Job Conditions and Cognitive Health

Alzheimer's Disease and related dementias (ADRDs) impact more than 6 million adults in the United States (U.S.), with an estimated lifetime risk of 42% [1,2,3]. Paid work is a central activity that takes up a large share of adults' waking hours across the life course [4], and growing evidence indicates that it is closely tied to cognitive health [5,6]. Protective job conditions such as mental enrichment and job autonomy, along with risky factors like elevated operational demands and occupational hazards, have been shown to influence later-life cognitive health [7,8,9]. Specifically, consistent with cognitive reserve theory [10], recent studies show people who have higher levels of cognitively challenging, socially enriching (e.g., working with people, training/learning opportunities at work), and autonomous jobs have *lower* risks of cognitive decline in later life [9,11]. In contrast, people who have jobs involving hazardous exposures (e.g., loud noise, prolonged exposure to toxic solvents) or repetitive tasks (e.g., controlling machines & processes) have been shown to have *increased* cognitive risks [7,8,9]. Furthermore, chronic exposures to physical stress (i.e., through physically demanding occupations), interpersonal conflicts, irregular work schedules, and extreme environmental conditions (e.g., extreme heat) have also been shown to be associated with chronic cardiovascular strain, diminished physical capacity, and neuroinflammation that escalate risks of cognitive decline and ADRDs later in life [7,8,9,13,15].

Research Questions

Although occupational exposures have been linked to cognitive health, these associations have not been comprehensively evaluated using population-level longitudinal data. First, few longitudinal studies have examined multiple aspects (e.g., mental, social, physical) of both cognitively protective and risky job conditions [12,13,14,15,16]. Further, most existing studies in

this area have primarily examined occupational exposures job at a single point in time (e.g., before retirement) [e.g., 7,11]. Consequently, it is unclear how *lifetime average* exposures to cognitively protective and risky job conditions associate with cognitive function in midlife (i.e., age 55), changes in cognitive functioning after midlife when early dementia-related cognitive decline and impairment are often observed, and the risk of becoming cognitively impaired in the early stages of later life (i.e., around age 70) [1, 18].

Our study addresses these gaps using longitudinal data drawn from the Health and Retirement Study (HRS), leveraging a newly developed linkage to Occupational Information Network (O*NET) data that makes it possible to comprehensively evaluate how average lifetime occupational exposures influence mid-life cognitive function, changes in cognitive function, and risks of cognitive impairment later in life [17]. We address the following three research questions: (RQ1) How is the life-time average exposure to cognitively enriching and risky job conditions associated with overall cognitive function in midlife? (RQ2) How are these exposures associated with cognitive changes after midlife and into early stages of later life (i.e., age 70 or 71)? (RQ3) How are these exposures associated with the probability of experiencing cognitive impairment (indicative of dementia risks) by the early stages of later life?

Data and Methods

Data

This study leverages a novel dataset we developed and tested that includes lifetime work conditions/exposures through mid-life derived from O*NET and HRS respondent data [17]. We incorporate cognitive function data from all available HRS study waves and a recently released user-developed probability-based dementia risk measures for adults 65+ [18]. To account for early-life factors that may shape later-life cognitive function, we leverage the early-life

experiences data drawn from the HRS Cross-Wave Childhood Health and Family Aggregated file.

Study Samples

We draw our sample for RQ1 from all HRS waves for people with (a) valid data on cognitive functioning in midlife (age 55 or 56) and (b) valid O*NET-linked work history data upon entry, and (c) full data on all control measures (see below) (*n*=7,504). Occupational exposures are weighted based on total job tenure for each reported job, accounting for about 78% of respondents' total work histories [17, 19], and merged with O*NET data at the detailed occupation level (1980 or 2000 Census codes, as relevant). The samples for RQ2 include only those who also have data on cognitive function at age 70 or 71, when cognitive impairment associated with dementia etiology is commonly observed [1] (*n*=1,744). For RQ3, we evaluate a sub-sample who has data on Cognitive Impairment Not Dementia (CIND) probability (*n*=1,271).

Measures

Cognitive Function and ADRD Risks

We use two types of cognitive function measures: (1) a standard count measure available in the core HRS data and (2) a standardized probability-based measure of CIND, available to HRS participants 65 years and older until 2016, before HRS transitioned to online cognitive assessment [18]. The count measure is collected at baseline/midlife (at age 55 or 56) and Time 2 (at age 70 or 71) using a well-established 27-point cognition measure of memory, working memory, and mental processing. The 27-point cognitive score is imputed for missing and available for all non-proxy respondents in HRS [20].

CIND is significantly associated with future dementia risks [21]. The potential for reversibility of cognitive losses consistent with CIND also offers a critical opportunity for

interventions [21]. Thus, this study evaluates the probability of CIND based on a continuous estimate of cognitive abilities that has been calibrated for socio-economic differences (e.g., sex, race, education) to more accurately estimate risks of dementia and cognitive impairment at the population level (values range from 0 to1) [18].

Job Conditions

Job condition indicators are drawn from the O*NET database. For each measure detailed in ***Table 1*** below, using respondents' self-reported work histories, we created average lifetime exposure scores weighted according to each respondent's job tenure, reported when they entered the HRS study (i.e., at age 51-56). Using individual job condition indicators, we subsequently created nine indices (social enrichment, mental enrichment, autonomy, operational tasks, work schedules, hazard, interpersonal conflict, physical demand, temperature of work environment) hypothesized to be related to cognitive function. To account for population-level variation in job conditions and exposures, all items were first standardized using z-scores based on the full O*NET occupational distribution in the U.S. population in each associated year of exposure [17].

Table 1. *Measures of Job Conditions*

O*NET Measure	Questionnaire
Social	
Contact with others	How much contact with others (by telephone, face-to-face, or otherwise) is needed to perform your current job?
Training and coaching others	What level of complexity of training and teaching others is needed to perform your current job?
Resolving conflicts & negotiating with others	What level of complexity of resolving conflicts and negotiating with others is needed to perform your current job?
Making decisions & solving problems	What level of complexity of making decisions and solving problems is needed to perform your current job?
Mental	
Making decisions & solving problems	What level of complexity of making decisions and solving problems is needed to perform your current job?
Processing Information	What level of complexity of processing information is needed to perform your current job?
Interpreting the meaning of information for others	What level of complexity of interpreting the meaning of information for others is needed to perform your current job?
Autonomy	

Independence	To what extent do occupations satisfy the work value of independence, i.e., allowing "employees to work on their own and make decisions"?
Freedom to make decisions	How much freedom do you have to make decisions without supervision?
Unstructured work	How much freedom do you have to determine the tasks, priorities, or goals of your current job?
Operational	
Controlling machines & processes	What level of complexity of controlling machines and processes is needed to perform your current job?
Handling and moving objects	What level of complexity of handling and moving objects is needed to perform your current job?
Inspecting equipment, structures, & materials	What level of complexity of inspecting equipment, structures, or materials is needed to perform your current job?
Hazard	
Exposed to high places	How often does your current job require that you be exposed to high places?
Exposed to hazardous equipment	How often does your current job require that you be exposed to hazardous equipment?
Exposed to minor burns, cuts, bites, or stings	How often does your current job require that you be exposed to minor burns, cuts, bites, or stings?
Exposed to contaminants	How often does your current job require that you be exposed to contaminants (such as pollutants, gases, dust, or odors)?
Exposed to bright or inadequate lighting	How often does your current job require that you be exposed to bright or inadequate lighting conditions?
Spend Time Climbing Ladders, Scaffolds, or Poles	How much time in your current job do you spend climbing ladders, scaffolds, poles, etc.?
Sounds or noise levels are distracting or uncomfortable	How often does your current job require that you be exposed to sounds or noise levels that are distracting or uncomfortable?
Work Schedule	
Schedule regularity	How regular are the work schedules for this job?
Physical Demand of Work	
Frequency of kneeling, crouching, stooping, or crawling	How much time in your current job do you spend kneeling, crouching, stooping, or crawling
Frequency of bending, twisting the body	How much time in your current job do you spend bending and twisting your body?
Frequency of exposure to working in cramped spaces and awkward positions	In your current job, how often are you exposed to working in cramped spaces and awkward positions?
Frequency of exposure to whole body vibration	In your current job, how often are you exposed to whole-body vibration?
Static Strength	The ability to exert maximum muscle force to lift, push, pull, or carry objects.
Interpersonal Conflict	

Frequency of conflict situations	How often do you deal with conflict situations?
Frequency of dealing with unpleasant or angry people	How often do you deal with unpleasant, angry, or discourteous people?
Frequency of dealing with physically aggressive people	How often do you deal with violent or physically violent people?
Temperature of Work Environment	
Very hot (above 90° F) or very cold (under 32° F) temperatures	In your current job, how often are you exposed to very hot (above 90° F) or very cold (under 32°F) temperatures?

Statistical Controls

Regardless of the age at which individuals entered the HRS, we measure our baseline variables during the wave in which individuals were either 55 or 56 years old. We control for baseline/midlife cognitive function when applicable and factors that may impact cognitive health: sex, race, years of education, poverty ratio, working status, urbanicity, depressive symptoms, self-rated health, birth cohort, and early life cognitive enrichment/risks (father's years of education, childhood SES, and childhood health). Further, we considered two job-level factors that may also relate to cognitive health: 1) whether respondents reported working at baseline, and 2) whether respondents reported working in a physically demanding job at baseline. Our sample includes respondents no longer working by the time they entered the HRS, so this measure is categorical and accounts for work status and physical demands for those still employed (1=not working, 2=working in a not physically demanding job, and 3=working in a physically demanding job).

Analyses

For RQ1, we used Ordinary Least Squares (OLS) regression models to examine the association between each job condition indicator (and index) and midlife cognitive functioning at baseline (age 55 or 56), net of controls. To address RQ2 and RQ3, we used OLS regression models to test the association between each job condition indicator (and index) and cognitive

functioning, and separately, the association with probability of CIND at Time 2 (age 70 or 71), controlling for baseline cognitive function and controls. To contextualize our findings, we used marginal effects calculations for midlife cognitive function, Time 2 cognitive function (accounting for baseline cognitive function), and the probability of CIND (accounting for baseline cognitive function) for people with high levels of occupational exposures (i.e., at the 75th percentile) versus those with low levels of exposures (i.e., the 25th percentile). All models use robust standard errors.

Key Findings

On average, participants' baseline cognitive function was 16.83 (*SD* = 3.87). Among those who survived to age 70, the mean cognitive score was 16.04 (*SD* = 4.05) and had a CIND probability of 16% (*SD* = 0.26). The majority of our sample was white, female, with an average of 13.55 years of education (*SD* = 2.87) at baseline. One in five were not employed at baseline, and half lived in urban areas. Mean CES-D was 1.39 (*SD* = 1.95) at midlife. About 79% self-reported good, very good, or excellent health. Approximately half of the sample is drawn from the original HRS cohort (born 1931-1941).

Results for RQ1 indicate that higher *social enrichment* (β = 0.0.096, *p* = 0.00), *mental enrichment* (β = 0.134, *p* = 0.00), and *occupational autonomy* (β = 0.081, *p* = 0.00) were significantly associated with higher midlife cognitive function scores. High scores on *operational tasks* (β = -0.074, *p* = 0.00) and *occupational hazards* (β = -0.119, *p* = 0.00) were significantly associated with lower midlife cognitive function scores. *Schedule irregularity* was negatively associated with cognitive function at midlife (β = -0.034, *p* = 0.01). *Interpersonal conflicts* were not significantly associated with midlife cognitive function. Additionally, p*hysical*

demands of work (β = -0.154, *p* =0.00) and exposure to *extreme temperatures* at work (β = -0.072, *p* =0.00) were negatively associated with midlife cognitive function.

Results for RQ2 indicate that *social enrichment* and *occupational autonomy* were not significantly associated with change in cognitive function between baseline and Time 2. In contrast, higher levels of *mental enrichment* of work were associated with reduced decline in cognitive function (β= 0.123, *p* = 0.00). Higher scores on *operational tasks*, *schedule irregularity,* and *interpersonal conflicts* were not significantly associated with cognitive decline later in life. *Occupational hazards* (β = -0.082, *p* =0.02), *physical demand* of work (β = -0.086, *p* =0.01), and exposure to *extreme temperatures* at work (β = -0.055, *p* =0.04) were all associated with elevated cognitive decline at Time 2.

In addressing RQ3, we observe that *contact with others* (i.e., a dimension of social enrichment) (β= -0.032, *p* = 0.044) and *mental enrichment* (β= -0.026, *p* = 0.036) were related to reduced probability of CIND. *Autonomy* was not significantly associated with CIND risks later in life. Alternatively, *operational tasks* (β= 0.021, *p* = 0.054), exposure to *extreme temperatures* (β= 0.017, *p* = 0.124), *schedule regularity* (β= 0.019, *p* = 0.069), and *interpersonal conflicts* were not significantly associated with increased risks of CIND later in life. Additionally, *physical demand* of work (β =0.030, *p* =0.026) and *occupational hazards* (β =0.03, *p* =0.038) were both significantly associated with elevated risk of cognitive impairment.

Beyond statistical significance, we evaluate the contextual relevance of our study findings by calculating the predicted values for each exposure, holding all other control factors at the mean, using Stata post-estimation command *margins*. For comparison, we examined our findings relative to the most well established factor shown to shape cognitive function in later life – years of education. Our findings show that lifetime average exposures to protective and

risky occupational exposures play a significant role in shaping differences not only in association with shaping cognitive function through midlife, but also in shaping the rate of cognitive decline and risks of cognitive impairment in the subsequent period as people move into later life. For instance, *mental enrichment* is the most protective exposure associated with cognitive decline in later life, where each SD increase in mental enrichment of work is associated with the same cognitive benefits one might experience by having about 2.78 more years of education.

Discussion and Policy Relevance

This study uses a novel dataset we created to comprehensively evaluate how lifetime occupation exposures influence cognitive health in mid- and later life. Eight out of nine average lifetime exposures to job conditions we examined were significantly associated with midlife cognitive function. Four job conditions (mental enrichment, occupational physical demands, occupational hazards, and exposure to extreme temperatures at work) significantly predicted cognitive decline in the period after midlife. Mental enrichment, occupational physical demands, and occupational hazards also significantly increased individuals' risks of cognitive impairment later in life. That is, these three exposures not only influence level of cognitive functioning by midlife, but also significantly influence cognitive decline after midlife and whether decline leads to cognitive impairment. These findings suggest that average lifetime occupational exposures have a persisting impact on cognitive health, and public health interventions that improve job conditions may be a critical pathway for reducing individual and societal productivity losses associated with exposure to cognitively risky jobs.

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