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RESEARCH ARTICLE

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A nationwide Swedish study of age at retirement and dementia risk

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Objectives: The aim of this nationwide study was to examine the association between age at retirement and dementia risk, with a follow-up period of up to 24 years.

Methods/design: This cohort study comprised Swedish citizens born in 1930 who were alive in the year 1990 (n = 63 505). The cohort was followed for incidents of dementia through data provided by the Swedish National Patient Register and the Cause of Death Register. Age at retirement and socioeconomic variables were retrieved from Statistics Sweden.

Results: During the follow-up, 5181 individuals received a dementia diagnosis. Competing risk regression models, adjusted for sex, education, marital status, occupation, and previous history of cardiovascular diseases, showed that later-than-average retirement age was associated with decreased dementia risk.

Conclusions: The present results support the idea that individuals who retired at an older age have a decrease risk of dementia. However, as this was an observation study, unmeasured factors, such as premorbid cognitive level and genetic predisposition, may have influenced our findings and remains to be elucidated in future studies.

KEYWORDS
age at retirement, aging, cognitive aging, cognitive decline, dementia, retirement

1 | INTRODUCTION

It has been argued that an enriched environment throughout life may provide an individual with a higher cognitive reserve that may compensate for age-related cognitive decline and consequently postpone onset of dementia.[1,2] Suggested proxies for cognitive reserve include educational attainment, leisure activities, and social activities. A factor that is highly relevant to the cognitive reserve hypothesis is an individual's work life, but this factor has so far received less attention.

There are several reasons why job-related factors may be potential moderators of age-related cognitive decline and dementia onset. First, we typically spend a large portion of our adult life at the work place, and many people receive majority of their social contacts and mental stimulating activates from their works. Second, this type of activity (in modern society) declines, often abruptly, as we retire. At this point, it is relevant to point out that the typical timing of pension/retirement actually coincides with the average age of onset of decline that has been observed across a variety of process-based (or "fluid" as opposed to "crystallized") cognitive abilities, is discernible around age 60 or 65 years.[3,4]

The potential protective effect of staying active longer for dementia is of fundamental importance also from a socioeconomic perspective. We may need to work longer to cope with increased costs associated with population aging seen in Western countries, and this issue have consequently been addressed in a few previous studies.[5-8] For example, Lupton et al[5] conducted a retrospective study, based on probable AD

cases, showing later retirement age to delay the onset of AD. Another retrospective study by Grotz et al[6] on AD patients that were referred to clinical centers for evaluation, indicated similar results in initial analyses. However, after considering potential bias due to reverse causality (ie, that persons may retire because of cognitive impairment) the effect of retirement on dementia risk was no longer significant.[6] Furthermore, a large-scale register based study,[8] involving self-employed workers in France, revealed a hazard ratio for dementia risk of 0.97 (95% confidence interval [CI]) per extra year of age at retirement. However, this study includes only self-employed craft workers and shopkeepers, with a specific health and pension insurance plan, and thereby limiting the generalization of the findings to the full population.

Furthermore, there are reasonably large differences in the effect of retirement depending on whether an individual retires earlier due to ill health or if timing of retirement coincides with that expected with the national setting.[9] Poorer physical health may result in premature retirement, resulting in a much smaller retirement income. This may affect the opportunities for various recreational activities and lifestyle habits that in turn,[10] might increase the risk of dementia. It is therefore possible that earlier retirement increases the risk of dementia not due to less/extra engagement in work activity, but because of health factors and socioeconomic factors. Hence, it is important that studies investigating the relationship between age at retirement and incidence of dementia consider all of these factors.

The objective of the present study was, therefore, to extend pervious work on the association between age at retirement and risk of dementia, while considering a number of factors (eg, education, socioeconomic situation, and health) that might modify this association. For this purpose, we examined longitudinal data from an extensive national registry. A Swedish birth cohort, aged 60 years at baseline (and born in 1930), were followed with regard to incident of dementia over a period of up to 24 years.

Key points

- Prior research has suggested that the transition from work to retirement can lead to reduced cognitive stimulation, which may have a deteriorating effect on a person's cognitive health and indicate an increased risk of subsequently receiving a dementia diagnosis.
- This study showed that later-than-average age of retirement was associated with a decreased risk of dementia.
- These findings supports the idea that higher age at retirement is associated with reduced risk of dementia. However, it also highlight the complexity of retirement's relationship to dementia and suggest that underlying factors, such as premorbid cognitive level and genetic predisposition, may have influenced the findings and need to be considered in future studies before any causal inferences are drawn.

2 | MATERIALS AND METHODS

2.1 | Data source

This study was based on data from the Linnaeus database,[11] a national, population-based, database with linked data from various national registers, including data from Statistics Sweden, the Swedish National Patient Register, and the Swedish Cause of Death Register. Data from Statistic Sweden contains information regarding demographic characteristics, education level, income from taxations, and data on pensions from the national retirement pension system. The Swedish National Patient Register captures inpatient register, with hospital-based diagnosis care, and the Swedish Cause of Death Register comprises register of causes of death (main and contributory). All registers include the entire Swedish population, involve annually data, and use diagnosis classifications from the International Classification of Diseases (ICD). The Swedish National Patient register has shown predictive value of approximately of 85% to 95% for most diagnoses,[12] and the Cause of Death Register has an underlying cause of death reported in among 96% of all individuals.[13]

2.2 | Participants

The sample included all individuals born in 1930 that where alive in the year 1990. We excluded persons 17 514 who earned zero income due to unemployment or other reasons, 17 with dementia diagnosis prior to 1990, and 154 whose education level was missing, leaving a final sample of 63 505 individuals. Persons who were unemployment were excluded since this study aimed to examine the effect of leaving paid work on dementia.

2.3 | Retirement variable

Timing of retirement is defined as the first year when income from pension benefits is equal to or exceeds 50% of the total annual earnings (including employment income, income from self-employment, and disability benefits).[14] Pension benefits are the sum of income from old-age public pension, occupational pensions, early pension, or voluntary private pension. The reason for using this definition of retirement is that timing of retirement in Sweden is not always clear-cut. For many people, retirement is a gradual transition, and some people continue to work part-time.

2.4 | Diagnoses of dementia and death

Dementia diagnoses were retrieved from both the National Patient Register and the Cause of Death Register. These registers have been shown to provide a high specificity for detecting dementia and moderate sensitivities (ie, missing dementia cases).[15,16] The following codes from ICD-10 were used for to confirm the dementia diagnosis; F00 (Alzheimer's disease), F01 (vascular dementia), and F03 (dementia of

unspecified type). Diagnosis of dementia from ICD-8 and ICD-9 (code 290) was also included to find dementia cases before 1997. Date of diagnosis of death (all causes) was derived from death records in the Swedish Cause of Death Registry.

2.5 | Covariates

In addition to age and sex, several sociodemographic variables collected at baseline (1990) were considered as potential confounders. The sociodemographic factors included were education (classified as low [≤ 9 years], intermediate [10-12 years], and high [≥13 years]), marital status (married vs not married), and employment (defined as in blue and white collar, self-employed, and unknown). We also adjusted for previous history of cardiovascular diseases (CVD) during the years 1980-1990. CVD was defined by the first hospitalization caused by coronary heart disease, stroke, or heart failure and were coded according to the ICD-8 and ICD-9 codes (410-414, 428, 430-438, and 440-448).

2.6 | Statistical methods

Differences in background characteristics between participants who developed dementia or remained dementia-free were tested used chi-square tests (categorical variables) and student's *t*-test (continuous variables).

We estimated the risk of developing dementia during follow-up by retirement age by using competing risk regression (CRR) modeling treating mortality as a competing event.[17] In competing risk data, an individual can potentially fail from several competing events, here, the competing events are dementia and death. In such analysis, an individual who die is no longer at risk of dementia and is treated essentially as censored, in opposed to the ordinary Cox regression where censoring is assumed unrelated to an individual's risk of developing dementia (ie, censoring is uninformative).[18]

For the CRR models, proportional hazards (PH) assumption was assessed by fitting models including time-by-covariate interactions for covariates showing a nonrandom patterns against time by plotting Schoenfeld's residuals. Significant interactions were found to for sex, marital status, and history of cardiovascular disease and were thus included in the final model to account for the violation of the PH assumption. A significant parameter estimate indicates that the hazard ratio associated with this factor is not constant over time.

Time to event was calculated as date of entry into the study (1990) to the year of dementia diagnosis, being lost-to-follow-up, death, or date of final follow-up (2014), depending on which event came first. Statistical analysis was performed using the *cmprsk* package in R (R Core Team, 2018).[18,19]

3 | RESULTS

During the 24-year follow-up, 5181 (9.6%) individuals had developed dementia and 21 065 (39.1%) died without a dementia diagnosis. Mean (SD) time of censoring was 20.9 (5.2) years and mean time to dementia diagnosis was 19.2 (4.4) years. Those who had developed dementia at follow-up were significantly more often women, less likely to be married, less highly educated, and less likely to have white-collar jobs at baseline. They were also more likely to have died at follow-up, see Table 1.

The distribution of age at retirement in this sample is shown in Figure 1. Most persons (44.1%) retired at age 65 years old, an age that corresponds well with the most common retirement age in Sweden. About 40.5% retired before 65 years, and 15.3% retired after 65 years.

We first evaluated the association between retirement age and risk of dementia for the full sample. A competing risk regression model, adjusting for sex, showed a trend, although not significantly, toward decreased risk of dementia with increase age of retirement (HR = 0.99, 95% CI 0.97-1.00, P = .065). Additional adjustment for marital status, education, employment, history of cardiovascular disease, and covariate-by-time interactions for sex, marital status, and history of cardiovascular disease revealed a significant association, whereas increase age of retirement with 1 year was associated with a 1.02-fold lower risk of dementia (HR = 0.98, 95% CI 0.97-1.00, P = .045), see Table 2.

We thereafter analyzed the three different categories of retirement age: early (aged ≤64 years of age), usual (65 years of age; reference category), and late (≥ 66 years of age). In a fully adjusted analysis, the results show that those who retired at 66 years and over had a 2.9-fold lower risk of dementia (HR = 0.35, 95% CI 0.24-0.49, P < .001), than those who retired at 65 years. However, the effect was attenuated over time as indicated by a significant time-by-covariate interaction for late retirement age (HR = 1.05, 95% CI 1.03-1.07, P < .001). This suggests that the strong positive effect of later retirement age on dementia risk was more pronounced at younger ages and decreases over time. There was no significant association among those who retired earlier (between 61 and 64 years of age). The results are found in Table 3.

To take into account the possibility that retirement was in part a result of dementia, a sensitive analysis was done by excluding individuals diagnosed with dementia or died within 3 years after retirement (N = 1528). The results yield similar to those of the primary analyses, in that later retirement was associated with a decreased risk of dementia (HR = 0.78, 95% CI 0.76-0.80, P < .001). However, the effect was attenuated over time as indicated by a significant time-by-covariate interaction for retirement age (HR = 1.01, 95% CI 1.01-1.01, P < .001). This suggests that the positive effect of later retirement age on dementia risk was more pronounced at younger ages and that after the age of 80 years only small and nonsignificant effects were found.

4 | DISCUSSION

The present study examined whether age of retirement is associated with incidence of dementia in a nationwide Swedish cohort study with up to 24 years of follow-up. After controlling for several potentially

TABLE 1 Baseline characteristics of participants who remained or did not remain dementia free at follow-up

Characteristic	No dementia, n = 57 423	All-cause dementia, n = 6082	*P*-Value
Man, n (%)	28 980 (50.5)	2921 (48.0)	<.001
Age at retirement, mean (SD)	64.3 (1.59)	64.3 (1.52)	.129
Married, n (%)	42 036 (73.2)	4347 (71.5)	.004
Education, n (%)			
≤9 years	29 904 (52.1)	3273 (53.8)	.010
10-12 years	18 456 (32.1)	1927 (31.7)	.477
≥13 years	9063 (15.8)	882 (14.5)	.009
Employment			
Blue-collar jobs	22 027 (38.4)	2397 (39.4)	.111
White-collar jobs	22 787 (39.7)	2306 (37.9)	.008
Self-employed	4482 (7.8)	477 (7.8)	.937
Unknown	8127 (14.1)	902 (14.9)	.156
Prior cardiovascular diseases, n (%)	2293 (4.0)	245 (4.0)	.921
Dead, n (%)	25 104 (43.7)	4645 (76.4)	<.001
Age at event of death, mean (SD)	76.9 (5.77)	80.4 (3.85)	<.001

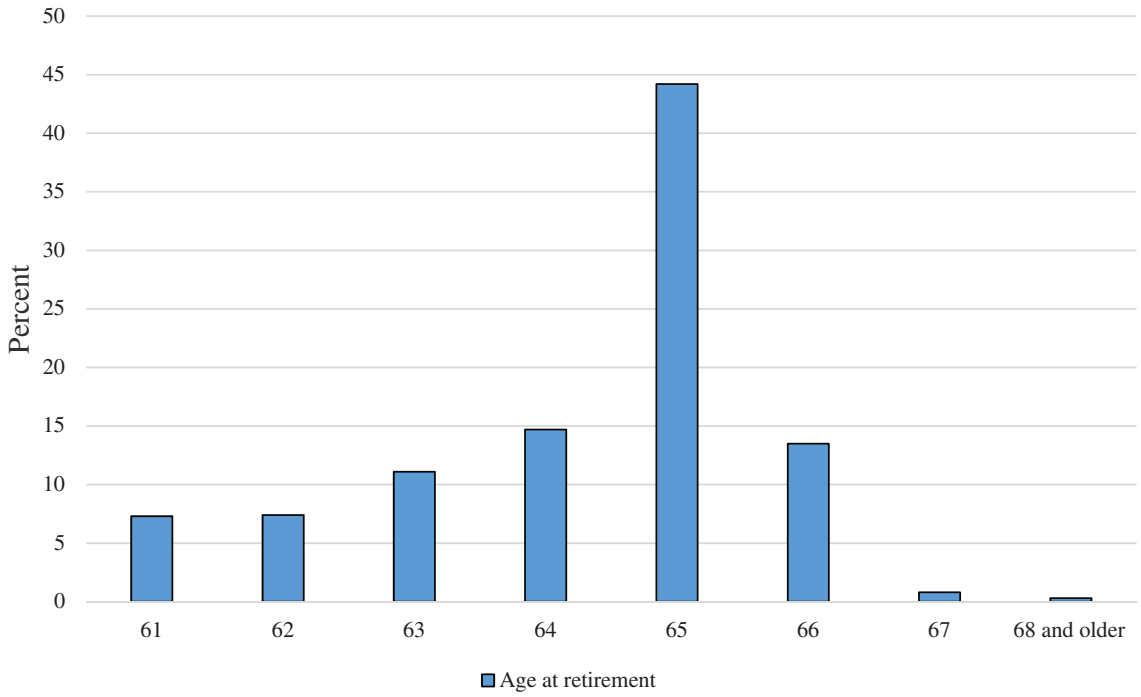

FIGURE 1 Histogram showing age at retirement [Colour figure can be viewed at wileyonlinelibrary.com]

confounding factors (ie, sex, education, marital status, occupation, and previous history of cardiovascular diseases), we found age of retirement to be associated with decreased risk of dementia.

According to the literature, a later age of retirement is related to decreased dementia risk, including later onset of AD,[5-8] and better preserved cognitive function.[20] The results from the present study, showing that a higher age of retirement is associated with a reduced risk of dementia, are consistent with these earlier findings. A common explanation for why delaying retirement may be beneficial for cognitive health is that retirement may be associated with a drop in mental and social stimulation. Accordingly, it has been proposed that people who work for a longer time keep up their cognitive level for a longer period, thereby reducing the risk of dementia diseases or delaying its onset.[5-8] As such, the results are consistent with a "use it or lose it" perspective and the cognitive reserve hypothesis.[2,21]

However, before strong conclusions related to causality can be drawn, further research focused on potential mediating factors and including additional uncontrolled factors is required. With regard to

TABLE 2 Cox regression competing risk estimates of the association between age at retirement and dementia, fully adjusted model

Characteristic	Rate ratio (95% confidence interval)	*P*-Value
Age at retirement	0.98 (0.97-1.00)	.045
Sex		
Women	Reference	
Man	1.59 (1.27-2.00)	<.001
Marital status		
Unmarried	Reference	
Married	0.57 (0.45-0.72)	<.001
Education		
≤9 years	Reference	
10-12 years	0.96 (0.91-1.02)	.19
≥13 years	0.92 (0.84-1.00)	.047
Employment		
Blue-collar jobs	Reference	
White-collar jobs	0.97 (0.91-1.03)	.32
Self-employed	1.02 (0.92-1.12)	.74
Academic profession	0.66 (0.33-1.32)	.24
Unknown	1.02 (0.94-1.10)	.62
Prior cardiovascular disease	2.51 (1.58-3.97)	<.001
Male × time in study	0.97 (0.96-0.98)	<.001
Married × time in study	1.03 (1.01-1.04)	<.001
Prior cardiovascular disease × time in study	0.95 (0.93-0.98)	<.001

TABLE 3 Cox regression competing risk estimates of the association between early, usual, and late age at retirement and dementia, fully adjusted model

Characteristic	Rate ratio (95% confidence interval)	*P*-Value
Age at retirement		
Early (61-64 years)	1.00 (0.95-1.06)	.890
Usual/common (65 years)	Reference	
Late (≥66 years)	0.34 (0.24-0.49)	<.001
Sex		
Women	Reference	
Man	1.63 (1.29-2.04)	<.001
Marital status		
Unmarried	Reference	
Married	0.57 (0.45-0.73)	<.001
Education		
≤9 years	Reference	
10-12 years	0.96 (0.91-1.02)	.210
≥13 years	0.92 (0.84-1.00)	.044
Employment		
Blue-collar jobs	Reference	
White-collar jobs	0.98 (0.91-1.04)	.450
Self-employed	1.01 (0.92-1.12)	.820
Unknown	1.02 (0.94-1.10)	.650
Prior cardiovascular disease	2.35 (1.48-3.74)	<.001
Late retirement × time in study	1.05 (1.03-1.07)	<.001
Male × time in study	0.97 (0.96-0.98)	<.001
Married × time in study	1.03 (1.01-1.04)	<.001
Prior cardiovascular disease × time in study	0.96 (0.93-0.98)	<.001

the mechanisms underlying the observed link between retirement and dementia, factors such as cognitively and socially stimulating activities at work and during people's spare time, as well as changes in these that may follow retirement need to be considered. For some people, retirement may be associated with an abrupt reduction in activity engagement, and living a less active life has been found to be associated with more rapid cognitive decline.[22,23] Furthermore, retirement may increase the feelings of loneliness that can lead to serious mental and physical health consequences in addition to the risk of developing dementia later in life.[24]

The complexity of one's work is a suggested mediator of the association between retirement and cognitive change; it has been proposed that retirement has a more adverse effect on cognitive performance among individuals with more complex occupations,[25] although recent work from our research group[26] could not find any association between dementia and complexity of work. Although we had no measure of work complexity in this study, our categorization of employment and educational level likely overlaps somewhat with the complexity notion in the sense that higher education and white- as opposed to blue-collar work are associated with work complexity.

Our data, extracted from a national registry, did not allow for distinguishing among individuals depending on engagement in either social or leisure activities or perceived loneliness. Regarding uncontrolled factors here and in other studies, future studies must rule out, for example, the possibility that genetic factors account for the timing of dementia. For example, variations in early cognitive ability level are generally deemed to have a substantial genetic basis,[27] and a higher cognitive level has been associated with lower dementia risk,[28,29] it could be that cognitive ability level is positively associated with working longer as well. Thus, further research considering a wider set of measures is needed to fully establish the causal link between the timing of retirement and dementia and, in such a case, what factors mediate this effect.

Findings from studies that examine the impact of retirement on dementia, including those from this study, need to be understood in the context of the country of study. In Sweden, the retirement age is flexible and part-time pensions are possible after the age of 60 years. For people born in 1930 (as in this study), pensions is based on an individual's 15 years of highest earnings, and 30 years of labor market participation are required for full pension[30] The low incentive to retire

late may result in selection bias in that those who still continue to work past the average age of retirement have better health and also find their work more meaningful than those who retire at a more typical age—factors that may be protective of dementia. A recent study from Sweden also supports these lines of reasoning in that those who continued working after age 65 years were found to have a 6.8% greater chance of reporting better health (subjective) than those who retired at 65 years. However, the reported positive effect on subjective health was only transitory and disappeared after 6 years. The authors suggest that the disappearance of the beneficial effect on subjective health depends on the idea that the positive impact of work environment in the form of social contact and interaction is no longer apparent.[31] A similar pattern was observed in this study, as the positive effect of later retirement age decreased over time.

There are several strengths of the present study. A major strength is the large population-based sample that includes a complete Swedish birth cohort, thereby minimizing the risk of selection bias and allowing for a powered analysis. A follow-up time of up to 24 years and the possibility of adjusting for multiple possible confounding variables are also strengths. However, the database that was used has its limitations; for one thing, there is a lack of information concerning occupational complexity and mental and social leisure activities, both before and after retirement. In addition, all dementia diagnoses were provided by the national registry covering data from specialist healthcare at the hospital, but did not include diagnoses made in primary care, likely resulting in missed dementia cases. Moreover, the results need to be viewed in a national context. More specifically, countries differ in pension systems, employment policies, labor market conditions, possibilities to engage in activities outside the workforce, and cultural norms. It is possible that such variations moderate the effect of timing of retirement on dementia. Finally, in our study we defined age of retirement as the first year when income from pension benefits is equal to or exceeds 50% of total earnings. However, other definitions of age of retirement may have produced different results. This study also included a rather small variation in retirement age; a larger range in retirement age may have provided stronger findings.

In summary, the results from this nationwide study show that a later age of retirement is associated with a decreased risk of dementia even when major demographic and socioeconomic and health-related factors are considered. More research is needed to validate this link and study the underlying mechanisms, such as how job characteristics and involvement in leisure activities, as well as premorbid cognitive level and genetic predisposition, affect the association between retirement and dementia.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data are available through Statistic Sweden (http://www.scb.se/en/) and the National Board of Health and Welfare (https://www.socialstyrelsen.se/en/) for researchers who meet their criteria for access to confidential data. The Swedish law of Research Ethics states that research based on register data has to be approved from a Regional Research Ethical Committee. Other researchers may access the same data by using the same manner as authors of this study.

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