manual exposure and health limits work in the parsimonious specification, this becomes insignificant with additional control variables.

A key limitation of the fixed effect models are that they are identified only by the changes in job demands and disability outcomes occurring during the study period. As noted previously, many of these transitions happen before age 50. There is little variation in key dependent and independent variables for the panel data sample (only 10% of workers experience a job transition with a large (1 standard deviation or greater) change in their level of non-routine cognitive demands, 3% routine cognitive, and 6% routine manual demands between ages 50 and 65). Only 10% of workers in our sample change their SSDI application and receipt status and 23% change health limits work during this time. It is likely that this lack of variation late in life explains why studies that only observe job demands later in life often do not find relationships between job characteristics and health.

Robustness

We examined the sensitivity of our findings to a variety of sample compositions and to alternative measures of job demands previously used in the occupational health literature. We re-estimated Eq. (1)

[3] The full set of coefficients for this specification is reported in Appendix Table 1.

[4] The full set of coefficients for this specification is reported in Appendix Table 2.

separately for men and women, as the men in our sample worked longer (average tenure 39.9 versus 34.0 years) and typically worked in jobs with comparatively higher non-routine cognitive and routine manual demands and lower routine cognitive demands. Coefficients follow similar patterns for both genders; higher non-routine and routine cognitive demands are both associated with lower SSDI application and receipt rates and lower probability of health limiting work (Appendix Table 3). Coefficients were frequently larger in magnitude for women, though these would translate to similar effect sizes after adjusting for women's shorter tenures and lower exposures.

Our sample inclusion criteria trades off a larger and potentially more representative sample to ensure that we capture the majority of job demands encountered across a career, i.e. those with 3 or fewer job changes prior to HRS entry. Estimates were similar in significance and direction when we estimated Eq. (1) using the full sample of respondents known to be working at age 30 regardless of observed tenure (Appendix Table 4).

A limitation of our research design is that we cannot correct for endogenous job selection or transitions. However, we can examine the sensitivity of our results to additional controls for movement in and out of job demands. When we add transition indicators indicating early career (before the age of 45) or late career (after the age of 45) changes in job demands, the estimated effects of job demands are similar to results without these controls (Appendix Table 5).

Since patterns of occupational exposure and SSDI claiming have both changed over time, we re-estimated Eq. (1) separately for each birth cohort of HRS respondents (Appendix Table 6). Results are generally consistent across cohorts, though not always statistically significant, possibly because of the small sample sizes at the cohort level.

Discussion

In this paper we assessed the effect of job demands on health and retirement outcomes later in life. Using comprehensive data form the Health and Retirement Study and O*Net, we consistently found that more intense lifetime exposure to routine manual job demands was associated with a higher likelihood of applying for and receiving Social Security Disability Insurance and reporting a health condition that limited work at age 62. In contrast, SSDI application and receipt was lower among those with greater exposure to non-routine cognitive interpersonal demands.

Methodologically, this paper highlights the importance of having ways of measuring lifetime exposures as well as exposures at a particular point in life. Our results contrast those of Schmitz (2016), for example, who found no relationship between contemporaneous health and physical job demands experienced late in life. This difference likely reflects the increasing level of selection into job characteristics over time given that those who are still working in physically demanding jobs after multiple years of exposure are likely healthiest, and able to retire at later ages, while those who are quickly harmed by physical or cognitive demands early on leave the work force after high average exposure to a given characteristic. Similarly, Carr et al. (2016) found no effects of physical demands on the probability of retirement, but their exposure measures were derived from the current job only. Fletcher et al. (2011) found non-trivial effects of cumulative measures of physically demanding work on self-rated health in a younger cohort, also highlighting the importance of accounting for early-life exposure and transitions.

We focused on three distinct job demands; non-routine cognitive interpersonal, routine cognitive, and routine manual. Although we interpret coefficients in relation to average exposure to the other job characteristics, it is important to note that most workers jobs are a combination of characteristics that are associated with better versus worse later life health. This view of job demands can be useful not only for forecasting future population-level disability given the strong predictive power of characteristics of the age 30 job, but for informing human resources strategies to modify job demands in response to early signs of worker disability.

Declaration of interest

The authors have no conflicts of interest.

Acknowledgements

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Appendix

Data appendix

Occupations are collected using different coding systems across the different HRS waves. Interviews from 1992 to 2004 used the 1980 Census Occupational Classification codes; interviews in 2006 and 2008 used the 2000 US Census codes; and the interview in 2010 used the 4-digit 2010 US Census codes. We converted all of these codes to 2010 Standard Occupational Classification (SOC) codes using appropriate crosswalks from the US Census Bureau, the Bureau of Labor Statistics, and the National Crosswalk Service Center.

Each O*Net occupational code is composed of a six-digit Standard Occupation Codes (SOC) code followed by a two-digit component taking values from 00 to 12. Thus, each O*Net code consists of eight digits. However, only the six-digit SOC component is linkable to the HRS sample. We therefore aggregated O*Net code characteristics within SOC codes by averaging characteristics across multiple O*Net codes, where available. This way we were able to assign characteristics to all SOC codes except for 22 codes. For 20 of these 22 codes, we used similar O*Net codes (judged by their description) to impute values of the missing characteristics with average values across these O*Net codes. For the remaining 2 codes (11–1031, Legislators and 55–1010, an unspecified military occupation) we were unable to find similar codes with non-missing characteristics so we dropped them from the dataset. These occupations accounted for a negligible proportion of the total number of jobs in our sample. After generating the composite job demand scales, we conducted another imputation procedure, which replaced characteristics of 77 of 121 codes that did not exist in the version of the O*Net dataset that was available (v.19.2), but are present in the HRS dataset. Where possible, we relied on the O*Net website (www.onetonline.org) for suggestions of the top ten similar O*Net codes and used the average of their characteristics to impute the values for the missing codes. Where these were not available, we used between one and seven codes judged to be similar by the occupation title and imputed the missing values with their average. At the end of this stage, the final dataset contained information for 892 jobs identified by their SOC code. The final sample contains 729 respondents with job characteristics imputed via this procedure. The job demand measures were then standardized with a mean of zero and standard deviation of one. Since the distribution of workers into job characteristics varies over time and we focus on a sample whose careers

span several decades, we do not attempt to weight occupations by worker distribution at a given point in time. Generally, a higher, positive score indicates a higher level of the characteristic in an occupation, while negative scores indicate levels lower than the average across the full set of occupations.

We then linked O*Net descriptors to each job held by HRS respondents by the SOC component, which were obtained as described above by using crosswalks to various versions of the Census Occupational Classification codes. Assigning each job a demand score then allowed us to derive respondent-level measures of exposure to each demand depending on the job duration and intensity of exposure for each job held, as described in Section "Robustness". Since job duration is a necessary component of these exposure measures, we also performed several imputation procedures for respondents that had missing data on job start or job end date as follows. First, for 204 respondents who have job start years after job end years, we substituted the two years under the assumption that they were introduced incorrectly. For 76 respondents with missing years for start date of their oldest job, we imputed these values with the midpoint between the year of their eighteenth birthday and the end year of that job. For 511 respondents with one reported job but missing start or end years, we replaced the missing values accordingly to match the total tenure they report in other questions in their first available HRS interview. For another 4625 jobs we imputed missing values of job years with information provided in other questions of the HRS, such as the using the start year of a respondent's third job as the missing end year of his second job.

Table A1
Exposure to cumulative job demand scores and later life disability and health.

VARIABLES	(1) Ever applied for SSDI	(2) Ever applied for SSDI	(3) Ever received SSDI	(4) Ever received SSDI	(5) Health limiting work at 62	(6) Health limiting work at 62
Total Score						
NR Cognitive Interpersonal	−0.00040***	−0.00035***	−0.00027***	−0.00024***	−0.00037***	−0.00028***
	(0.000076)	(0.000075)	(0.000064)	(0.000065)	(0.000094)	(0.000092)
Routine Cognitive	−0.00038***	−0.00024**	−0.00028***	−0.00019**	−0.00028**	−0.00013
	(0.000095)	(0.000095)	(0.000078)	(0.000080)	(0.00012)	(0.00012)
Routine Manual	0.00036***	0.00035***	0.00026***	0.00026***	0.00049***	0.00045***
	(0.000098)	(0.000098)	(0.000082)	(0.000084)	(0.00013)	(0.00012)
Years Missing Job Demands	−0.0055**	0.0074***	−0.0039**	0.0051***	−0.00070	−0.0019
	(0.0023)	(0.0022)	(0.0019)	(0.0019)	(0.0027)	(0.0026)
Demographic Characteristics						
Age last reported	0.0012***	−0.00036	−0.00044	−0.000035	−0.000084	0.00073
	(0.00036)	(0.00043)	(0.00030)	(0.00036)	(0.00047)	(0.00055)
Black	0.073***	0.057***	0.048***	0.037***	0.046***	0.023**
	(0.0088)	(0.0084)	(0.0074)	(0.0072)	(0.011)	(0.011)
Missing race	0.020	0.00075	0.017	0.0028	−0.013	−0.040*
	(0.019)	(0.018)	(0.016)	(0.016)	(0.024)	(0.023)
Hispanic	0.0035	−0.0091	−0.011	−0.020	−0.034*	−0.049***
	(0.015)	(0.014)	(0.013)	(0.013)	(0.019)	(0.018)
Missing ethnicity	−0.059	−0.061	0.0030	−0.0058	0.0045	−0.028
	(0.13)	(0.11)	(0.097)	(0.089)	(0.16)	(0.14)
Lower than high school	0.12***	0.066***	0.081***	0.045***	0.13***	0.052***
	(0.011)	(0.011)	(0.0094)	(0.0095)	(0.014)	(0.014)
High school	0.048***	0.030***	0.037***	0.025***	0.050***	0.026**
	(0.0086)	(0.0083)	(0.0075)	(0.0073)	(0.010)	(0.010)
Female	−0.0037	−0.011	−0.0043	−0.0096	−0.0068	−0.014
	(0.0077)	(0.0075)	(0.0066)	(0.0065)	(0.0094)	(0.0092)
Health as a child						
Very good health		0.019**		0.016**		0.045***
		(0.0086)		(0.0075)		(0.010)
Good health		0.048***		0.037***		0.079***
		(0.010)		(0.0088)		(0.013)
Fair or poor		0.11***		0.070***		0.15***
		(0.014)		(0.012)		(0.018)
Missing health		0.023		0.024		0.067
		(0.033)		(0.027)		(0.046)
Family socioeconomic status						
Average		−0.000058		−0.0076		−0.0098
		(0.015)		(0.013)		(0.018)
Poor		0.016		0.0099		0.029
		(0.016)		(0.013)		(0.019)
Varied		0.026		0.016		0.034
		(0.044)		(0.037)		(0.053)
Missing		0.020		0.0071		0.043
		(0.036)		(0.029)		(0.050)
Ever had job benefits						
ESI coverage		−0.14***		−0.096***		−0.17***
		(0.0079)		(0.0069)		(0.0098)
Pension plan from job		−0.023**		−0.011		−0.041***
		(0.0096)		(0.0082)		(0.012)
Pension income		0.051***		0.038***		0.084***
		(0.0094)		(0.0082)		(0.011)
Health behaviors						
Current Smoker		0.040***		0.015**		0.048***
		(0.0083)		(0.0073)		(0.010)

(*continued on next page*)

Table A1 (*continued*)

VARIABLES	(1) Ever applied for SSDI	(2) Ever applied for SSDI	(3) Ever received SSDI	(4) Ever received SSDI	(5) Health limiting work at 62	(6) Health limiting work at 62
Vigorous Physical Exercise		−0.079***		−0.055***		−0.13***
		(0.010)		(0.0087)		(0.012)
Overweight or Obese		0.032***		0.012*		0.026***
		(0.0081)		(0.0069)		(0.0098)
Observations	9452	9452	9452	9452	9307	9307

Notes: Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Coefficients are average marginal effects of variable on application for SSDI, receipt of SSDI, or reporting of health limitations at 62. HRS Respondents with 75+% of job tenure with a known occupation at age 30, excluding those in AHEAD sample, linked to O*net job characteristics. "Total Score" refers to cumulative score of Acemoğlu and Autor (2011) exposure to job demands across all lifetime jobs. Standard errors are clustered by household. NR = non-routine, ESI = employer-sponsored health insurance.

Table A2
Average exposure to job demands and later life disability and health.

VARIABLES	(1) Ever applied for SSDI	(2) Ever applied for SSDI	(3) Ever received SSDI	(4) Ever received SSDI	(5) Health limiting work at 62	(6) Health limiting work at 62
Average Score						
NR Cognitive Interpersonal	−0.0069**	−0.0067**	−0.0043*	−0.0041	−0.0057	−0.0046
	(0.0030)	(0.0029)	(0.0026)	(0.0025)	(0.0037)	(0.0036)
Routine Cognitive	−0.013***	−0.0098***	−0.0098***	−0.0080***	−0.0092**	−0.0057
	(0.0036)	(0.0035)	(0.0031)	(0.0031)	(0.0046)	(0.0045)
Routine Manual	0.022***	0.020***	0.016***	0.014***	0.028***	0.024***
	(0.0038)	(0.0037)	(0.0033)	(0.0033)	(0.0049)	(0.0048)
Years Missing Job Demands	−0.0096***	−0.0100***	−0.0067***	−0.0069***	−0.0056**	−0.0051**
	(0.0022)	(0.0021)	(0.0019)	(0.0019)	(0.0026)	(0.0025)
Total Years Worked	−0.0096***	−0.0074***	−0.0068***	−0.0054***	−0.012***	−0.0087***
	(0.00040)	(0.00040)	(0.00035)	(0.00035)	(0.00051)	(0.00052)
Demographic Characteristics						
Age last reported	0.0048***	0.0041***	0.0038***	0.0031***	0.0072***	0.0060***
	(0.00040)	(0.00048)	(0.00034)	(0.00040)	(0.00054)	(0.00062)
Black	0.055***	0.044***	0.035***	0.027***	0.025**	0.0089
	(0.0084)	(0.0081)	(0.0071)	(0.0070)	(0.011)	(0.011)
Missing race	0.0027	−0.0065	0.0064	−0.0016	−0.037	−0.051**
	(0.018)	(0.018)	(0.016)	(0.016)	(0.023)	(0.022)
Hispanic	−0.0098	−0.018	−0.021*	−0.026**	−0.050***	−0.059***
	(0.014)	(0.014)	(0.013)	(0.013)	(0.018)	(0.018)
Missing ethnicity	−0.10	−0.088	−0.027	−0.025	−0.0073	−0.035
	(0.094)	(0.094)	(0.075)	(0.075)	(0.16)	(0.14)
Lower than high school	0.091***	0.054***	0.060***	0.037***	0.095***	0.039***
	(0.011)	(0.011)	(0.0093)	(0.0094)	(0.014)	(0.014)
High school	0.040***	0.026***	0.031***	0.023***	0.044***	0.023**
	(0.0084)	(0.0082)	(0.0073)	(0.0072)	(0.010)	(0.010)
Female	−0.031***	−0.030***	−0.023***	−0.023***	−0.038***	−0.034***
	(0.0076)	(0.0075)	(0.0066)	(0.0065)	(0.0093)	(0.0092)
Health as a child						
Very good health		0.018**		0.015**		0.043***
		(0.0084)		(0.0074)		(0.010)
Good health		0.044***		0.034***		0.075***
		(0.0100)		(0.0086)		(0.013)
Fair or poor		0.099***		0.059***		0.14***
		(0.014)		(0.012)		(0.018)
Missing health		0.0013		0.0088		0.044
		(0.031)		(0.027)		(0.046)
Family socioeconomic status						
Average		0.015		0.0034		0.0046
		(0.014)		(0.013)		(0.017)
Poor		0.034**		0.023*		0.045**
		(0.015)		(0.013)		(0.019)
Varied		0.030		0.017		0.038
		(0.045)		(0.037)		(0.054)
Missing		0.049		0.027		0.070
		(0.034)		(0.029)		(0.049)
Ever had job benefits						
ESI coverage		−0.095***		−0.065***		−0.12***
		(0.0079)		(0.0069)		(0.010)
Pension plan from job		−0.016*		−0.0065		−0.035***
		(0.0093)		(0.0081)		(0.012)

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Table A2 (*continued*)

VARIABLES	(1) Ever applied for SSDI	(2) Ever applied for SSDI	(3) Ever received SSDI	(4) Ever received SSDI	(5) Health limiting work at 62	(6) Health limiting work at 62
Pension income		0.041***		0.030***		0.072***
		(0.0093)		(0.0081)		(0.011)
Health behaviors						
Current Smoker		0.034***		0.012		0.043***
		(0.0081)		(0.0072)		(0.010)
Vigorous Physical Exercise		−0.071***		−0.049***		−0.12***
		(0.0097)		(0.0084)		(0.012)
Overweight or Obese		0.034***		0.014**		0.032***
		(0.0079)		(0.0068)		(0.0096)
Observations	9452	9452	9452	9452	9307	9307

Notes: Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Coefficients are average marginal effects of variable on application for SSDI, receipt of SSDI, or reporting of health limitations at 62. HRS Respondents with 75+% of job tenure with a known occupation at age 30, excluding those in AHEAD sample, linked to O*net job characteristics. "Average Score" refers to the Acemoğlu and Autor (2011) exposure to job demands, averaged across years worked. Standard errors are clustered by household. NR = non-routine, ESI = employer-sponsored health insurance.

Table A3
Exposure to cumulative job demand scores and later life disability and health by gender.

VARIABLES	(1) Ever applied for SSDI	(2) Ever applied for SSDI	(3) Ever received SSDI	(4) Ever received SSDI	(5) Health limiting work at 62	(6) Health limiting work at 62
Men						
NR Cognitive Interpersonal	−0.00045***	−0.00041***	−0.00035***	−0.00032***	−0.00031***	−0.00024**
	(0.000089)	(0.000087)	(0.000076)	(0.000076)	(0.00011)	(0.00011)
Routine Cognitive	−0.00035***	−0.00023**	−0.00028***	−0.00020**	−0.00013	0.0000005
	(0.00011)	(0.00011)	(0.000093)	(0.000093)	(0.00015)	(0.00015)
Routine Manual	0.00018	0.00021*	0.00015	0.00018*	0.00038**	0.00041***
	(0.00012)	(0.00012)	(0.000098)	(0.000099)	(0.00015)	(0.00015)
Extended Controls	No	Yes	No	Yes	No	Yes
Observations	5602	5602	5602	5602	5522	5522
Women						
NR Cognitive Interpersonal	−0.00033**	−0.00022	−0.00011	−0.000044	−0.00060***	−0.00043**
	(0.00015)	(0.00015)	(0.00012)	(0.00013)	(0.00018)	(0.00018)
Routine Cognitive	−0.00046**	−0.00028	−0.00028*	−0.00018	−0.00068***	−0.00047*
	(0.00018)	(0.00019)	(0.00015)	(0.00016)	(0.00024)	(0.00024)
Routine Manual	0.00079***	0.00062***	0.00053***	0.00044***	0.00081***	0.00055**
	(0.00019)	(0.00019)	(0.00015)	(0.00016)	(0.00025)	(0.00024)
Extended Controls	No	Yes	No	Yes	No	Yes
Observations	3850	3850	3850	3850	3785	3785

Notes: Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Coefficients are average marginal effects of variable on application for SSDI, receipt of SSDI, or reporting of health limitations at 62. HRS Respondents with 75+% of job tenure with a known occupation at age 30, excluding those in AHEAD sample, linked to O*net job characteristics. "Total Score" refers to cumulative score of Acemoğlu and Autor (2011) exposure to job demands across all lifetime jobs. All regressions control for age, sex, race, ethnicity, educational attainment, and the number of job years with missing characteristics. Extended controls include health as a child, family socioeconomic status, ever having ESI coverage, pension status, and health characteristics (smoking, being overweight/obese, vigorously exercising). Standard errors are clustered by household. NR = non-routine, ESI = employer-sponsored health insurance.

Table A4
Exposure to cumulative job demand scores and later life disability and health (known working at age 30).

VARIABLES	(1) Ever applied for SSDI	(2) Ever applied for SSDI	(3) Ever received SSDI	(4) Ever received SSDI	(5) Health limiting work at 62	(6) Health limiting work at 62
Total Score						
NR Cognitive Interpersonal	−0.00033***	−0.00027***	−0.00022***	−0.00018***	−0.00035***	−0.00026***
	(0.000065)	(0.000065)	(0.000055)	(0.000056)	(0.000082)	(0.000080)
Routine Cognitive	−0.00032***	−0.00018**	−0.00022***	−0.00014**	−0.00024**	−0.000065
	(0.000079)	(0.000079)	(0.000064)	(0.000066)	(0.00010)	(0.00010)
Routine Manual	0.00047***	0.00046***	0.00035***	0.00035***	0.00062***	0.00057***
	(0.000083)	(0.000084)	(0.000068)	(0.000070)	(0.00011)	(0.00011)
Years Missing Job Demands	−0.0063***	−0.0075***	−0.0049***	−0.0056***	−0.0016	−0.0025
	(0.0018)	(0.0017)	(0.0015)	(0.0015)	(0.0021)	(0.0020)
Demographic Characteristics						
Age last reported	−0.0019***	−0.0010***	−0.00096***	−0.00049*	−0.00097***	−0.00027
	(0.00028)	(0.00032)	(0.00022)	(0.00026)	(0.00036)	(0.00041)
Black	0.061***	0.049***	0.038***	0.030***	0.042***	0.023***
	(0.0067)	(0.0065)	(0.0056)	(0.0054)	(0.0088)	(0.0084)
Missing race	0.015	0.0011	0.020*	0.0093	0.0094	−0.010
	(0.014)	(0.013)	(0.011)	(0.011)	(0.017)	(0.016)
Hispanic	−0.0069	−0.018*	−0.012	−0.018**	−0.039***	−0.054***
	(0.010)	(0.010)	(0.0088)	(0.0088)	(0.013)	(0.013)
Missing ethnicity	−0.069	−0.072	−0.0050	−0.011	−0.038	−0.061
	(0.11)	(0.10)	(0.084)	(0.078)	(0.14)	(0.13)
Lower than high school	0.11***	0.064***	0.068***	0.041***	0.11***	0.047***
	(0.0081)	(0.0082)	(0.0068)	(0.0070)	(0.010)	(0.010)
High school	0.046***	0.032***	0.033***	0.026***	0.048***	0.028***
	(0.0064)	(0.0062)	(0.0054)	(0.0053)	(0.0078)	(0.0077)
Female	−0.011*	−0.017***	−0.011**	−0.015***	−0.015**	−0.022***
	(0.0055)	(0.0054)	(0.0046)	(0.0046)	(0.0068)	(0.0067)
Health as a child						
Very good		0.0090		0.0062		0.032***
		(0.0065)		(0.0055)		(0.0078)
Good		0.045***		0.027***		0.063***
		(0.0077)		(0.0064)		(0.0096)
Fair or poor		0.10***		0.066***		0.15***
		(0.010)		(0.0085)		(0.013)
Missing health		−0.020		0.0046		−0.0033
		(0.027)		(0.021)		(0.037)
Family socioeconomic status						
Average		−0.0011		−0.0049		0.00027
		(0.011)		(0.0090)		(0.013)
Poor		0.014		0.0079		0.044***
		(0.011)		(0.0096)		(0.014)
Varied		0.0086		0.0016		0.038
		(0.031)		(0.026)		(0.037)
Missing		0.055*		0.019		0.10***
		(0.029)		(0.022)		(0.040)
Ever had job benefits						
ESI coverage		−0.11***		−0.077***		−0.15***
		(0.0058)		(0.0049)		(0.0072)
Pension plan from job		−0.020***		−0.0058		−0.040***
		(0.0067)		(0.0056)		(0.0085)
Pension income		0.040***		0.029***		0.075***
		(0.0069)		(0.0058)		(0.0082)
Health behaviors						
Current Smoker		0.040***		0.016***		0.047***
		(0.0061)		(0.0051)		(0.0077)
Vigorous Physical Exercise		−0.074***		−0.050***		−0.12***
		(0.0076)		(0.0064)		(0.0089)
Overweight or Obese		0.022***		0.0043		0.022***
		(0.0060)		(0.0049)		(0.0072)
Observations	16,158	16,158	16,158	16,158	15,933	15,933

Notes: Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Coefficients are average marginal effects of variable on application for SSDI, receipt of SSDI, or reporting of health limitations at 62. HRS respondents known to be working at 30, excluding those in AHEAD sample, linked to O*net job characteristics. "Total Score" refers to cumulative score of Acemoğlu and Autor (2011) exposure to job demands across all lifetime jobs. All regressions control for age, sex, race, ethnicity, educational attainment, and the number of job years with missing characteristics. Extended controls include health as a child, family socioeconomic status, ever having ESI coverage, pension status, and health characteristics (smoking, being overweight/obese, vigorously exercising). Standard errors are clustered by household. NR = non-routine, ESI = employer-sponsored health insurance.

Table A5
Exposure to cumulative job demand scores and later life disability and health, controlling for job changes.

VARIABLES	(1) Ever applied for SSDI	(2) Ever applied for SSDI	(3) Ever received SSDI	(4) Ever received SSDI	(5) Health limiting work at 62	(6) Health limiting work at 62
Total Score						
Total NR Cognitive Interpersonal	−0.00035***	−0.00032***	−0.00024***	−0.00021***	−0.00028***	−0.00020**
	(0.000078)	(0.000077)	(0.000066)	(0.000067)	(0.000097)	(0.000095)
Total Routine Cognitive	−0.00035***	−0.00022**	−0.00025***	−0.00017**	−0.00028**	−0.00014
	(0.000097)	(0.000096)	(0.000080)	(0.000081)	(0.00012)	(0.00012)
Total Routine Manual	0.00036***	0.00033***	0.00027***	0.00026***	0.00057***	0.00050***
	(0.00010)	(0.00010)	(0.000085)	(0.000086)	(0.00013)	(0.00013)
Transitions						
Early to Lower NR Cognitive Interpersonal	−0.0044	−0.011	0.0059	0.0012	0.016	0.012
	(0.016)	(0.016)	(0.014)	(0.014)	(0.020)	(0.019)
Early to Lower Routine Cognitive	−0.037	−0.042	−0.033	−0.033	−0.015	−0.014
	(0.030)	(0.027)	(0.026)	(0.026)	(0.034)	(0.033)
Early to Lower Routine Manual	0.041***	0.035**	0.0061	0.0020	0.0087	0.00052
	(0.015)	(0.014)	(0.013)	(0.013)	(0.020)	(0.019)
Early to Higher NR Cognitive Interpersonal	−0.022	−0.012	−0.0087	−0.0017	−0.040**	−0.026
	(0.015)	(0.015)	(0.013)	(0.013)	(0.018)	(0.017)
Early to Higher Routine Cognitive	0.020	0.025	0.027	0.031	0.098***	0.10***
	(0.029)	(0.028)	(0.025)	(0.024)	(0.034)	(0.032)
Early to Higher Routine Manual	0.032	0.027	0.022	0.020	−0.0087	−0.013
	(0.020)	(0.019)	(0.017)	(0.016)	(0.026)	(0.025)
Late to Lower NR Cognitive Interpersonal	−0.027**	−0.020	−0.027**	−0.022*	−0.039**	−0.032**
	(0.014)	(0.013)	(0.012)	(0.012)	(0.016)	(0.016)
Late to Lower Routine Cognitive	−0.086***	−0.069**	−0.11***	−0.093***	−0.076**	−0.055*
	(0.031)	(0.030)	(0.034)	(0.033)	(0.035)	(0.034)
Late to Lower Routine Manual	−0.046**	−0.025	−0.038**	−0.025	−0.064***	−0.037*
	(0.018)	(0.017)	(0.016)	(0.015)	(0.022)	(0.021)
Late to Higher NR Cognitive Interpersonal	−0.018	0.00048	−0.023	−0.0078	−0.077***	−0.054***
	(0.016)	(0.016)	(0.015)	(0.014)	(0.020)	(0.019)
Late to Higher Routine Cognitive	−0.018	−0.0024	−0.025	−0.014	−0.012	−0.0032
	(0.031)	(0.029)	(0.030)	(0.029)	(0.036)	(0.034)
Late to Higher Routine Manual	−0.018	−0.0045	0.00020	0.011	−0.035	−0.017
	(0.019)	(0.018)	(0.016)	(0.016)	(0.024)	(0.023)
Extended Controls	No	Yes	No	Yes	No	Yes
Observations	9452	9452	9452	9452	9307	9307

Notes: Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Coefficients are average marginal effects of variable on application for SSDI, receipt of SSDI, or reporting of health limitations at 62. HRS Respondents with 75+% of job tenure with a known occupation at age 30, excluding those in AHEAD sample, linked to O*net job characteristics. "Total Score" refers to cumulative score of Acemoğlu and Autor (2011) exposure to job demands across all lifetime jobs. A transition to high exposure was defined as a worker starting a new job with an Autor/Acemoglu score greater than 1, if their previous job had an Autor/Acemoglu score of 1 or less than 1. A transition to low exposure was defined as the reverse transition. Transitions were considered early if they occurred at age 45 or younger, and considered late if they occurred older than 45. All regressions control for age, sex, race, ethnicity, educational attainment, and the number of job years with missing characteristics. Extended controls include health as a child, family socioeconomic status, ever having ESI coverage, pension status, and health characteristics (smoking, being overweight/obese, vigorously exercising). Standard errors are clustered by household. NR = non-routine, ESI = employer-sponsored health insurance.

Table A6
Exposure to cumulative job demand scores and later life disability and health, by HRS cohort.

VARIABLES	(1) Ever applied for SSDI	(2) Ever applied for SSDI	(3) Ever received SSDI	(4) Ever received SSDI	(5) Health limiting work at 62	(6) Health limiting work at 62
Children of the Depression (b. 1924–30)						
Total NR Cognitive Interpersonal	−0.00013	−0.00015	−0.00021*	−0.00023**	0.000012	−0.0000095
	(0.00013)	(0.00013)	(0.00011)	(0.00012)	(0.00030)	(0.00029)
Total Routine Cognitive	−0.00022	−0.00012	−0.00027*	−0.00022	−0.00083*	−0.00088**
	(0.00020)	(0.00021)	(0.00016)	(0.00017)	(0.00046)	(0.00039)
Total Routine Manual	0.00034*	0.00025	0.00041**	0.00036**	0.00081	0.00088*
	(0.00021)	(0.00021)	(0.00019)	(0.00018)	(0.00049)	(0.00047)
Extended Controls	No	Yes	No	Yes	No	Yes
Observations	449	443	442	436	449	447
Initial HRS Cohort (b. 1931–41)						
Total NR Cognitive Interpersonal	−0.00045***	−0.00044***	−0.00035***	−0.00033***	−0.00034***	−0.00029**
	(−0.00011)	(−0.00011)	(−0.0001)	(−0.000099)	(−0.00013)	(−0.00013)
Total Routine Cognitive	−0.00041***	−0.00031**	−0.00035***	−0.00028**	−0.00018	−0.000068
	(−0.00013)	(−0.00013)	(−0.00011)	(−0.00011)	(−0.00017)	(−0.00017)
Total Routine Manual	0.00027*	0.00031**	0.00021*	0.00026**	0.00042**	0.00050***
	(0.00025)	(0.00024)	(0.00022)	(0.00022)	(0.00030)	(0.00029)

(*continued on next page*)

Table A6 (*continued*)

VARIABLES	(1) Ever applied for SSDI	(2) Ever applied for SSDI	(3) Ever received SSDI	(4) Ever received SSDI	(5) Health limiting work at 62	(6) Health limiting work at 62
Extended Controls	No	Yes	No	Yes	No	Yes
Observations	4656	4656	4656	4656	4571	4571
War Baby (b. 1942–47)						
Total NR Cognitive	−0.00057***	−0.00049**	−0.00041**	−0.00034*	−0.00075***	−0.00068***
Interpersonal	(0.00020)	(0.00021)	(0.00018)	(0.00019)	(0.00024)	(0.00024)
Total Routine Cognitive	−0.00012	0.000097	−0.000070	0.000080	−0.000054	0.00011
	(0.00027)	(0.00027)	(0.00022)	(0.00022)	(0.00031)	(0.00030)
Total Routine Manual	0.00035	0.00027	0.00024	0.00021	0.00026	0.000053
	(0.00025)	(0.00024)	(0.00022)	(0.00022)	(0.00030)	(0.00029)
Extended Controls	No	Yes	No	Yes	No	Yes
Observations	1134	1131	1134	1131	1087	1084
Early Baby Boomer (b. 1948–53)						
Total NR Cognitive	−0.00017	−0.000042	−0.000067	−2.0e−07	−0.00023	−0.000082
Interpersonal	(0.00018)	(0.00018)	(0.00015)	(0.00016)	(0.00024)	(0.00024)
Total Routine Cognitive	−0.00073***	−0.00028	−0.00044**	−0.00017	−0.00071**	−0.000072
	(0.00026)	(0.00027)	(0.00022)	(0.00022)	(0.00032)	(0.00032)
Total Routine Manual	0.00068***	0.00055**	0.00031	0.00022	0.0011***	0.00078**
	(0.00024)	(0.00023)	(0.00019)	(0.00019)	(0.00032)	(0.00031)
Extended Controls	No	Yes	No	Yes	No	Yes
Observations	1602	1598	1602	1598	1596	1592
Mid Baby Boomer (b. 1954–59)						
Total NR Cognitive	−0.00051**	−0.00022	−0.000091	0.00013	−0.00046	−0.00019
Interpersonal	(0.00022)	(0.00023)	(0.00016)	(0.00018)	(0.00028)	(0.00028)
Total Routine Cognitive	−0.00062**	−0.00018	−0.00015	0.00030	−0.00089**	−0.00031
	(0.00028)	(0.00034)	(0.00018)	(0.00024)	(0.00041)	(0.00043)
Total Routine Manual	0.00062**	0.00026	0.00050**	0.00038	0.00036	−0.00013
	(0.00029)	(0.00029)	(0.00023)	(0.00023)	(0.00041)	(0.00040)
Extended Controls	No	Yes	No	Yes	No	Yes
Observations	1609	1608	1609	1602	1602	1601

Notes: Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Coefficients are average marginal effects of variable on application for SSDI, receipt of SSDI, or reporting of health limitations at 62. HRS Respondents with 75+% of job tenure with a known occupation at age 30, excluding those in AHEAD sample, linked to O*net job characteristics. "Total Score" refers to cumulative score of Acemoğlu and Autor (2011) exposure to job demands across all lifetime jobs. HRS cohort (b. 1931–1941) was first interviewed in 1992; CODA cohort (b. 1924–1930) and WB cohort (b. 1942–1947) were first interviewed in 1998; EBB cohort (b. 1948–1953) was first interviewed in 2004; MBB cohort (1954–1959) was first interviewed in 2010. All regressions control for age, sex, race, ethnicity, educational attainment, and the number of job years with missing characteristics. Extended controls include health as a child, family socioeconomic status, ever having ESI coverage, pension status, and health characteristics (smoking, being overweight/obese, vigorously exercising). Standard errors are clustered by household. NR = non-routine, ESI = employer-sponsored health insurance.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jeoa.2018.12.003.

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