Is retirement beneficial for mental and cardiovascular health?

An epidemiological study of old-age retirement as predictor of treatment for mental and cardiovascular disorders

Kasper Olesen

PhD thesis

This thesis has been submitted to the Graduate School at the Faculty of Health and Medical Sciences, University of Copenhagen
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2014
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PhD thesis
Submitted: May 2014
Defended:

ISBN XXX-XX-XXXX-XXX-X

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Preface

This thesis was conducted at the Department of Occupational and Environmental Health, Bispebjerg University Hospital, from October 2011 to May 2014. The PhD project was funded by a grant from the Danish Work Environment Research Fund (grant number: 25-2010-09).

Many people have contributed to the process of designing and conducting the project. Notable among these are my academic advisors Jens Peter Bonde, Reiner Rugulies and Naja Hulvej Rod who has contributed with valuable guidance, insights from their fields, and support throughout the project. Furthermore I would like to thank current and former colleagues at the Department of Occupational and Environmental Health at Bispebjerg University Hospital; the National Research Centre for the Working Environment; and the Department of Social Medicine at University of Copenhagen for their involvement in my project and supportive companionship during the process.

Kasper Olesen
May, 2014
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1 Introduction

Low birth cohorts and increased longevity throughout the OECD countries will result in relatively more retirees compared to active workers in the coming decades which will put strain on the economy [1]. It has been estimated that the ratio of unemployed to employed in Europe will increase from 1:3 in 2004 to 1:1 in 2050, without intervention [2]. A straightforward solution to the financial challenge is to increase the retirement age with the increase of the expected life expectancy [3]. In Denmark the future statutory retirement age is already partly dependent on changes in life expectancy. Despite decades of debating financial consequences of retirement the question of public health has been comparably absent in the debate. Furthermore scientific studies on health consequences of retirement have until recently been scarce whilst Danish studies on the subject have been non-existing. Thus politicians in Denmark and other countries are discussing increased retirement age with limited knowledge of the health consequences for their populations.

Retirement is a major life event which most people can expect to go through at some point in their life. It usually involves a range of changes for the individual such as changes in social life, physical activity, and changes in individual identity. It is well established that work environment may affect health in many different settings and thus it would be a logic consequence that removal of all work environment also would affect health. A study by Westerlund and colleagues published in The Lancet 2009 [4] shows that retirement is beneficial for self-reported health. Further studies have also suggested that retirement comes as a relief for the retirees [5-11]. That was of course good news for the retirees, but it also send an ominous message to the younger generations – particularly as we can expect the retirement age to be increased in the future.
1.1.1 Retirement policies in Denmark

The demographic changes have already influenced retirement policies in Denmark and have also changed the attitude towards retirement in the population. During the follow-up period (1992-2010), there were three main types of retirement available in Denmark: Old-age pension (OAP), Post-employment wage program (PEW), and disability pension, which is available for workers at any age who for medical or psychological reasons are unable to work. However, for the purpose of this project we only included types of retirement where old-age is a main criteria. Thus, health consequences following disability pension was not a topic of this project.

In Denmark the publicly financed OAP was available at the age of 67 (since 1999 it was 65 years for people born after 1 July 1939) and covers all citizens regardless of previous attachment to the labour market and with no health criteria whatsoever. In 1979 PEW was introduced, making it possible for many people to retire already at the age of 60. At the time of the introduction unemployment was high in Denmark and a primary aim of the scheme was to reduce unemployment in the younger age groups by giving old worn-out workers the possibility to retire before the general retirement age [12]. However, being "worn-out" was not a criterion for PEW which soon became a popular path to early retirement and within a few years the proportion of 60-66 year-old citizens in the labour force fell considerably. PEW was also the preferred retirement program during the follow-up period in this project, particularly among workers with low wages who could retain a higher percentage of their income compared to workers with higher wages. The only criteria for PEW was being 60 and have sufficient seniority in an unemployment insurance fund. Thus, it was also possible to enter PEW without being employed. In 1999 the requirements for entry into PEW were revised for people born after 1 July 1939 making it financially more attractive to postpone retirement until after the age of 62. Following the reform in 1999, the age of eligibility was still 60 years, but at the same time the OAP age was lowered to the age of 65, which meant that people born after 1 July 1939 were eligible to enter PEW at the age of 60–65.
1.1.2 Why Danes retire early

As already indicated, financial circumstances is a major motivation for the retirement decision. In Denmark it became increasingly popular to postpone retirement to the age of 62 following policy changes from 1999 where retirement from the age of 60 became less economic attractive. This was confirmed by our own study data [data not shown]. There is also a clear association between job groups and retirement where workers from job groups with low income took retirement relatively early. One could claim that educational level rather than payments was the real predictor for the retirement decision. However, workers with relatively high education and low income (or attractive pensions), such as school teachers or nurses, are still among the job groups with early retirement further indicating that financial circumstances is an independent predictor for early retirement.

Besides wage and pension, job group is also an independent predictor for early retirement. Workers in physical demanding jobs tend to retire early [13].

Family situation has also shown to influence retirement decisions [14]. First, spouses often synchronize retirement [15]. This mechanism results in early retirement for a worker with an older spouse and relatively late retirement when the spouse is younger. This mechanism is responsible for general earlier retirement among women compared to men, as the woman is often the younger part of a couple. Another suggested predictor is grandchildren which may be a contributing factor for decision of early retirement [16]. The last mechanism may however be less pronounced in Northern Europe as the family bonds are comparably weaker compared Central or South Europe [17].

An intuitive and strong predictor for early retirement is job satisfaction. A recent Danish study has found strong association between psychosocial work environment and intention to quit the job among hospital employees [18].

Finally, health has also shown to be a predictor for early retirement [19-20]. This is in line with the original intention of the PEW program concerning worn-out workers. However it imposes risk of reverse causality for researchers studying health effects of retirement.
1.1.3 Mechanism by which retirement affects health

Retirement involves many changes and has been suggested to affect health in various ways. Taken together, retirement involves removal of both deleterious and healthy work environment as well as providing increased opportunities for both deleterious and rewarding leisure time activities. In addition the individual perception of the retirement process, life changes, and prospects for the future may also involve changes for individual health. The process can be divided into physical, social, psychological, and lifestyle changes which directly or indirectly may influence health. Retirement involves many life changes which have already been subject of studies on health. It is well known that physical activity is important for cardiovascular health, thus we can assume that changes in physical activity as a consequence of a major life event may also affect cardiovascular health. However, it is largely unknown if the retirement process modify associations between lifestyle and health. I.e. it has been discussed if benefits of work related physical activity are similar to beneficial effects from leisure time physical activity [21].

All these mechanisms are somewhat speculative as they have only been analysed directly in relation to retirement in a limited extent. For example, studies have shown that involuntary unemployment has adverse effects on health [22-24], whereas recent studies have found evidence for beneficial health effects of retirement [4-11]. Even though both situations involve loss of a job the difference in health outcome indicates that the context is important when evaluating health effect of a specific mechanism.

As retirement involves many changes it is possible that some of the changes have positive impact on a health outcome whilst other aspects of retirement simultaneously have negative impact on the same outcome. This makes it difficult to identify single mechanisms by which retirement affect health.

Even more, many of the mechanisms which link retirement to health are complex and may result in a beneficial outcome for some individuals whilst being deleterious for others. Thus, to get comprehensive understanding of all health effects of retirement, many studies of various health outcomes are needed. Analyses on sub-populations and workers with specific work-environment can help.
Figure 1 below gives a simplified illustration of health changes during the retirement process. The amount of beneficial and deleterious effects of retirement may differ for each individual, depending on work environment and personal factors, resulting in different health outcomes for each individual. It was the hypothesis in this project that beneficial effects would outweigh the deleterious effects resulting in net health improvements following retirement in larger populations.

Figure 1: Mechanisms by which retirement affects health

Post-retirement health includes both short- and long term health effects of retirement even though the figure does not separate between them. Some effects of retirement may effectuate immediately after retirement or even before the actual point of retirement, such as stress relief, whereas other effects influence health long term. Weight gain is an example of such long term effect.
1.1.4 Physical consequences

Retirement, as a major life event, may have a strong influence on leisure time [25,94]. Consequences of retirement for physical activity have two dimensions. Retirement from a physical demanding work involves less work related physical activity whereas retirement gives increased opportunities for physical activity for all individuals. Studies have shown that overall physical activity declines following retirement [26-28], even though individual workers, for example workers with desk-based jobs, may increase their total physical activity in the retirement. This overall decline may be a consequence of leisure time sedentary behaviour, such as an increase in television viewing time [29] replacing work-related physical activity. However, it has been suggested that physical activities at work may not have the same beneficial health effects as leisure time physical activities [21]. Thus, replacing work-related physical activity with voluntary leisure time of physical activity may be beneficial even though the total amount of activity is unchanged.

Lifestyle and physical activity has been suggested as predictor for mental disorders [30,91-93] as well as an established predictor for cardiovascular health [31-33]. Thus changes in physical activity following retirement may be responsible for changes in mental and cardiovascular health. The changes will to a high extent depend on the job and on personal factors, i.e. retirement from a job with limited physical demands will only result in minor physical activity, and opportunity for leisure time of physical activity does not necessarily result in any such activities. In a 2012 review Barnett and colleagues found evidence for increased leisure time physical activity, however it is unclear whether total physical activity also increased [26]. If we expect more sedentary work tasks in the future we may also expect that retirement will be associated with a higher relative increase in physical activity compared to now.

In addition to the question of more versus less physical activity following retirement, it may also be important to distinguish between different kinds of physical activity. In some cases activity can be healthy and rewarding whereas in others, the activity may have a deteriorating effect on health – such as muscular skeletal disorders. Muscular-skeletal disorders are not within the scope of this project, however if a disorder involves lack of mobility it may also affect cardiovascular [31-33] and mental health [34].
Studies on other lifestyle factors have shown that retirement is associated with changes in weight [35,36] and minor changes in alcohol consumption [37].

1.1.5 Social consequences

The social work environment, often referred to in the broader term psychosocial, has been suggested as a predictor for both cardiovascular and mental health. Loneliness is associated with higher risk of mental health problems among older adults [38]. Social activity has been suggested as predictor for mental health [39-40] and physical activity [41] which in turn may influence the risk of cardiovascular health [31].

Many jobs involve daily contact with colleagues, customers, and clients. For many workers social interaction at work constitutes a significant part of the total social interactions in life. Particularly as social relationships outside of work has often emerged from work-related activity. Thus retirement may for some individuals involve immediate and long-term reduction in interaction with other people. However, as with physical activity, the freedom of retirement also provides better opportunity for social interaction with family and friends outside of work. Such interactions are often characterised by being voluntary and more personal than work-related interactions. Bullying may be more frequent in environments with involuntary social interactions, which is a risk factor for depression [42-43]. A Danish 2012 study showed that up to 10 percent of the participating workers were occasionally exposed to bullying [43], which indicates that social interaction at work also have negative consequences for many workers. Thus social participation in retirement may affect health differently compared to social participation at work [44,45]. Social interactions in general has also been suggested as predictor for health [45,46].

1.1.6 Psychological consequences

Retirement may involve changes in psychological well-being [103] or even in aims for life or even loss of identity. Psychological research has shown that self-esteem is at a relatively low point in retirement, particularly among men.
who has relatively higher self-esteem earlier in life. This low point can be explained by the retirement status [47]. Socio-economic status and self-esteem are also associated [48] and a retiree who found his or her job rewarding and unable to find new meaningful goals may feel retirement as a loss. In such cases retirement from occupation may result in loss of identity, or even meaning of life [49].

Such feelings may contribute to changes in lifestyle and mental disorders which again can affect cardiovascular health. Furthermore, loss of job, as a major life event, may be psychological stressful for the individual to go through, which may have adverse effects on health [23]. Contrary, retirement from an unsatisfying job may have the opposite effect if the retiree is able to replace his or her work with rewarding activities in retirement.

1.1.7 Existing knowledge

The topic is defined by its exposure, “retirement”, rather than a particular outcome. As retirement can have consequences on various aspects of life, various outcomes of retirement have been analysed. Early studies of consequences of retirement on health did not produce consistent results [50]. They were characterized by relatively small study populations, cross-sectional designs, and lack of distinguishing between types of retirement. Furthermore, all the studies were generally characterized by works on data designed for other purposes. In 1981 Minkler expressed it in this way:

"The contention that retirement may have an adverse effect on health has become increasingly popular with the recent categorization of this phenomenon as a stressful life-event. The small numbers of empirical studies examining the health outcomes of retirement, however, appear neither to support nor refute this hypothesis. Moreover, the serious methodological problems inherent in most of these studies caution against the generalization of findings" [50]

Even though this was written 30 years ago it is to a large extent still valid and descriptive of the challenges researchers have been facing ever since. The number of studies in the field are still relatively limited and findings some-
what contradicting. Even though the methodology has been considerably improved, most studies still face methodological challenges to an extent where the reliability is still being discussed. Another challenge is the various possible outcomes of retirement which can be subject for studying. It cannot be assumed that a health consequence measured with one outcome will be the same if the outcome is changed to another aspect of health. This can be a contributing factor to the lack of consistency between studies.

1.1.8 Retirement and mental health

Most health outcomes have only scarcely been studies in relation to retirement. As a notable exception mental health has been outcome in a relatively high share of the studies within the field [7,51-67]. There is no straightforward explanation for this high representation but could be caused by an intuitive association between retirement and mental health rather than the somatic outcomes.

Despite the consistency in analysed outcomes the results of early studies have not been consistent. Some early studies have found improvements in mental health following retirement [51-56], other studies found no effect [57-60,67], whereas some studies found retirement deleterious [61-66].

However, in more recent studies researchers consistently found beneficial effects of retirement on self-reported mental health [4-6,8]. In a study of self-reported health among workers in the French GAZEL cohort Westerlund and colleagues demonstrated a clear association between retirement and perceived general health [4]. The authors took advantage of cohort data with high statistical power and yearly measurements of health. A clear decline in prevalence of suboptimum health was observed during the retirement. The study was an unambiguous message that retirement was followed by clear improvements in perceived health. In the following years a range of studies were carried out on the GAZEL cohort with similar exposure and methods but different outcomes. Westerlund and colleagues demonstrated that retirement was also associated by a steep decline in prevalence of fatigue [5] with results similarly convincing to the study from the previous year. A study finding reduced sleep
disturbance following retirement was in line with findings from previous studies [9]. A study on alcohol intake, although not a direct measure for mental health, only found a minor increase around the point of retirement [37]. Another longitudinal study also on a French cohort likewise found reduction in complaints of sleep disturbance after retirement [10]. A 2010 study with participants from the British Whitehall II cohort also found evidence of improved mental health [6] using similar methods. Other studies also produced results supporting the notion that retirement is beneficial for mental health [68].

The studies together represented relatively convincing evidence to conclude that retirement was beneficial for perceived mental health. However, two major questions remained unanswered. First, were the results applicable to other populations with different work-life, culture, and retirement policy? Second, to which extent could the results be reproduced in studies not relying on self-reported measures for health?

Simultaneously with the present project further studies were published on retirement and mental health. Three studies on Finnish data with usage of psychiatric medication as outcome [7,65,66] were published. By analysing recorded purchases of prescriptive antidepressants Oksanen and colleagues confirmed their hypothesis that statutory retirement is beneficial for mental health [7]. Despite the authors’ conclusion, their results were not as convincing as in the studies of the GAZEL cohort. Oksanen and colleagues observed an actual reduction of antidepressant use before retirement followed by a decline following the retirement. They do however base their conclusion on the fact that the prevalence of antidepressant purchase is at a lower level after the retirement. In a study including all employees from the city of Helsinki, Laaksonen and colleagues did not find a decrease in use of psychotropic drugs following old-age retirement [65]. The authors observed a steady increase during the follow-up without any change in the trend around retirement. Leinonen and colleagues carried out yet another analyses of psychotropic use around transition to retirement among Finnish workers [66]. The study had particular focus on socio-demographic factors but found no change on antidepressant medication around retirement regardless of social factors. Thus there is a discrepancy in results between studies using self-reported endpoints compared to studies using psychotropic use/purchase as endpoint. It is
however unknown if the Finnish studies can be reproduced outside of Finland. It is furthermore unknown if studies on other medically certified outcomes, such as diagnosed depression, will be in line with the Finnish studies on psychotropic drugs or show a different pattern. Thus, it is yet unknown how studies on mental health around retirement depend on the measure.

In a very recent systematic review van der Heide and colleagues analysed effects of retirement on mental health across available studies [68]. From the literature, the authors find strong evidence for improvements in mental health following retirement. However, the studies by Laaksonen [65] and Leinonen [66], which did not support the conclusion of van der Heide, were not included in the review. Inclusion of those two studies would have challenged the conclusions by van der Heide.

1.1.9 Retirement and CVD

Work-related psychosocial exposures have been suggested to affect cardiovascular health [69]. However, consequences of retirement for CVD have only scarcely been studied. In a Finnish study based on 402 old-age retirees, Tuomi and colleagues analysed consequences of retirement on cardiovascular health [70]. They found an increased prevalence of CVD following retirement. Despite a two-wave design the study did not deal with possible selection into retirement where unhealthy workers are more likely to retire than their more healthy colleagues. Westerlund and colleagues did not find evidence of changed risk of CHD [5] in relation to retirement using health trajectory analysis. Using time to event analysis, Moon and colleagues found increased risk of IHD following retirement in an US representative cohort study [71]. Behncke found that the risk of developing a serious cardiovascular disease is increased following retirement [72]. Together those recent studies suggest something between no association and a modest increased risk of CVD following retirement. The findings of Westerlund and colleagues should be interpreted in the light of a study from 2009 [4], where the authors with a similar method and population found strong evidence of beneficial effects of retirement on self-reported health. Those results are however based on study populations representing broad populations.
As earlier mentioned the topic of health consequences following retirement is not well understood and early studies are inconsistent in their findings. Westerlund and colleagues did however perform a minor breakthrough within the field as they, using appropriate methods, were able to somewhat consistently report beneficial health effects of retirement [4-9]. Only one of those studies was directly related to cardiovascular health [5]. Despite the effort, many aspects are still not well understood and the results of Westerlund and colleagues have only been repeated in few populations. Furthermore, many recent studies reporting health benefits of retirement has been performed on the self-reported GAZEL cohort. It was largely unknown whether studies using medically certified endpoints also would provide evidence of health improvements following retirement. Results from Behncke [72] and Moon [71] indicated that retirement could increase risk of cardiovascular diseases.

Table 1 is a list of important studies on mental or cardiovascular health following retirement. The studies in the list have all met following criterions:

1) They all have mental health or mental health related outcomes, including conditions which are not direct measures of mental such as headache, sleep disturbance and overall subjective health. Some studies analyse mental health among several different outcomes. Those studies are also included but only results on the mental health related outcome is reported.

2) They all analyse consequences of retirement where old-age is a main criteria. Studies on unemployment or disability pension are not included.

3) They all use longitudinal data which is crucial for valid conclusions, as previously described. Furthermore they all use data either specifically designed for analyses of health following retirement or data with consecutive measurements of health and retirement status. Thus a study with a baseline survey and a follow up X years after does not qualify. High quality studies using qualitative methods would have been considered, unfortunately no such studies exists to our knowledge.

4) The manuscripts are in English and available for search at PubMed.
### Table 1: Studies on mental health related outcomes following retirement

<table>
<thead>
<tr>
<th>First author, publication year</th>
<th>Population</th>
<th>Total number of participants</th>
<th>Follow-up type</th>
<th>Data source</th>
<th>Outcome</th>
<th>Reported health effect of retirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neuman, 2008</td>
<td>Health and Retirement Study (US)</td>
<td>16,265</td>
<td>IV probit model</td>
<td>Self-report</td>
<td>Depression (CESD screening)</td>
<td>No effect</td>
</tr>
<tr>
<td>Neuman, 2008</td>
<td>Health and Retirement Study (US)</td>
<td>16,265</td>
<td>IV probit model</td>
<td>Self-report</td>
<td>Subjective Health</td>
<td>Beneficial</td>
</tr>
<tr>
<td>Vahtera, 2009</td>
<td>GAZEL (French)</td>
<td>14,714</td>
<td>Health trajectory</td>
<td>Self-report</td>
<td>Sleep disturbance</td>
<td>Beneficial</td>
</tr>
<tr>
<td>Westerlund, 2009</td>
<td>GAZEL (French)</td>
<td>14,104</td>
<td>Health trajectory</td>
<td>Self-report</td>
<td>Suboptimum health</td>
<td>Beneficial</td>
</tr>
<tr>
<td>Westerlund, 2009</td>
<td>GAZEL (French)</td>
<td>14,104</td>
<td>Health trajectory</td>
<td>Self-report</td>
<td>Fatigue</td>
<td>Beneficial</td>
</tr>
<tr>
<td>Jokela, 2010</td>
<td>Whitehall II (British)</td>
<td>14,714</td>
<td>Health trajectory</td>
<td>Self-report</td>
<td>Mental wellbeing</td>
<td>Beneficial</td>
</tr>
<tr>
<td>Zins, 2011</td>
<td>GAZEL (French)</td>
<td>12,384</td>
<td>Health trajectory</td>
<td>Self-report</td>
<td>Alcohol consumption</td>
<td>Beneficial</td>
</tr>
<tr>
<td>Marquie, 2011</td>
<td>VISAT study (French)</td>
<td>12,183</td>
<td>Health trajectory</td>
<td>Self-report</td>
<td>Headache</td>
<td>Beneficial</td>
</tr>
<tr>
<td>Leinonen, 2013</td>
<td>Finnish national representative data</td>
<td>10,873</td>
<td>Health trajectory</td>
<td>Self-report</td>
<td>Psychotropic drugs</td>
<td>Beneficial</td>
</tr>
<tr>
<td>Oksanen, 2011</td>
<td>Finnish public sector</td>
<td>7,138</td>
<td>Health trajectory</td>
<td>Register</td>
<td>Psychotropic drugs</td>
<td>Beneficial</td>
</tr>
<tr>
<td>Sjösten, 2011</td>
<td>GAZEL (French)</td>
<td>12,913</td>
<td>Health trajectory</td>
<td>Self-report</td>
<td>Headache</td>
<td>Beneficial</td>
</tr>
<tr>
<td>Laaksonen, 2012</td>
<td>Employees from Helsinki</td>
<td>4,496</td>
<td>Health trajectory</td>
<td>Self-report</td>
<td>Psychotropic drugs</td>
<td>Beneficial</td>
</tr>
<tr>
<td>Leinonen, 2013</td>
<td>Finnish national representative data</td>
<td>19,877</td>
<td>Health trajectory</td>
<td>Self-report</td>
<td>Depression (CESD screening)</td>
<td>No effect</td>
</tr>
</tbody>
</table>

### Table 2: Studies on cardiovascular health following retirement

<table>
<thead>
<tr>
<th>First author, publication year</th>
<th>Population</th>
<th>Total number of participants</th>
<th>Follow-up type</th>
<th>Data source</th>
<th>Outcome</th>
<th>Reported health effect of retirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behncke, 2011</td>
<td>ELSA (English survey)</td>
<td>5,427</td>
<td>IV Propensity model</td>
<td>Self-report</td>
<td>Cardiovascular disease</td>
<td>Deleterious</td>
</tr>
<tr>
<td>Moon, 2012</td>
<td>Health and Retirement Study (US)</td>
<td>5,422</td>
<td>Time to event analysis</td>
<td>Self-report</td>
<td>Stroke and MI</td>
<td>Deleterious</td>
</tr>
<tr>
<td>Westerlund, 2010</td>
<td>GAZEL (French)</td>
<td>14,104</td>
<td>Health trajectory analysis</td>
<td>Self-report</td>
<td>Coronary heart disease &amp; M</td>
<td>No effect</td>
</tr>
</tbody>
</table>
Table 1 shows existing studies and their main findings. Even though results are inconsistent over a longer period, prospective studies from 2009 and a few years onwards consistently suggested that retirement was beneficial for health. However, those studies are mainly based on self-reported data, notably from the French GAZEL cohort. Studies based on different populations and medically certified outcomes are warranted.

### 1.1.10 Aim
Previous studies have shown that workers report improved health following their retirement, but it is unknown if the results can be reproduced in other populations using medically certified health outcomes. It was the aim of this project to analyse consequences of retirement for heart disease and depression using registry-linkage data. The project is supposed to complement existing studies by including full population data and medically certified outcomes which has not been studied previously. If we could show a beneficial effect of retirement on mental and cardiovascular health in the Danish population, chances are that the findings are somewhat universal.

We limited our analyses to types of retirement where old-age is a main criteria.
2 Methodological challenges within the field

Researchers have faced a range of methodological challenges when studying health consequences of retirement. Recognizing and dealing with those challenges have shown to be important for the quality of studies within the field. Even though methodological challenges are present in all research they still shape the methodological choices within the field and may compromise the quality of research. Early studies were often cross-sectional and it is now generally accepted that prospective studies are superior [5] when examining health effects of retirement, because selection retirement is often predicted by health [6,19,20,73].

2.1.1 Reverse Causality / Selection into retirement

Determining the order of causality is a challenge in many epidemiological studies. The methodological challenge is of particular importance in this field as poor health is associated with early retirement [6,19,20,73]. Thus retirees are expected to have worse health than their former colleagues of the same age. This has been used as an argument for discrepancy in results between early cross-sectional studies and more recent longitudinal studies [5]. Thus the older cross-sectional studies tended to report worse effects of retirement than newer prospective ones which somewhat consistently report beneficial effects of retirement. As a consequence almost all recent studies on health following retirement have used longitudinal designs where the order of events (retirement / deleterious health) can be established.

However, a longitudinal design alone does not solve the problem completely. If certain vulnerable individuals, who are still healthy, is more likely to be retired than other workers due to the vulnerability, this might introduce bias as the pool of retired workers will develop illness faster than those still working. A prime example of such vulnerability is obesity. Obese workers are more likely to retire early [74] whereas obesity is a well-known predictor for cardiovascular diseases. Only if the vulnerability can be identified and measured it can be accounted for by inclusion of adjustments in a statistical model such as
cox regression. Such selection mechanism is an example of the healthy worker effect where the workers only stay in hazardous working conditions as long as they remain healthy, thus giving the impression of a healthy work environment. The healthier worker bias is difficult to elucidate by confounding adjustment. A recent solution has been to use health trajectory analysis to circumvent the healthy worker effect [4-9]. Health trajectory analysis is a within-individual design, where prevalence of a disease is measured repeatedly before and after retirement for all participants. Thus healthy and unhealthy workers will contribute equally to the pre- and post-retirement estimates. Finally the trends in prevalence can be observed, either with a statistical estimate or simply visually, to evaluate if there is any change in prevalence around the point of retirement. A reduced prevalence around retirement and onwards will then indicate a beneficial effect of retirement for the study population. Such approach has been popular within the field since Westerlund and colleagues first used it in 2009 [4].

2.1.2 Confounding by age
Age is an important confounder in studies of retirement and health, as age is correlated with both retirement status, mental health [96] and a well-established predictor for cardiovascular health. In many methodological designs adjustment for age is relatively straightforward; however that is not always the case. When all participants in a study population retire at the same age, workers cannot be compared directly to retirees of the same age. Furthermore when following the same individuals over time, before and after retirement, effects of age will influence the results. Westerlund and colleagues have used such within-individual analysis in a study of self-reported suboptimum health in the French GAZEL cohort from 2009 [4] and repeated the design several times since [5-9,37]. Many studies within the field are actually not adjusted for age. Westerlund was able to show health trajectories affected by age and still with clear changes in trend around retirement [4]. However, when results are less clear and confidence limits larger, the interpretation of effect by age and retirement can be more difficult to separate. An example of the latter is the results by Leinonen [66].
2.1.3 Selection into the study population

In many cases reaching the retirement age has been a criteria for inclusion in the study [4-9,37]. In cases where the studied outcome is potentially fatal, such as MI, there is a risk of underestimating the number of events before retirement, as participants with fatal events before retirement never will reach retirement age and fulfil the inclusion criteria. This potential bias may result in overestimation of deleterious effects of retirement.

Unemployment, disability pension, or any other absence from paid work may also result in exclusion from the working cohort and/or study population. In some cases such irregular work is also associated with outcome of an analysis such as severe depression. If participants with no- or irregular work, are excluded at baseline the prevalence of the outcome may also be severely underestimated. This is the case when participation in the workforce at baseline is an inclusion criterion, e.g. Moon [71]; when retirement is an inclusion criterion, i.e. Westerlund [4], and when workforce participation at certain points in time is an inclusion criterion, i.e. [7].

A possible solution to this potential bias is to include irregular workers in the study population when possible. However, this first of all requires available data, and second it involves a risk of noise on the results if the researcher is interested in the transition from work to retirement and no other sorts of transition such as, from unemployment to retirement.

It was with those considerations in mind that the approach for our study was developed.
3 Methods

3.1.1 Population

Our base population consisted of all individuals born from 1930 to 1950 who were Danish residents in the period from 1990 to 2010. Depending on design we limited the study population further due to factors such as work force participation and disease history. However, due to insufficient labour market data we only studied events from 1992.

For article 1 and 3 very similar populations were chosen. For article 2 the population was somewhat different mainly because reaching retirement was a necessity for entering the population and because the participants had to be followed for up to 5 years before and after retirement. Figure 2 and 3 are flow diagrams showing how the populations were selected:

For article 1 and 3 it was the aim to assume a baseline population which consisted of active workers with no previous events of IHD and HTD. As we only had data on hospital treatment back to 1990 we did not know if the participants had experienced previous events of the outcome. Thus, the baseline population was far from healthy but we were able to show that our results
didn’t change significantly if participants using any kind of cardiovascular medication were omitted from the population.

For article 1 we did not assume a baseline population free from diseases. Treatment for mental disorders one year was strongly associated with treatment other years as well. If we omitted participants with previous events of depression at the age of 60, we would also considerably reduce the prevalence in the following years whilst the amount of incident cases should not be affected. Therefore, previous illness was not an exclusion criterion for participation in analysis of mental disorders. Furthermore, as regular work and severe depression are adversely associated [75-78], exclusion of participants who were not fully active workers was also problematic for the abovementioned reasons. The solution was to only exclude workers if they were not part of the workforce. Thus, all participants who were employed or ready to take a job (such as the unemployed) were included. Other individuals, such as workers on disability pension, were excluded.

3.1.2 Registers used

Table 3 shows the registers and variables used in the analyses. Only data actually used for analyses in the 3 articles are included. Data on sex, age, family type, residence, and migration were obtained from the Civil Registration System [79]. The register also included a unique personal identification number that allowed for individual level linkage to other administrative and health registers. Data on hospital discharge and deaths from cardiovascular diseases were obtained from the Danish National Patient Registry [80] and the Danish Registry of Mortality [81]. These registers include diagnoses of all hospital discharges since 1990 and all deaths since 1977. Information on hospital treatment for depression was drawn from The Danish Central Psychiatric Research Register [82] that includes all discharge codes for in- and outpatients with psychiatric treatment and diagnoses in Danish hospitals since 1969. Information on purchase of antidepressants was drawn from the Danish National Prescription Registry [83], a national Danish registry containing data on all purchases of prescription medication at Danish pharmacies since January 1st, 1995. We obtained data on old-age pension from the Register-based Labour Force Statistics [84] on PEW, and disability pension from the Danish Register for Evaluation of Marginalization [85].
The Population Education Register [86] provided information on highest completed education among participants. The Salary Information Register [87] provided information on disposable income.

<table>
<thead>
<tr>
<th>Table 3: Register used for analyses</th>
<th>Variables (content):</th>
<th>Used for articles:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic Registers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Civil Registration System [79]</td>
<td>Sex, age, family, residence</td>
<td>1,2,3</td>
</tr>
<tr>
<td>Population Education Register [86]</td>
<td>Highest education</td>
<td>1,2,3</td>
</tr>
<tr>
<td>Salary Information Register [87]</td>
<td>Disposable income</td>
<td>1,3</td>
</tr>
<tr>
<td><strong>Occupational Registers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Danish Reg. for Evaluation of Marginalization [85]</td>
<td>Early retirement, work status</td>
<td>1,2,3</td>
</tr>
<tr>
<td>Register-based Labour Force Statistics [84]</td>
<td>Retirement, Occup. group</td>
<td>1,2,3</td>
</tr>
<tr>
<td><strong>Health Registers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Danish National Prescription Registry [83]</td>
<td>Antidepressant purchase</td>
<td>2,3</td>
</tr>
<tr>
<td>Danish Central Psychiatric Research Register [82]</td>
<td>Hospitalization for depression</td>
<td>2,3</td>
</tr>
<tr>
<td>Danish Registry of Mortality [81]</td>
<td>Fatal event of MI</td>
<td>1,3</td>
</tr>
<tr>
<td>Danish National Patient Registry [80]</td>
<td>HTD for MI and depression</td>
<td>1,3</td>
</tr>
</tbody>
</table>

### 3.1.3 Assessment of retirement

Retirement was measured using register information from the Danish Register for Evaluation of Marginalization [85] and Register-based Labour Force Statistics [84]. Participants were considered retired from the first time they took retirement. That is receiving payment from the PEW program or being registered with retirement as the primary occupational status in the Register-based Labour Force Statistics. Workers who retired on disability pension were removed from the study population.

The measure involves certain challenges. Often the retirement process is not clean-cut and may involve a gradual process from full time work to full time retirement. This could be a period of unemployment preceding the retirement point, as unemployment is a strong predictor for retirement [62]. In those
cases the retirement point was considered the day of change from unemployment to retirement rather than the change from work to unemployment. Another challenge is part time work as a limited amount of work is allowed despite subsidies and official status as retired. In all cases the first registration of benefits from a retirement program was considered the point of retirement.

3.1.4 Assessment of MI
Relevant diagnosis included Acute MI, MI or complications following MI (ICD-8 codes of 410; ICD-10 codes of I21 to I23). Furthermore those data were supplemented with data from Danish Register of Mortality [81] as fatal events of disease may happen without hospitalization. The admission date was considered the time of the event.

3.1.5 Assessment of Depression
Relevant diagnosis included hospital treatment due to depression (ICD-10 codes of F32 to F33). Again, the admission date was considered the time of the event. For analyses of prevalence, individuals being hospitalized during a calendar year were considered prevalent that given year.

Antidepressants were defined as medications coded N06A by the anatomical therapeutic chemical classification [97]. Individuals having redeemed at least one purchase of antidepressant during a calendar year were categorized as prevalent antidepressant purchasers. Likewise hospital treatment for depression during a calendar year resulted in categorization as having depression that year.

3.1.6 Statistical analysis
Two methods were used in order to analyse the data. Cox proportional hazards model [98,101] was chosen for analysis of myocardial infarction whereas logistic regressions with generalized estimating equations (GEE) were used for analysis of depression [99]. In the analysis of job groups, Cox regression was chosen for both outcomes to increase the comparability between the analyses.
3.1.7 Article 1 and 3

Cox regression is a method for investigating the effect of several variables upon the time a specified event takes place, in this case onset of MI or depression. The probability of our endpoint, the hazard, is estimated using the following equation:

\[ H(t) = H_0(t) \times \exp(b_1X_1 + b_2X_2 + b_3X_3 + \cdots + b_kX_k) \]

Where \( X_1 \ldots X_k \) are a range of predictor variables and \( H_0(t) \) is the baseline hazard at time \( t \), representing the hazard for an individual with the value 0 for all the predictor variables. By dividing both sides of the above equation by \( H_0(t) \) and taking logarithms, we obtain:

\[ \ln \left( \frac{H(t)}{H_0(t)} \right) = b_1X_1 + b_2X_2 + b_3X_3 + \cdots + b_kX_k \]

\( H(t) / H_0(t) \) is the hazard ratio. The coefficients \( b_1 \ldots b_k \) are those of our interest, and can be interpreted similar to coefficients of multiple logistic regression. [98,101]

The investigated variables can either be fixed at baseline, such as sex, or changing over time such as retirement status. Cox regression was favoured over other methods as it offers significant advantages: Cox regression gives opportunity to analyse longitudinal data with variables changing over time, which is crucial as the exposure variable is time dependant. Also Cox regression can handle censoring well, which is necessary when including participants with fatal events before their retirement. [98,101]

When analysing prospective data where individuals are followed over time, investigated factors measured with variables may also change with time. A covariate is time dependent if a participant can change status during the follow-up; e.g. income. A covariate is fixed if its values cannot change with time, e.g. sex. Furthermore some variables may be considered fixed and measured by its baseline value even though it potentially could change over time during follow-up. The only variable in our analyses we treated as time-dependent was the measure of our exposure - retirement. In our analyses all participants
were active workers at baseline but during follow-up most participants took retirement. As Cox regression can handle such time-dependant variables the method is well suited for analysis of retirement and onset of disease. Other variables may change over time as well, such as income or residence, however changes in income and residence following retirement could also be an effect of retirement rather than only a predictor. Adjusting for a mediating factor could blur our association of interest. Hence we decided not to consider all variables except retirement status as fixed and measured them during the entire follow-up by its baseline value.

3.1.8 Article 2
For analysis of depression we used logistic regressions with GEE’s [85]. For each year during follow-up the prevalence of depression among the participants was calculated. Only participants with valid data before and after retirement were considered for the analysis population. The year of retirement was set as year-0 and the prevalence before and after retirement (year -5 to year +5) was estimated. The estimates were shown in a diagram showing a health trajectory before and after retirement for the population. A change in disease prevalence around retirement would be indicative of an association between retirement and disease. We hypothesized a reduced disease prevalence following retirement. One advantage of this method is that prevalence of disease is measured within the same group of participants across the entire follow-up. Thus the model is by design adjusted for all covariates that does not change over time. This is a major advantage in a register study where many important factors does not appear in the registers and are impossible to adjust for in a statistical model.
4 Results

Risk of MI, hospital treatment for depression, and purchase of antidepressants were analysed in relation to retirement. The findings were reported in three papers. The first paper was analysing risk of MI following retirement. The second paper was analysing trends in hospital treatment for depression and antidepressant purchase around retirement, whereas the third paper analysed risk of MI and HTD with specific focus on some larger job groups representing knowledge-, client- or manual work.

Even though we have had access to data from a full national population, descriptive statistics for our study population differ from other national statistics as our study population was selected on various criterions. Participants not occupied with regular full-time work at baseline were excluded. Thus participants from lower social classes also have poor representation in our study population compared to available national data. Figure 4 shows population characteristics of the retirement pattern of the population used for the time to event analyses (article 1).
Figure 4 shows the proportion of active and retired workers in the study population by age group. By design all workers were active at the age of 60. During follow-up most of the workers took retirement and at the age of 67 a vast majority of the workers had taken retirement. At the beginnings of the follow-up the figure represents 617,551 workers due to right-censoring the number diminishes at the end. Workers with low income generally retired at an earlier age. A contributing reason for the difference could be the PEW, which gives workers with low wages relatively higher incentives to retire early. Among those early retirees were also teachers and day-care workers with relatively high education and low physical demands in their job. Self-employed, highly educated workers and other workers with high incomes were on the other hand the participants with high average retire age.

In the study population we found a moderately increased risk of MI following retirement (HR = 1.11 (1.05-1.16)). The association is weak but nevertheless statistically significant. In further analyses we stratified on retirement age, calendar year of retirement, retirement program, sex, socioeconomic status, income and education, co-habitation, and residence. However, in neither of those analyses we found effects which differed significantly from the main effect for the full population. It was however still our hypothesis that work environment and MI is associated and therefore a hypothesis, that removal of work environment, such as with retirement, would alter the risk of MI. Consequently we hypothesised that the alteration of risk would depend on the kind of work environment from which the individual retired. Thus we designed another study were we used national representative data to identify job groups with 3 different types of work environment: Knowledge-work, client-work and manual work. The corresponding job groups were identified in our full population via register data, and analyses of risk of MI following retirement were carried out in each individual group. However, for neither of the analysed job groups we found results different from the previously reported main effect of 1.11. For knowledge workers the estimate was (HR=1.19; 95% CI:1.06-1.33), for client work the estimate was (HR=1.14; 95% CI:0.96-1.35) and manual work the estimate (HR=1.13; 95% CI:0.97-1.31).
Based on previous recent studies [4,5,7] we hypothesised that retirement is beneficial for mental health. We modelled prevalence of antidepressant purchase and hospital treatment for depression around the year of retirement and adjusted the values for the increasing secular trend in treatment for mental disorders. We were then visually able to observe the trend and see if it changed around or after the point of retirement. We did not observe the hypothesised effect of retirement neither for antidepressant purchase nor for HTD. For antidepressant purchase we observed an increasing trend during the entire observation period. For HTD we observed a steep increase in prevalence starting before retirement and stabilizing following the retirement without decline to the low levels 3-5 years before retirement. Thus we did not confirm our hypothesis that retirement is beneficial for mental health. Furthermore we carried out analyses of HTD following retirement among workers of knowledge-, client-, and manual work, this time using Cox-regression. Neither of those analyses showed beneficial effects of retirement regardless of the work environment. We did however observe different estimates of deleterious effects for retirement from each work domain. For knowledge workers the estimate was [HR=1.27; 95% CI:0.83-1.93], for client work the estimate was (HR=1.37; 95% CI:1.06-1.77) and manual work the estimate (HR=1.86; 95% CI:1.20-1.89). If anything, those estimates indicate increased risk of HTD following retirement rather than confirming our hypothesis.

Thus the overall hypothesis of the project, that retirement is beneficial for cardiovascular and mental health, was not confirmed by findings from any of our studies.
Discussion

It was our original hypothesis that removal of deleterious work environment would be beneficial for mental and physical health. Thus the health problems among elderly workers could be solved by improvements in work environment for this group. This hypothesis was based on findings from earlier studies and was not confirmed. However, our findings were in line with more recent results. Moon and colleagues [71] found increased risk of MI and stroke following retirement in a US representative population. Behncke also report deleterious cardiovascular effects of retirement [72]. Thus the only recent study on CVD following retirement which does not find increased risk of CVD is Westerlund and colleagues [5] who do not find any effect of retirement on cardiovascular health. Studies on mental health following retirement tell a similar story. In two Finnish studies on psychotropic use neither Laaksonen [65] nor Leinonen [66] found evidence for beneficial effects of retirement.

Thus our findings are different from the studies which originally influenced our hypothesis but in line with more recent studies on the topic. The recent development is disappointing as researchers only a few years ago talked about consistency in findings [7] which now seems to be more complex than anticipated.

There are several potential explanations for the discrepancy between our results and earlier studies. Westerlund and colleagues explained the previous consistency in results by consistent use of longitudinal designs [7] instead of cross-sectional designs which were normal in early studies [50]. There is however another noteworthy observation when comparing results on recent studies on health following retirement, including results from this project. Studies with subjective outcomes tends to report beneficial effects of retirement to a higher extent than studies using more objective or medically certified outcomes. Westerlund and colleagues’ study on self-report benefits from 2009 [4] reported clear benefits; the same did other GAZEL studies on self-reported fatigue [5], sleep disturbance [8] and headache [9]. Also outside the GAZEL cohort beneficial effects of retirement was found [6,10,11], indicating that the tendency does not emerge from special work or retirement conditions among the GAZEL workers. Studies on alcohol consumption [37], which despite being self-reported does not involve perception of a condition, only showed minor effects of retirement. Likewise, no association was found between retirement
and chronic condition in another analysis based on the GAZEL cohort. Roberts found reduced cognitive performance among retirees from the Whitehall II study, using a short-term memory test [100]. Among other medically certified outcomes neither Laaksonen [65] nor Leinonen [66] found beneficial effects of retirement on psychotropic drug use, whilst Moon [71] and Behncke [72] found deleterious effects of retirement on CVD. Finally in our project we found no beneficial effects of retirement, when using medically certified outcomes from national health registries.

The studies on the GAZEL cohort is generally of high quality, the design is longitudinal with yearly measurements, the methods are thoroughly described, the number of participants high, and the results have been reported in high ranked journals such as The Lancet [4] and BMJ [5]. Thus scientific quality is not a satisfying explanation for the discrepancy. Furthermore in a study of chronic conditions and fatigue [5] on the same population using similar methods, Westerlund and colleagues found no effects of retirement on chronic conditions but beneficial effects on fatigue. Likewise, in another double-outcome study, Neuman [11] found beneficial effects of retirement on subjective health but no effect on chronic conditions on his study on data from “the US Health and Retirement Study” [11]. Thus different study populations or different methodology is insufficient explanations on why retirement seems to be beneficial for “subjective health” but not for medically certified health. Also it has to be acknowledged that medically certified outcomes and subjective perception of health are in fact different outcomes so the results are not per se in conflict.

Retirement may be beneficial for some health aspects while deleterious for others. If we assume that none of the referred studies are severely biased we may conclude that individuals may feel better following their retirement despite unchanged risk of illness.

There is a potential bias when using self-reports to estimate prevalence of morbidity around the point of retirement. Individuals may tend to compare themselves to a reference group of their peers [88,102]. Older workers may generally compare themselves to their younger and relatively healthier colleagues, whereas relatively young retirees to a larger extend may compare themselves to other retirees, resulting in a lower standard for “good health” [89]. Signs of sub-optimum health may also become more obvious for workers who are daily exposed to challenges from the work environment compared to
retirees who may less frequently be confronted with the limits of their mental and physical capacities. Thus, active worker might perceive their health as worse than retired worker even if their risk of chronic diseases is identical.

The studies on GAZEL data is generally of high quality [68] and thus unlikely to be severely biased. Both findings from the present project and previous studies, mainly based on the GAZEL cohort, bring important and unbiased messages to the table. An overall explanation of the different results could be that many workers have a subjective feeling of improved health following retirement; however their medical health condition has not improved accordingly. It also has to be noted that Oksanen and colleagues actually found beneficial effects of retirement on antidepressant use [7] even though two other Finnish studies were unable to verify the conclusion [65,66]. Thus the above-mentioned conclusion is not based on consistent findings. Further studies on medically certified outcomes are needed to evaluate the effect of retirement on objective health.

5.1.1 Method discussion

It was an aim of the project to analyse health consequences of retirement using full population data with medically certified outcomes. The registry-linkage approach offered several advantages compared to existing studies. We were able to utilize a larger pool of data than any other previous study on the topic. Furthermore, with register data we could analyse health effects from retirement in a full population free of unintended selection mechanisms into our study population. We were also able to obtain precise data back in time without the limitation of possible recall bias among the participants. Furthermore we had the advantage of standardised categorisation. However the registries possessed a major drawback. They were never constructed with scientific research as main purpose and did not contain all information of relevance. Particularly information of qualitative character, such as lifestyle, motivation for retirement, expectations to the future and degree of social life was completely missing. Another main limitation was the Danish retirement structure with a flexible retirement age, which introduced risk of selection into retirement.
Until Westerlund and colleagues published their first study on health following retirement in 2009 [4], a popular methodological approach was to estimate prevalence of disease before and after retirement and then determine the effect of retirement on health based on the trend in prevalence, often referred to as the health trajectory. The approach was used by the studies based on the GAZEL cohort [4-9,36,37] but also by studies using different data sources [6,7,65,66]. Other recent studies have taken different approaches and used time to event analysis or instrumental variable models (IV models) [10,11,67,71,72]. The popularity of health trajectory analysis may emerge from its advantages regarding confounding adjustment and reverse causality. If all participants in a study population retire at the same age, it will not be possible to use methods which compare workers to retirees of the same age. Furthermore, if the retirement age is flexible and to some extent is influenced by some vulnerability of the participants, the analyses will still have to be adjusted for that vulnerability. Health trajectory analysis offers certain advantages and limitations. One major advantage is that the models are based upon within-individual change and inherently adjusted for all factors which do not change within an individual over time. Thus the models are adjusted for known and unknown factors which could predict early retirement, as well as being associated with the outcome event. This is a huge advantage in a register study with limited access to measures for relevant cofounders. Unfortunately the analysis also has noteworthy weaknesses. First of all, it works best when analysing prevalence of an illness, as the analysis is vulnerable to bias if analysing incidence. When analysing incidence, participants who have experienced an event will be excluded from further analyses, introducing unbalance in the representation over time, as vulnerable participants may be overrepresented in the first part of the trajectory before they are censored. Another weakness emerges if the event, or an associated effect can prevent the participant from taking retirement or for other reasons be excluded from the study. For example, potential participants with fatal events of a cardiovascular disease before their retirement, will never be considered in the study if retirement is an inclusion criterion for the study population. As a result pre-retirement prevalence will be underestimated.
5.1.2 Method choice 1

With those considerations in mind we decided to use Cox regression when analysing incidences of MI. As fatal events of MI before retirement would introduce bias we sacrificed the advantages of the health trajectory model in favour of Cox regression which gave good opportunity for handling censoring and our time-dependant exposure, retirement. Furthermore, cardiovascular diseases are not strong predictors for non-health based early retirement [19,20], which was also confirmed by data from our own population. An explanation could be that being at risk of a serious disease does not necessarily affect work capacity, particularly not when being treated. Individuals might also choose to continue working despite illness because of perceived beneficial effects of engaging in a challenging and rewarding activity [19]. The risk of reverse causality, i.e. ill workers retire early, was not as imminent as if exposure and outcome were strongly correlated. Thus we opted Cox-regression as our favourite methodological approach for analysing the association between retirement and MI. In this design we followed active and retired workers free of IHD. At each point in time we model the risk of incident MI among participants in each group and test if participants in one of the group have an increased risk compared to the other.

5.1.3 Method choice 2

For the analysis of mental disorders we did however use a health trajectory model. Mental disorders are, to a higher extent than cardiovascular disease, associated with early retirement [19,20]. Mental disorders often involves absence of ordinary full-time work [24], and treatment for depression at old age is often associated with treatment earlier in life (Data not shown) making it problematic to establish the causal order of exposure and outcome. Thus we had the following special challenges:

1) We could not assume a healthy baseline population.

2) Using full-time work as inclusion criterion for the study population at a given baseline, would introduce bias as participants vulnerable to mental disorders is expected to be overrepresented among less active workers.
3) We would be unable to establish the causal direction of retirement and poor mental health.

To accommodate those challenges we decided to use health trajectory analysis rather than Cox-regression for the analyses of mental disorders. Mental disorders are not directly fatal which makes health trajectory analysis a viable option unlike an analysis of MI. Thus we took a methodological choice that turned out to be the same as the authors of the three previous studies of psychotropic drug use in relation to retirement [7,65,66].

5.1.4 Strengths and limitations

The main strength of the methods was the large unselected population data comprising full national data for 2 decades. The present registers provided data of high quality with respect to completeness and comparability virtually without non-response, loss of follow up or recall bias. Furthermore, the data allowed prospective designs which are important for analysis of health in relation to retirement [8] in order to reduce the risk of reverse causality by establishing the temporal sequence of retirement and the health outcome. The utilization of national health registries allowed analyses on medically certified outcomes which gave opportunity to study health outcomes completely free of personal perception, which could have been modified by retirement status. It is however still a limitation that hospital admission may be influenced by factors such as socio-economic status [90]. Our data is limited to treated illness and does not reflect a complete picture of illness in the population. However, only if retired workers were more or less prone to seek treatment than active workers, this would be a source of bias. The Scandinavian welfare state setting of the project ensured free access to medical care for the participants regardless of social status. Thus poor economy followed by retirement is unlikely to affect decisions to seek health treatment.

A common limitation of registry-linage studies is lack of information on health behaviour and work environment. Thus, we had no direct measures for work environment, lifestyle, job satisfaction, reason for retirement, etc. With regard to the work environment, Westerlund and colleagues reported that the beneficial effect of retirement on self-rated health was strongest among employees
with the most adverse work environment [4]. This indicates that the work environment might be an important effect modifier, which unfortunately we did not have opportunity to include directly in our study. Our third article, where we compared different job groups, was an attempt to make up for this shortcoming.

Reverse causality, or a healthy worker effect, is an inherent issue when studying health effects of retirement. If individuals at increased risk of an illness are more likely to retire than their lesser disposed colleagues, we would expect to observe a non-causal higher risk of MI among the retired workers. We chose our statistical approach specifically to address this possible bias, which resulted in use of both time to event analysis and health trajectory analysis. In Cox regression we were able to only include active workers in regular jobs free of previous IHD at age 60 into the study. It has to be noted that even though this approach solves potential problems with reverse causality, there may still be potential bias due to confounding. If vulnerable but undiagnosed workers are more likely to retire early than other workers, this vulnerability is a confounder. An example of such potential confounder is obesity which may be correlated with both early retirement and MI. In the health trajectory analysis the vulnerable participants were given equal weight both the years before and after retirement. Possible selection into retirement based on factors associated with MI could still have occurred in our time to event analyses. Such selection could explain the moderate increase in risk of MI we observe following retirement as well as the increased risk of HTD among most job groups.

Another limitation regards the measure of mental health. Antidepressant usage is relatively common whereas hospital treatment for depression is uncommon and only involves more severe cases. Prescribed antidepressants can be purchased for reasons other than depression. Furthermore a study comparing Danish purchases of antidepressants to the results from a questionnaire screening indicates that residents with low SES are underrepresented when using antidepressant purchase as indicator of depression [90]. As HTD is an actual medical diagnosis of depression, and not an imperfect proxy, misclassification is only a problem if the diagnosis is wrong. Thus, when using HTD as indicator of depression we sacrifice specificity for high sensitivity. With antidepressant purchase both sensitivity and specificity are mediocre. However,
despite lower specificity all purchasers of antidepressants have been consulting a physician who has opted for a prescription. Thus we assume the purchasers of antidepressants have, if not depression, some suboptimum mental health which nevertheless is undesirable.

### 5.1.5 Perspectives

The field is still far from fully explored, but if we assume that working at an old age is not harmful for medically diagnosed health it will be good news from a policy point of view. As addressed in the introduction residents throughout the OECD countries may have to work to an old age – in Denmark the future retirement age is already by law made dependent on longevity. This means that the future generations may actually be able to work longer without being at an increased risk of chronic disease. However, our study was carried out during our current retirement structure. We can assume that our results can be extrapolated to a future scenario in which the retirement age has been considerably increased. Unfortunately we have no way to test that claim.

The feeling of health improvements among retirees, as shown by Westerlund and colleagues [4-9], is still an important concern which may be worse with increased retirement age. The feeling of improved health following retirement indicates room for improvements in the work environment for elderly workers. It should be the aim of future studies to identify and address deleterious working conditions for the oldest active workers, as we can expect to see more active workers in their 60’s and even 70’s in near future.
6 Summaries

6.1.1 English summary

Previous studies have shown beneficial health effects of retirement on self-reported health. It was largely unknown if the findings could be extrapolated to other populations and be confirmed using medically certified endpoints.

It was the overall aim of the project to investigate if retirement is beneficial for cardiovascular- and mental health. We furthermore analysed whether retirement from particularly demanding work is beneficial for mental and cardiovascular health.

In our first study we examined if the risk of myocardial infarction (MI) was reduced following retirement in a Danish population sample. Information on retirement and MI were obtained from Danish national registers on 617,511 participants. Three percent of the population were diagnosed with MI during the follow up period. Retirement was associated with a modestly higher risk of MI with a hazard ratio (HR) of 1.11 (95% CI=1.06-1.16) when comparing retired workers with active workers of the same age. We did not confirm our overall hypothesis that retirement was beneficial for cardiovascular health.

In the second study we analysed health trajectories of mental health in relation to retirement. Again, we hypothesized that retirement is beneficial for mental health in accordance with existing literature. After adjusting for the increasing secular trend in treatment of mental disorders we analysed prevalence of antidepressant purchase and hospital treatment for depression (HTD) among 245,082 Danish residents who took retirement from 2000-2006. For both outcomes we observed an increased prevalence of treatment for mental disorders during the observation window. As prevalence of treatment increased during or after retirement without declining to pre-retirement levels, we rejected our hypothesis, that retirement is beneficial for mental health.

In the third study we analysed effects of retirement on HTD and MI within job groups with particularly high job demands. Using cox-regression we followed
38,373 knowledge workers with high cognitive demands, 64,554 client workers with high emotional demands, and 28,050 manual workers with high physical demands. In neither of the job domains we found beneficial effects of retirement despite the relief from jobs with high demands. On the contrary, we found increased risk of HTD among manual workers (HR = 1.86; 95% CI: 1.20-2.89) following retirement.

In conclusion we did not find beneficial effects of retirement on cardiovascular and mental health following retirement. This was particularly surprising with respect to mental health as previous studies indicated beneficial effects. Use of medically certified endpoints is a possible explanation of the apparent discrepancy between our study and previous studies on self-reported health.
6.1.2 Dansk Resume (Danish Summary)

Tidligere studier af selvvurderet helbred har påvist helbredsforbedringer som følge af tilbagetrækning fra arbejdsmarkedet. Det er dog uvist, om disse fund også gælder i andre populationer eller med medicinske malinger som udfald.

Det var formålet med dette projekt at undersøge om pensionering er gavnligt for mental sundhed og risiko for hjertesygdom. Yderligere ville vi undersøge om pensionering var særlig gavnlig for personer i jobs med særligt krævende arbejdsmiljø.

I vores første studie undersøgte vi om risikoen for myokardie infarkt blev reduceret som følge af pensionering. Vi indhentede og sammenkoblede data fra de danske registre på 617.511 deltageres pensionering og eventuelle MI diagnoser. Tre procent af deltagerne blev diagnosticeret med MI I løbet af opfølgningsperioden. Pensionering og MI viste sig at hænge sammen med en hasard ratio på 1,11 (95% konfidensinterval = 1,06-1,16) når efterlønnere og pensionister sammenlignedes med deltagere på arbejdsmarkedet. Således kunne vi ikke bekræfte hypotesen, at pensionering nedsætter risikoen for MI.

I vores andet studie undersøgte vi forløbet af populations helbredskurver omkring tilbagetrækningstidspunktet. Med udgangspunkt i den eksisterende litteratur var vores hypotese, at pensionering er gavnligt for mental sundhed. Efter at have taget højde den øgede behandling af psykisk sygdom, undersøgte vi prævalensen af hospitalsindlæggelse og køb af antidepressiver i årene omkring tilbagetrækningstidspunktet blandt 245.082 danskere der gik på pension i perioden 2000-2006. For begge udfald fandt vi en general stigning I sygdomsbehandlingen under opfølgningsperioden. Omfanget af hospitalsbehandling for depression og køb af antidepressiver steg i forbindelse med pensionering uden at falde tilbage til udgangsniveauet og vi kunne dermed afvise vores hypotese, at pensionering var gavnligt for psykisk helbred.

I tredje studie analyserede vi effekten af pensionering for hospitalsbehandling for depression og MI, indenfor udvalgte jobgrupper med høje krav i arbejdsmiljøet. Ved brug af cox-regression fulgte vi 83.373 vidensarbejdere med høje kognitive krav; 64.554 omsorgsarbejdere med høje følelsesmæssige
krav og 28.050 manuelle arbejdere med høje fysiske krav. Vi fandt ikke
helbredsforbedrende effekter i nogen af de undersøgte jobgrupper, på trods af
kravene i det arbejdsmiljø de forlod. Omvendt fandt vi en øget risiko for
hospitalsbehandling for depression blandt manuelle arbejdere (HR = 1,86;
95% CI: 1,20-2,89) efter deres pensionering.

Konklusionen på projektet blev, at vi foreløbig måtte forkastede hypotesen
ikke fandt gavnlige effekter af pensionering på hjertesygdom og depression.
Dette var særligt overraskende i forhold til psykisk helbred, idet tidligere
studier i høj grad har indikeret gavnlige effekter. Brugen af registerdata og
lægeordineret medicin og diagnosticering er en mulig forklaring på
misforholdet mellem resultaterne fra vores projekt og tidligere studier
baseret på selvrappor tert helbred.
6.1.3 References

1 OECD, Health Reform: Meeting the Challenge of Ageing and Multiple Morbidities, OECD Publishing


7 Appendices

Article 1: Does retirement reduce the risk of myocardial infarction? A prospective registry linkage study of 617,511 Danish workers

Article 2: Is retirement beneficial for mental health? – A national registry-linkage study of hospital treatment for depression and antidepressant purchases before and after retirement of 245,082 Danish residents

Article 3: Does Occupational Exposure Modify the Risk of Myocardial Infarction and Depression Following Retirement? – A study of Hospital Treatment for Myocardial Infarction and Depression among 623,993 Elderly Danish Residents
Does retirement reduce the risk of myocardial infarction? A prospective registry linkage study of 617,511 Danish workers

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Accepted 20 November 2013

Abstract

Background: Recent studies have suggested that retirement may have beneficial effects on health outcomes. In this study we examined whether the risk of myocardial infarction (MI) was reduced following retirement in a Danish population sample.

Methods: Participants were 617,511 Danish workers, born between 1932 and 1948, entering the study at the age of 60, without previous known incidents of ischaemic heart disease. Information on retirement and MI were obtained from Danish national registers. A Cox proportional hazard model was used to address the relation between retirement and onset of MI, while adjusting for age, sex, income, occupational position, education, cohabitation and immigrant status. The participants were followed for up to 7 years.

Results: Of the study population, 3% were diagnosed with MI during follow-up. Retirement was associated with a modestly higher risk of MI with a hazard ratio of 1.11 (95% confidence interval: 1.06, 1.16) when comparing retirees with active workers of the same age.

Conclusions: This study does not support the hypothesis that retirement reduces risk of MI. On the contrary, we find that retirement is associated with a modestly increased risk of MI.

Key words: Work, retirement, myocardial infarction, occupational health
Introduction

Demographic changes throughout the industrialized world will in the coming decades increase the proportions of retirees relative to the active workforce, and thus substantially impact on the economy. One strategy to address the demographic change is to raise the age of retirement in the population. However, little is known about potential health consequences of raising the retirement age.

Early studies on retirement and health consequences have produced inconsistent results. Some studies have found that health improves after retirement, whereas others were inconclusive or found a detracting effect on health after retirement. More recent studies based on prospective data more consistently indicate an improvement of health outcomes after retirement. If this apparent beneficial health effect of retirement could be corroborated in further studies, it would raise a major concern about the current plans of increasing the retirement age in several countries. However, most of these recent studies have examined self-reported measures, and studies that used medically certified outcomes have either shown a lack of association or suggested a deleterious effect of retirement. Studies with cardiovascular disease (CVD) as outcome are scarce, but recent findings have either shown lack of association or deleterious effects of retirement.

CVD is a major cause of morbidity and mortality in most high-income countries among middle-aged and elderly individuals. Exposures to adverse working conditions, in particular psychosocial factors, have been found to be prospectively associated with onset of CVD. As exposure to adverse working conditions is naturally terminated at time of retirement, the risk of CVD could also be expected to decrease. Conversely, retirement could also be associated with deleterious consequences such as loss of status, lack of stimulating activities or feelings of emptiness.

In this article we aim to examine the prospective relationship between retirement and risk of CVD based on unique detailed registry-linkage data on retirement and first-time incident MI. Our hypothesis is that retirement is associated with a reduced risk of MI due to a termination of exposure to adverse work conditions at time of retirement. We tested for both short-term and long-term effects of retirement, as retirement itself may be a stressful event triggering an immediate health effect, whereas other consequences of retirement such as life-style changes may take a longer time to affect health. Registers provide important advantages over questionnaire-based studies, by containing virtually complete information on all individuals in the population, only a negligible loss of follow-up due to migration, a standardized statutory recording of data and a large study population allowing high statistical power.

Materials and Methods

Study design and population

All Danish citizens have a unique personal identification number that allows for individual-level linkage to administrative and health registers. In this study we utilized this resource to create a registry-based cohort study including all Danish citizens born between 1932 and 1948. They were identified in the Central Person Registry (n = 1,066,964) and entered the study at the age of 60 years. Individuals who were not fully active workers at the age of 60, e.g. part-time working, on long-term sick leave or unemployed, were excluded (population reduced to 627,884). Based on hospital discharge records from 1990, we further excluded participants with a known history of ischaemic heart disease (IHD) before the age of 60 (ICD-8 codes 410 to 414, ICD-10 codes 121 to 125), population reduced to 618,065). Finally, we excluded individuals with missing data on variables used in the analyses, yielding a final cohort of 617,511 workers.

Assessment of retirement

We obtained data on occupational position and retirement from the Danish Register for Evaluation of Marginalization (DREAM) and the register-based labour force statistics. During the follow-up period (1992–2009), there were three main types of economic retirement available in Denmark. (i) The old-age pension, which was available for all workers at the age of 65 years and above: Possibilities

Key Messages

- In a nationwide register-based study, no health beneficial effect of retirement on incidence of MI was found.
- Instead, retirement was associated with a modestly increased risk of MI.
- These results are congruent with recent studies indicating that retirement might be protective against poor self-reported health, but not against medically certified health endpoints.
to keep working beyond the age of 65 relied on workplace culture and policy. (ii) The post-employment wage programme (PEW), which was available for qualifying workers from the age of 60. The eligibility for using PEW relied purely on age and sufficient tenure as a member of an unemployment fund. PEW was one of the major means by which Danes took early retirement during the follow-up. It was particularly attractive for workers with low wages as they could retain a higher percentage of their income compared with workers with higher wages. From 1999, PEW was revised, making it economically more attractive to stay active in the labour market longer. (iii) The disability pension, which was available for workers at any age, who for medical or psychological reasons are unable to work. For the purpose of this study we only considered retirement due to old age and due to the PEW. We consequently censored participants if they were awarded a disability pension, as MI following disability pensioning could be a consequence of their suboptimum health rather than a consequence of the retirement. Based on the retirement information from DREAM, we created a time-dependent retirement status variable with three categories: (i) Not retired, (ii) Newly retired (i.e., being retired for no more than 26 weeks) and (iii) Retired.

Assessment of MI
Data on hospital discharge and deaths were obtained from the Danish National Patient Registry and the Danish Registry of Mortality. These registers include diagnoses of all hospital discharges since 1990 and all deaths since 1977. Relevant diagnosis included acute MI, MI or complications following MI (ICD-8 codes of 410; ICD-10 codes of 121 to 123).

Assessment of baseline covariates
Information on sex, age, immigrant status, individual disposable income before retirement, highest education, residential area, cohabitation and cardiovascular medications were derived from national registers. All variables were measured immediately before the individual entered the study. All immigrants, regardless of nationality and ethnicity, were considered immigrants whereas Danes and descendants of immigrants constituted the group of Danes. Disposable income (i.e. income after taxes) was adjusted for inflation with the year of 2000 as base and divided into five categories of Danish kroner (DKK): ‘<100,000’, ‘100,000–200,000’, ‘200,000–300,000’, ‘300,000–400,000’ and ‘>400,000’. An income of <100,000 is less than a worker would normally earn even in a low-wage job. Some of the participants in the group have had periods of unemployment in the income year despite being fully economic active at the baseline. As the income group is mixed and the results are incomprehensible we have only included the group in the tables for the sake of completeness. Highest education was divided into four categories based on the categorization from Statistics Denmark: ‘Unknown education’, ‘Public school’, ‘Craftsman’ and ‘Higher education’. Residential area was divided into three categories: ‘Copenhagen’, ‘Larger municipalities’ (municipalities with more than 100,000 inhabitants) and ‘Other’ (smaller towns and rural areas). On the basis of categorization by Statistics Denmark, we classified occupational position into six grades according to employment grade and job title: Top leaders, High skill requirements, Medium skill requirements, Low skill requirements, Self-employed and Other. Cohabitation was defined as being in a formal relationship or residing with an unrelated person of the opposite sex with no more than 15 years age difference. Information on cardiovascular medication was drawn from the Register of Medicinal Product Statistics. Cardiovascular medications were defined as medications coded ‘C’ by the anatomical therapeutic chemical classification.

Statistical analysis
We used Cox proportional hazard models to calculate hazard ratios (HRs) and 95% confidence intervals (CIs) for the association between the time-dependent retirement status and incidence of MI. The analysis was based on 18 years (940 weeks) of continuous observation from 1992 to the end of 2009. Participants were followed up from the week they turned 60 years and until event (incident MI), censoring due to death, migration, disability pensioning, unemployment, sickness absence of more than 26 weeks or end of follow-up (i.e. completion of 7 years of follow-up), whichever came first. The follow-up ended after 7 years. At this point only a highly selected group of individuals remained as active workers. We adjusted the models for baseline measures of sex, immigrant status, disposable income, education level, occupational status, residential area, cohabitation and year of entering the study. The models were age-adjusted by design as the underlying time is proportionally equivalent to the age. A test for proportional hazards of the exposure variable supported use of the method ($P = 0.44$). To identify potentially vulnerable subgroups, we estimated separate models stratified by sex, occupational position, residential area and cohabitation. As persons with subclinical IHD may have a higher likelihood of early retirement, and to address such reverse causality, we included a sensitivity analysis on a sub-sample of the population free of any prescribed cardiovascular
medication before baseline. Because the register on prescribed medication was established in 1995, only participants who entered the study from 1996 onwards were included for this sensitivity analysis.

All statistical analyses were performed using SAS 9.2 (SAS Institute, Cary, NC).

**Results**

Table 1 shows the distribution of the study population at baseline and the percentage of active workers during follow-up. The percentage of workers still active was 58% at age 62, 27% at age 65 and 7% at age 67 years. Workers with lower education, skill requirements and income were more likely to retire early. An exception was the category of workers with very low disposable incomes (<100,000), which was the income group with most active workers across all ages during follow-up. Women, ethnic Danes, workers from outside Copenhagen and cohabiting workers were slightly more likely to retire early than their counterparts.

Table 2 shows the results of the baseline-year adjusted Cox regression model for the association between the time-dependent retirement status and risk of MI. In model 1, new retirees and retirees had a hazard rate similar to that of the reference group of active workers. When we adjusted for covariates, both the newly retired (HR = 1.08, 95% CI: 1.00, 1.17) and the retired (HR = 1.11, 95% CI: 1.06, 1.16) were at higher risk of MI compared with the reference group. The difference between model 1 and the fully adjusted model can mainly be explained by confounding by sex, as women generally retire earlier and have a
reduced risk of MI compared with men of the same age-group.

The sensitivity analysis showed that the risk of MI following retirement was similar for workers who did not use cardiovascular medication before baseline (HR = 1.13; 95% CI: 1.06, 1.20) and for workers who used cardiovascular medicine (HR = 1.10; 95% CI: 1.02, 1.17) (data not shown).

Table 3 shows the HR of retirement on risk of MI incidence stratified by sex, occupational position, residential area and cohabitation status. Most associations in the stratified models were modest and generally in line with the effects of the overall population shown in Table 2. Whereas men appeared to have a stable higher risk of MI following retirement, women appeared to experience a temporary benefit of retirement (HR = 0.84; 95% CI: 0.66, 1.03) followed by an increased risk later on (HR = 1.14; 95% CI: 1.03, 1.27). A relatively high estimated effect was found among retired top leaders (HR = 1.25; 95% CI: 0.99, 1.59), whereas retirees from larger municipalities appeared to have short-term (HR = 0.89; 95% CI: 0.65, 1.21) and long-term (HR = 0.92; 95% CI: 0.77, 1.10) reduced risk of MI following retirement.

Discussion

In this register-based study comprising an unselected sample of all Danish workers free of IHD, retirement was followed by a modestly increased risk of MI. These results are contrary to our hypothesis of a beneficial effect of retirement, which was based on recent European studies showing a beneficial effect of retirement on health endpoints such as self-rated health, sleep, fatigue and depression. However, the results are in line with recent studies on retirement and chronic disorder. For example, Westerlund and colleagues did not find the hypothesized benefits of retirement with respect to risk of chronic disease in the French GAZEL cohort, and Moon and colleagues found a higher risk of MI and stroke following retirement using the US nationally representative Health and Retirement Study. Behncke found that retirement raised the risk of cardiovascular diseases in a population of UK workers born before 1952. The present study places itself in between those studies, with its estimates of a modestly higher risk of MI following retirement. To our knowledge this is the first study that analyses onset of MI in an entire national population. We are also the first to establish the association between retirement and CVD without relying on self-reports. Earlier studies used smaller populations and the use of self-reported measurements rendered their results vulnerable to misclassification and selection bias.

The differences in results from studies based on medically certified and self-reported outcomes are not per se in conflict. Retirement may be beneficial for certain health aspects while deleterious for others. Several methodological issues could also explain differences between self-reported and medically certified outcomes when studying health trajectories following retirement. Individuals may tend to compare themselves with a reference group of their peers. Older workers may generally compare themselves with their younger and relatively healthier colleagues, whereas retirees to a larger extent may compare themselves with other retirees, resulting in a lower standard for ‘good health’. Signs of suboptimal health may also become more obvious for workers who are daily exposed to challenges from the work environment compared with retirees.

Table 2. Number of person-years and events. Results of two adjusted proportional hazard models estimating risk of MI among newly retired and retired workers compared with active workers, Denmark, 1992–2009

<table>
<thead>
<tr>
<th></th>
<th>Person-years (thousands)</th>
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<td>5800</td>
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<td>12 167</td>
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a Adjusted only for baseline year.
b Adjusted for baseline year, sex, occupational position, education, income, residential area, cohabitation and being immigrant.
Table 3. Number of person-years and events. Results of adjusted\textsuperscript{a} proportional hazard models estimating risk of MI among newly retired and retired workers compared with active workers with the same baseline characteristics, Denmark 1992–2009

<table>
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<th>HR</th>
<th>95% confidence limits</th>
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<td>Active workers (Ref)</td>
<td>1358</td>
<td>4789</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Newly retired workers</td>
<td>187</td>
<td>655</td>
<td>1.08</td>
<td>1.00</td>
</tr>
<tr>
<td>Retired workers</td>
<td>1916</td>
<td>4990</td>
<td>1.12</td>
<td>1.07</td>
</tr>
<tr>
<td>Living alone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active workers (Ref)</td>
<td>317</td>
<td>956</td>
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<td></td>
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<tr>
<td>Newly retired workers</td>
<td>40</td>
<td>104</td>
<td>0.95</td>
<td>0.77</td>
</tr>
<tr>
<td>Retired workers</td>
<td>404</td>
<td>909</td>
<td>1.10</td>
<td>0.99</td>
</tr>
<tr>
<td>Living with a partner</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active workers (Ref)</td>
<td>1320</td>
<td>4653</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Newly retired workers</td>
<td>185</td>
<td>654</td>
<td>1.10</td>
<td>1.01</td>
</tr>
<tr>
<td>Retired workers</td>
<td>1898</td>
<td>4891</td>
<td>1.11</td>
<td>1.06</td>
</tr>
<tr>
<td>Total</td>
<td>3403</td>
<td>10 198</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Adjusted for baseline year, sex, occupational position, education, income, residential area, cohabitation and being immigrant.
who may less frequently be confronted with the limits of their mental and physical capacities. Thus, active workers might perceive their health as worse than that of retired workers even if their risk of chronic disease was identical. Using a repeated within-individual measure of health around the retirement point has a potential disadvantage of underestimating fatal events before retirement if reaching retirement age is an inclusion criterion in the study. A discrete time to event analysis is, on the other hand, vulnerable to bias from selection into retirement based on health. Further, most of the recent studies that provide evidence for improved health following retirement have been performed on French data. Thus, cultural differences between countries could also have contributed to the discrepancies in findings.

The discrepancy in results between studies with self-reported and medically certified outcomes has also been found in studies using similar methods and populations. Westerlund and colleagues reported clear beneficial effects on self-reported health in the GAZEL cohort, whereas a study on chronic diseases with a similar population and method in GAZEL did not show any effect. This indicates that the differences in the results to a high extent emerge from the different natures of the outcomes and not only from different populations and statistical approaches.

Strengths and limitations

The main strengths of the study are the large unselected population sample, the 18 years of observations, and register-based assessment of both retirement and MI. Because the present study was based on registers of high quality with respect to completeness and comparability, we were able to study a full population virtually without nonresponse, loss of follow-up or recall bias. The prospective design reduced the risk of reverse causality by securing the temporal sequence of retirement and MI event. The Scandinavian welfare state setting of the study ensured free access to medical care regardless of social status.

Involuntary late-career job loss has previously been associated with higher risk of MI. A post hoc analysis of our data showed that retirement was often preceded with late career unemployment, and the modestly higher risk of MI following retirement might partly be due to involuntary job loss shortly before retirement.

A general limitation due to relying on register data is lack of information on health behaviours and the work environment. However, after adjustment for behavioural risk factors, body mass index, drinking and smoking, Moon and colleagues found a minor decline (HR change: 1.59 to 1.53) in the risk of CVD following retirement. With regard to the work environment, Westerlund and colleagues reported that the beneficial effect of retirement on self-rated health was strongest among employees with the most adverse work environment. This indicates that the work environment might be an important effect modifier, which, unfortunately, was not included in our study.

Reverse causality, or a healthy worker effect, is an inherent issue when studying health effects of retirement. If individuals at increased risk of MI are more likely to retire than their less so disposed colleagues we would expect to observe a non-causal higher risk of MI among the retired workers. To address this issue we only included active workers in regular jobs and free of previous IHD at age 60 years into the prospective study design. Further, we performed a sensitivity analysis in a sub-sample that was free of use of prescribed drugs for CVD or CVD risk factors, as an indicator of subclinical IHD. The results in the sensitivity analysis did not differ from the main result, indicating no substantial bias. In fact, workers using prescribed cardiovascular medications before baseline did not retire earlier than their seemingly more healthy colleagues. An explanation could be that being at risk of a serious disease does not necessarily affect work capacity, particularly not when being treated. Individuals might also choose to continue working despite illness because of perceived beneficial effects of engaging in a challenging and rewarding activity. Possible selection into retirement based on factors associated with MI could still have occurred, although we do not see any clear signs of this in our data. Such selection could be the explanation of the modestly increased risk of MI we observe following retirement. Finally, as workers with a previous history of IHD were excluded from the study, we cannot expand our conclusions to those workers. Thus, it remains unknown whether retirement is beneficial or harmful for workers with a previous history of IHD.

In conclusion, we observed a modestly increased risk of MI following retirement in an unselected population of 617,511 elderly Danish workers. Thus, the study does not support the hypothesis that retirement is beneficial for cardiovascular health.

Funding

This work was supported by the Danish Working Environment Research Fund [grant number: 25-2010-09].

Conflict of interest: None declared.

References


Is retirement beneficial for mental health? – A national registry-linkage study of hospital treatment for depression and antidepressant purchases before and after retirement of 245,082 Danish residents

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Key words: Health trajectory, retirement transition, mental health, depression, antidepressant medication, hospitalization

Word count: 2,984
ABSTRACT:

Objectives: The effect of retirement on mental health is not well understood. We examined the prevalence of hospital treatment for depression and purchase of antidepressant medication before, during and after retirement in a Danish population sample. We hypothesized that retirement was followed by reduced prevalence of hospital treatment for depression and antidepressant purchase.

Methods: Participants were 245,082 Danish workers who retired between 2000 and 2006. Information on retirement, hospital treatment and antidepressant purchases were obtained from Danish national registers. The yearly prevalence of hospital treatment for depression and antidepressant purchases were estimated in relation to the year of retirement from 5 years prior to the retirement year to 5 years after retirement. Using logistic regressions with generalized estimating equations we analysed the trends in prevalence before, during and after the retirement.

Results: Two out of thousand participants were hospitalized with depression in the year of their retirement and 63 out of thousand purchased antidepressant medication during the retirement year. An increase in hospital treatment for depression before and around retirement was followed by a decline from 2 years after retirement. Following retirement the prevalence of hospitalization dropped slightly from 0.21 percent (retirement +2 years) to 0.16 percent at the end of follow up (retirement +5 years). For antidepressant purchases we observed a steady increasing trend throughout the entire observation period.

Conclusions: This study did not confirm the hypothesis that retirement is beneficial for mental health measured by hospitalization with depression and treatment with antidepressants.

What this paper adds

- Recent studies using self-reported data have found health improvements following retirement.
- Studies on mental health, in relation to retirement, with medically certified endpoints have been scarce.
- In this study we did not find evidence for improvements in mental health following retirement when using hospital diagnosed depression and antidepressant purchase as endpoints.
BACKGROUND

Increasing life expectancy and decreasing fertility rates are reducing the proportion of gainfully employed individuals throughout the OECD (Organisation for Economic Co-operation and Development) countries.[1, 2] A possible mean to increase the proportion of active workers is to increase the statutory retirement-age. Despite recent high-quality studies on mental health and retirement,[3-5] the knowledge regarding the potential mental health consequences of such increase is still scarce.

Depression is associated with lower quality of life and one of the leading courses of years lost due to disability according to WHO.[6] Denmark is among the countries with the highest level of prescription of antidepressants in the OECD, only surpassed by Iceland, Australia and Canada.[2] The high treatment prevalence in Denmark may indicate a high prevalence of depression in the Danish population, although treatment prevalence could also be affected by other factors including availability and cost of health care.

Stressful life events and psychosocial factors at work have both been proposed as risk factors for depression.[7-9] Thus, removing exposure to adverse conditions at work by retirement might decrease the risk of depression. On the other hand, it is also possible that work provides protective factors, such as time structure and positive social relationships, and consequently the risk of depression might increase after retirement. Studies have shown that retirement may influence lifestyle patterns such weight gain,[10] leisure time physical activity [11] and increased alcohol consumption around the retirement [12] which may also influence mental health in relation to retirement.

Recent prospective studies with self-reported mental health outcomes found consistently improvements in mental health after retirement [13-17] whereas results from earlier studies were less consistent.[18-21] Studies on mental health with medically certified outcomes offer a different perspective than self-reported outcomes and give the opportunity for large-scale studies if register data are used. In three Finnish using treatments with antidepressants as the outcome, no clear improvements in mental health were found following old-age retirement.[3-5] Oksanen and colleagues did however find a decline in use of antidepressants around the retirement point.[3]

We aim to examine the effect of retirement on depression using national Danish registers of hospital treatment for depression (HTD). In addition, we studied effects of retirement on registered purchases of antidepressant medication which gave opportunity for analyses of mental health studies with high statistical power and for direct comparison with recent register studies on retirement with medication as endpoint.[3-5] Danish registers offer high quality data with regard to completeness and consistency,[23-26] and provide the opportunity to study effects of retirement on mental health in a full population study. Thus, bias due to selection into the study sample and to drop-out can be avoided in these register studies.

To our knowledge, effects of retirement on mental health have never been studied using hospital discharges as endpoint and never in a full national population. We hypothesize that retirement is associated with a reduced prevalence of HTD and antidepressant purchase when age is taken into account.
DESIGN AND METHODS

Population

All Danish residents have a unique personal identification number that allows for individual level linkage to administrative and health registers. We utilized this resource to create a registry based cohort study including all 356,932 Danish residents, who went on retirement from 2000 and 2006. The stationary retirement age in Denmark is 65 years, and we decided to e 31,068 participants who took retirement after the age of 68, as we suspect those older retirees to be a selected group with work-characteristics no longer representative for the overall population. Further, we excluded 7,134 participants who were lost to follow-up because of death or migration having more than one year with missing observations. We also excluded 71,242 participants who were not a part of the workforce before baseline, yielding an analytic sample of 245,082 participants.

Assessment of retirement

During the follow-up period (2000-2005), three main types of retirement were available in Denmark: a) Old-age pension, available for all workers at the age of 67 and above. From first of July 2004 workers born before first of July 1939 could retire on old-age pension already from the age of 65; b) Post-employment wage program (PEW), available for qualifying workers from the age of 60. The program was one of the major means by which Danes took retirement during the follow-up, although working beyond the age of 60 would progressively improve the pension. PEW was particularly popular among workers with low wages who could retain the highest percentage of their pre-retirement income during retirement; c) Disability pension, available for workers at any age who were unable to work for either medical or psychological reasons. We obtained data on old-age pension from the Register-based Labour Force Statistics,[26] on PEW and disability pension from the Danish Register for Evaluation of Marginalization (DREAM).[24] When a participant first time was awarded old-age pension or PEW in these registers the date was considered the time of retirement. Disability retirement was not considered as retirement for the purpose of this study and participants taking disability pension were not included in the study.

Assessment of HTD and antidepressant purchase

We used two different indicators of mental disorders which we analysed separately; HTD as primary diagnosis and purchase of prescriptive antidepressant drugs. Information on hospital discharges were drawn from The Danish Central Psychiatric Research Register that includes all discharge codes for in- and outpatient psychiatric treatment and diagnoses in Danish hospitals since 1969.[23] Relevant diagnosis included hospital treatment due to depression (ICD-10 codes of F32 to F33).
Information on purchase of antidepressants was drawn from the Danish National Prescription Registry, a national Danish registry containing data on all purchases of prescription medication at Danish pharmacies since January 1st, 1995.[25] Antidepressants were defined as medications coded N06A by the anatomical therapeutic chemical classification.[27] Individuals having redeemed at least one purchase of antidepressant during a calendar year were categorized as prevalent antidepressant purchasers. Likewise HTD during a calendar year resulted in categorization as having depression that year.

Assessment of covariates

Information on sex, cohabitation, disposable income, level of education and area of residence were derived from national registers. Income and area of residence are likely to change during the follow-up, most likely as a direct consequence of retirement. To avoid adjusting for mediating factors all covariates were measured before baseline i.e. five years before date of retirement.

Statistical analysis

The analyses were based on 11 years of observation, which covers 5 years of observation time before and after the year of retirement, defined as time 0. Using logistic regressions with generalized estimating equations we calculated the annual prevalence of depression and their 95% confidence intervals to visualize the trajectories in relation to the year of retirement. To analyse the trends in likelihood of depression and mental disorders, we divided the entire time-window into three periods, Pre-retirement (5 through 2 years before retirement), Retirement (a 3 year period centred around the time of retirement), and Post-retirement (2 through 5 years after retirement). We estimated the trend of mental health within each defined period by adding an interaction term between time-period and time. We chose an autoregressive correlation structure to take the intra-individual correlations between the yearly observations into account. The analyses were adjusted for baseline sex, cohabitation, disposable income, educational level, age at retirement and calendar year. By adjusting for calendar year the analyses were also adjusted for the increasing secular trends in medical treatment of mental disorders. We interpreted a change in the trend around or after retirement as an effect of retirement on mental health. All models were estimated separately for HTD and antidepressant drug purchase.

We tested the results for possible modifying effects of sex, cohabitation and education by constructing interaction terms between the baseline covariate, time-period (pre-retirement, transition, post-retirement) and time in relation to retirement.
RESULTS:

Table 1 shows the baseline characteristics of the study population at retirement with mutually adjusted odds ratios for prevalence of HTD and antidepressant purchase two years before retirement. Pre-retirement, women had a notably higher prevalence of antidepressant purchase compared to men, whereas the prevalence of HTD was more evenly distributed. Living alone, low income and high education were associated with a higher prevalence of both HTD and antidepressant purchases. Antidepressant drug purchases were evenly distributed across geographical regions, whereas HTD was more common among residents in Copenhagen than in other Danish regions.

Figure 1 shows the trend in HTD in relation to retirement. There was an increase in prevalence in the pre-retirement period, a further increasing trend during the transition phase followed by a stagnating high prevalence post-retirement. Tests for differences in trend during the entire observation were statistically significant (p < 0.001) indicating an association between retirement and trends in HTD.

Figure 2 shows the trends in prevalence in antidepressant purchases for early and late retirement. Overall, the prevalence of antidepressant treatment is increasing during the entire observation window. The increase is less pre-retirement, stable during the transition period and steepest post-retirement. Tests for differences in trend over time during the entire observation window were statistically significant (p < 0.001) indicating an association between retirement and antidepressant purchases.

Table 2 shows estimates for changes during each time-period (pre-retirement, transition, post-retirement) stratified by selected covariates. A modest statistically significant interaction effect was found for craftsmen who had reduced prevalence of HTD during the post-retirement period. For none of the sub-groups we observed a clear reduction in prevalence of mental disorder following retirement.
Figure 1: Estimated prevalence of HTD and their 95% CI in relation to year of retirement. HTD per 10,000

Figure 2: Estimated prevalence of antidepressive purchases and their 95% CI in relation to year of retirement. Anti-depressant purchasers per 100
### Table 1: Population characteristics

Odds ratio for HTD and antidepressant purchase 2 years before retirement

<table>
<thead>
<tr>
<th></th>
<th>HTD before retirement</th>
<th>Antidepressant purchase before retirement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No of individuals</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>123,868</td>
<td>1</td>
</tr>
<tr>
<td>Women</td>
<td>121,214</td>
<td>1.60</td>
</tr>
<tr>
<td>Cohabitation</td>
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<td></td>
</tr>
<tr>
<td>With a partner</td>
<td>202,697</td>
<td>1</td>
</tr>
<tr>
<td>Living alone</td>
<td>42,385</td>
<td>1.25</td>
</tr>
<tr>
<td>Yearly Disposable Income (EUR)</td>
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<td></td>
</tr>
<tr>
<td>&lt; 20K</td>
<td>30,613</td>
<td>1</td>
</tr>
<tr>
<td>20K-35K</td>
<td>125,631</td>
<td>0.73</td>
</tr>
<tr>
<td>35K-50K</td>
<td>61,123</td>
<td>0.70</td>
</tr>
<tr>
<td>&gt; 50K</td>
<td>27,715</td>
<td>0.50</td>
</tr>
<tr>
<td>Highest Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public school</td>
<td>90,722</td>
<td>1</td>
</tr>
<tr>
<td>Craftsman</td>
<td>100,300</td>
<td>1.06</td>
</tr>
<tr>
<td>Higher education</td>
<td>54,060</td>
<td>1.37</td>
</tr>
<tr>
<td>Residence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copenhagen area</td>
<td>16,408</td>
<td>1</td>
</tr>
<tr>
<td>Larger town</td>
<td>24,643</td>
<td>0.64</td>
</tr>
<tr>
<td>Smaller town / rural area</td>
<td>204,031</td>
<td>0.91</td>
</tr>
</tbody>
</table>
Table 2: Change in treatment for depression and antidepressant purchase during time period stratified by baseline characteristic.

Estimated with generalized estimating equations models

<table>
<thead>
<tr>
<th></th>
<th>Hospital treatment for depression</th>
<th>Antidepressant purchase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-retirement (year -2) vs (year -5)</td>
<td>Transition (year +1) vs (year -1)</td>
</tr>
<tr>
<td></td>
<td>OR 95% CI</td>
<td>OR 95% CI</td>
</tr>
<tr>
<td>Full population</td>
<td>1.07 0.88 1.31</td>
<td>1.15 0.98 1.35</td>
</tr>
<tr>
<td>Sex</td>
<td>p = 0.461</td>
<td>p = 0.001</td>
</tr>
<tr>
<td>Men</td>
<td>1.14 0.84 1.55</td>
<td>1.07 0.86 1.34</td>
</tr>
<tr>
<td>Women</td>
<td>1.02 0.77 1.34</td>
<td>1.23 0.98 1.54</td>
</tr>
<tr>
<td>Cohabitation</td>
<td>p = 0.375</td>
<td>p = 0.001</td>
</tr>
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<td>With a partner</td>
<td>1.21 0.96 1.53</td>
<td>1.16 0.97 1.40</td>
</tr>
<tr>
<td>Living alone</td>
<td>0.73 0.48 1.18</td>
<td>1.12 0.83 1.52</td>
</tr>
<tr>
<td>Highest Education</td>
<td>p = 0.024 (craftsmen) / 0.309 (higher education)</td>
<td>P = 0.445 (craftsmen) / &lt;0.001 (higher education)</td>
</tr>
<tr>
<td>Public School (ref)</td>
<td>1.02 0.72 1.46</td>
<td>1.24 0.93 1.65</td>
</tr>
<tr>
<td>Craftsmen</td>
<td>1.12 0.81 1.54</td>
<td>1.04 0.81 1.35</td>
</tr>
<tr>
<td>Higher education</td>
<td>1.02 0.69 1.51</td>
<td>1.24 0.93 1.65</td>
</tr>
<tr>
<td>Retirement program</td>
<td>p = 0.021</td>
<td>p = 0.819</td>
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<td>PEW</td>
<td>1.22 0.96 1.54</td>
<td>1.24 1.03 1.48</td>
</tr>
<tr>
<td>Old-age pension</td>
<td>0.87 0.59 1.29</td>
<td>0.98 0.71 1.34</td>
</tr>
</tbody>
</table>

Reported p values show tests for interaction of the covariate during the entire observation period.
DISCUSSION

Summary of findings

This study does not confirm the hypothesis that retirement is associated with improved mental health. However, the results suggest that retirement and mental health are differently associated depending on the measurement of the outcome.

Regarding HTD we observed an increasing prevalence of HTD throughout the period. The trend was most pronounced in the transition period, possibly due to reverse causality, that is, individuals with depressive disorder being more likely to retire due to their illness. Although this increasing prevalence in HTD was broken post-retirement, the prevalence remained high and we did not observe a notable decline in prevalence following the retirement. Highest education was shown to be a weakly modifying factor for HTD as workers with low education had an increasing prevalence of HTD during the post-retirement years.

Retirement was only weakly associated with antidepressant purchases as the steady increase before and after retirement was temporarily stopped during the transition phase. Thus, retirement did not result in a reduced prevalence but rather temporarily delayed the increasing trend in antidepressant purchases over time. A steep post-retirement increase in prevalent antidepressant purchasers indicates that any possible short-term benefits of retirement around the retirement-point were lost during the subsequent years.

Interpretation of the results

The post-retirement stagnation in prevalence of HTD may indicate that the effect of age on depressive disorder among participants in the workforce was stronger than the effect of age on participants who had retired. Such interpretation is, however, speculative as it relies on the assumption that the steep pre-retirement increase in HTD is explained by age and not by the up-coming retirement. If the increase in prevalence before retirement is unrelated to retirement, i.e. an effect of age, the post-retirement trend may be interpreted as a beneficial effect of retirement as the prevalence would have been even higher without the retirement. Contrarily, if the increased prevalence around the point of retirement was a consequence of the retirement an overall interpretation would be that retirement is deleterious for mental health as the prevalence of HTD remains at a relative high level after retirement without returning to the levels we observed 3-5 years before the retirement.

The prevalence patterns of the two examined indicators of depression differed. For HTD, the steepest increase in prevalence occurred during the transition period, whereas the steepest increase for antidepressant purchases was observed post-retirement. This difference could have at least two explanations: First, HTD is relatively rare and indicates severe depression, whereas antidepressant purchase could be an indication of a wider range of mental disorders. Thus, antidepressant purchase may not only be different measures of depression but also reflect different mental disorders.
Consequently, our results may indicate that retirement is differently associated with different mental disorders. Second, a gradual reduction in a person’s antidepressant purchases will not be captured in our study before the participant is free of any purchases during an entire calendar year. Thus, the increasing prevalence in antidepressant purchase during the whole study period may partly be explained by continued antidepressant treatment to prevent recurrence of the depressive disorder

**Comparison to other studies**

There has been conflicting findings regarding ageing and mental health.[16, 28] In this study, we observed an increasing prevalence of antidepressant purchases as the participants grew older. Thus, increasing age appears to be an important contributing factor for the observed increase in HTD and antidepressant purchase over the observation period.

In contrast to our results, findings from studies on retirement and mental health outcomes generally seem to favour the conclusion that retirement is beneficial for mental health. In a study on the British Whitehall cohort, statutory and voluntary retirement was associated with improved mental health.[16] Studies on the French GAZEL cohort found beneficial effects of retirement with respect to sleep disturbances,[15] self-reported depressive symptoms and mental fatigue [13] and self-rated health.[14] Another French study on effects of retirement on sleep disturbances confirmed the results from the GAZEL cohort.[29]

An exception from the abovementioned findings are studies on medication in relation to old-age retirement which generally find little or no effect of retirement.[3-5] Our findings on antidepressant purchases are consistent with other longitudinal studies examining trajectories over time in relation to old-age retirement which find no effect of retirement or suggest only minor benefits with respect to reduced medication. A Finnish study found a decrease in antidepressant use around the statutory retirement point [3] whereas another Finnish study found no change in use of psychotropic drugs following retirement.[4] A third Finnish study on antidepressant use on a representative sample of the full population found no effect of old-age retirement on antidepressant medication.[5] Our findings are in line with the results from the Finnish studies making them less dependent on specific labour markets and retirement patterns. Medically diagnosed depression has not previously been studied, and our study also adds to the current literature by showing no beneficial effect of retirement on HTD.

Taken together, these previous findings indicate that any beneficial effects of retirement on mental health may be limited to effects on symptoms and well-being rather than clinically significant outcomes. Our findings also supports the previously reported tendency that studies with medically certified outcomes do not find beneficial effects of retirement to the same extent as studies with self-reported endpoints.[13, 30]
Strengths and limitations

The large sample-size covering an unselected national study population of retirees are major strengths of this study. Furthermore, the use of register based predictors for mental disorders provided complete population data with high level of consistency and reliability. Register-based measures HTD and antidepressant purchase are free of the bias due to self-reports, differential attrition and recall bias.

Several limitations of this study have to be noted. There is an inherent risk of reverse causality when studying effect of retirement on mental health, as poor health may cause early retirement.[31] Mental disorder is a known predictor for early retirement in Denmark.[32] thus there could be higher prevalence of mental disorders during transition to retirement if mental disorder is a trigger of the retirement-decision. The flexible retirement age during the observation period has increased the risk of selection into retirement based on health criteria. However, the longitudinal design comparing the same individuals before and after retirement secured that individuals were given equal weight at all times across the follow-up regardless of vulnerability to mental disorders. The design also gave opportunity for adjustments for the increasing secular trend in treatment for mental disorders during the follow-up.

We could not distinguish between voluntary and involuntary retirement. The importance of such distinction has been shown previously in studies on health effects of involuntary job loss in earlier career.[33] These studies indicate that the context of the withdrawal from paid work is important for subsequent health, as involuntary job-loss was associated with increased risk of morbidity, including mental disorders.[33, 34] The beneficial effects of retirement, opposed to the deleterious effects of involuntary job loss, may be a result of having fulfilled society’s and one’s own expectations in retirement.[35]

Both HTD and antidepressant purchase have limitations as a proxy measures for mental disorders. Many cases of depression are treated outside of hospitals, which is indicated by the higher proportion of antidepressant purchase compared to HTD. But also regarding antidepressants, only a minor proportion of mental disorder cases seem to be treated in Denmark.[36] On the other hand, antidepressants are not only prescribed for treating depressions, but also for treating other disorders such as anxiety[37] or neuropathic pain.[38, 39] Thus, antidepressant purchase is not an indicator of a single specific diagnosis. A study on Danish register data has shown inconsistencies between depression measured by a self-rated symptom scale and register-based outcomes indicating an underestimation of prevalence of depression among individuals with low social-economic position when using register data.[40]

In conclusion, our findings do not confirm the hypothesis that retirement is beneficial for mental health. The prevalence for both hospital treated depression and antidepressants were higher post-retirement compared to pre-retirement. An increase in HTD was observed around the retirement point before a beneficial post-retirement trend took over. For purchases of antidepressants retirement only had a modest temporary beneficial effect.
Conflict of interests

The authors declare that they have no conflict of interests.

Funding

This work was supported by the Danish Working Environment Research Fund [grant number 20110013127/1].


Does Occupational Exposure Modify the Risk of Myocardial Infarction and Depression Following Retirement? – A study of Hospital Treatment for Myocardial Infarction and Depression among 623,993 Elderly Danish Residents

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Does Occupational Exposure Modify the Risk of Myocardial Infarction and Depression Following Retirement? – A national Registry-Linkage study of Hospital Treatment for Myocardial Infarction and Depression among 623,993 Elderly Danish Residents

Background: Recent studies have suggested that retirement may have beneficial effects on general and mental health. However, this was not confirmed in Danish studies using medically certified outcomes. In this study we analysed the influence of work-environment for the associations between retirement and hospital treatment for depression and MI.

Methods: Participants were 623,993 Danish workers, born between 1932 and 1948 entering the study at the age of 60. Information on retirement and hospital treatment were obtained from Danish national registers. Cox proportional hazard model was used to address the relation between retirement and onset of disease among knowledge-, client- and manual workers.

Results: Retirement was associated with higher risk of MI and hospital treatment for depression in all three job-domains.

Conclusions: This study did not find beneficial effects of retirement regardless of the work environment. High exposure of cognitive, emotional and physical demands did not modify the previously known associations between retirement and health.
Background

A growing body of prospective studies has recently investigated the effects of retirement on mental and somatic health outcomes [3-6, 10-12]. Studies tend to report improvements in health after retirement when self-reported measures are used [4, 5, 6, 13], whereas studies with medically certified outcomes largely have been inconclusive or shown negative health effects of retirement [3-5, 12, 16].

An association between work environment and health has been widely discussed and acknowledged. Psychosocial work environment has been suggested as predictor for mental health disorders and depression [1, 2] and for cardiovascular disease [14]. Retirement is a major life event where potential health-hazardous work-related exposures are relieved which may be beneficial for health. Most previous studies have used representative cohort data without information on work-environment or without statistical power to compare effect of retirement for specific group of workers. An exception is a study of Westerlund and colleagues [6] showing that workers with poor self-reported work-environment had the highest benefits of retirement, thus suggesting that work-environment may have an important modifying effect when analysing health consequences of retirement.

Recently two full-population studies have been carried out showing weak associations between retirement and health in Denmark [3, 10]. A potential explanation for the weaker associations between retirement and health in full-population studies may be that adverse health effects of retirement are blurring the results.

Danish registers provides opportunities to study health effects of retirement in a full national population with sufficient statistical power to detect differences between job groups. In register studies, psychosocial exposures in job groups can be assessed by assigning a level of exposure to every employee who belongs to the specific job groups.

By use of existing national questionnaire-data, with self-reported information on work-environment, we were able to associate workers job-group with a particular measure for work-environment exposure. By analysing health following retirement stratified by job-groups we are able to analyse if work-environment modify the association between retirement and health outcomes. The exposures are derived from large representative samples of the Danish workforce [29, 30].

In this article, we analyse the prospective association of retirement with risk of depression and myocardial infarction within a selected range of jobs each categorized into either knowledge work, client work or manual work. We hypothesized that retirement was differently associated with health
risk depending on pre-retirement occupation. Workers in client-work are particularly exposed to emotional demands, whereas knowledge work is associated with cognitive demands. If either of those work exposure are associated with health retirement from that occupation will involve a change in health trajectory following the retirement. Contrary to beneficial effects, retirement itself could also involve adverse health effects. Some retirees may experience emptiness, loss of identity or less physical activity. Beneficial or deleterious effects of retirement are likely to depend on the pre-retirement occupational position and its level of emotional, cognitive and physical demands.

We hypothesized that health effects of retirement was differently associated with myocardial infarction (MI) and Hospital treatment for depression (HTD) depending on the pre-retirement work environment. More specifically, we hypothesised that retirement was beneficial for workers with emotional demands (client workers) or cognitive demands (knowledge workers) with respect to risk of MI as retirement involves relief from occupational stress associated with emotional demands. Furthermore we hypothesized that retirement from emotional- or cognitive demanding occupations is beneficial for risk of HTD, as emotional and cognitive demanding activities are more easily retained among activities in retirement. Thus, the negative impact of retirement as major life-event is less pronounced in those job-groups.
Materials and methods

Context of the study

All Danish citizens have a unique personal identification number allowing individual level linkage to administrative and health registers. In this study we utilized this resource to create a registry based cohort study. All Danish citizens born between 1932 and 1948 were identified in the Central Person Registry (n = 1,066,964) and entered the study at the age of 60. Individuals who were not fully active workers at the age of 60, e.g. part-time workers, on long-term sick-leave or unemployed, were excluded (population reduced to 624,576). Further, we excluded participants with missing data on variables used in the analyses, yielding a base cohort of 623,993 workers.

When analysing MI we further excluded 9,079 individuals with a previous event of ischemic heart disease (IHD) (ICD-8 codes 410 to 414, ICD-10 codes I21 to I25) within the last two years from where we had data, yielding a study population of 614,914 participants. When analysing HTD we excluded 734 workers with a previous event of HTD (F32-F33) also within the last two years (n = 623,259). Furthermore, to avoid the non-interchangeable transition from ICD-8 codes to ICD-10 codes and lack of register records of out-patient treatments we further excluded individuals with baseline before 1995 in the analyses of HTD yielding a study population of 536,628 workers.

Selection of job groups

Based on national self-reported questionnaire data on work-demands we identified 12 job groups within three overall domains for analysis, each with either high physical, emotional or cognitive demands. This was based on existing national questionnaire data including a scale on emotional demands, a scale on cognitive demands and a single question on physical demands. Furthermore the questionnaire data contained DISCO-88 codes, the Danish version of the International Classification of Occupations (ISCO-88), which gave opportunity to identify similar job-groups in national register data. Thus, the questionnaire data was used exclusively to identify and select job-groups whereas all main analyses were performed on national register data. In some cases the job-groups in the National questionnaire data consisted of several smaller groups. In those cases we designed our categories in the register data to match those of the national questionnaire data.

The data on emotional demands at work was derived from a 2005 national questionnaire surveys of working Danes aged 20–59 years [28, 29] where we identified the four jobs with highest self-reported emotional demands; day-care workers, nurses, nurse aids and public school teachers.
Based on a scale of cognitive demands, also from the psychosocial work environment data of 2005 [28, 29], four jobs with the highest self-reported cognitive demands were identified to constitute the domain of knowledge work; engineers, physicians, academics and manager, where the job “manager” could be within any field of work. From national representative 2012 data [30] we used the single question “How physically hard is your job” was used to identify four jobs within the domain of manual work; postmen, house painters, carpenters and construction workers. To avoid job groups with too few participants we only considered job-groups with at least 3000 individuals in the registers suitable for the study population.

Assessment of retirement

We obtained data on occupational status, retirement, unemployment and long-term sickness absence from the Danish Register for Evaluation of Marginalization (DREAM) [17] and the Register-based Labour Force statistics [18]. Retirement was measured with a binary time-dependant variable. During the follow-up period (1992-2010), there were three main types of retirement available in Denmark: a) Old-age pension, which is available for all workers at the age of 65 and above, b) Post-employment wage program, which is available for qualifying workers from the age of 60 with increased economic benefits for later retirement. The program was one of the major means by which Danes took early retirement during the follow-up particularly among workers with low wages who could retain a higher percentage of their income compared to workers with higher wages. From 1999 PEW was revised making it economically more attractive to stay longer active on the labour market. c) Disability pension, which was available for workers at any age who for medical or psychological reasons were unable to work. For the purpose of this study we only considered retirement due to old age and due to the Post-Employment Wage Program as retirement. Participants awarded disability pension were excluded at baseline, as illness following disability pension could be a consequence of their illness rather than the retirement.

Assessment of Myocardial Infarction

Data on hospital discharge and deaths were obtained from the Danish National Patient Registry [20] and the Danish Registry of Mortality [21]. These registers include diagnoses of all hospital discharges since 1977 and computerized records for all individual deaths since 1970. Relevant diagnosis included hospitalization or death due to Acute MI, MI or complications following MI (ICD-8 codes of 410; ICD-10 codes of I21 to I23). The admission date was considered the time of the event.
Assessment of HTD

Data on HTD was derived from the Danish National Patient Register containing information on all admissions to Danish psychiatric in-patient facilities since 1969, and, since 1995, information from out-patient contacts [19]. Incidence of HTD was measured by ICD-10 codes of F32 and F33 as primary diagnosis. The admission date was considered the time of the event.

Assessment of other covariates

Information on sex, age, ethnicity, individual disposable income before retirement, highest education, area of residence and cohabitation were derived from national registers. All variables were measured immediately before the age of 60, i.e. the year before the individual entered the study. Disposable income (income after payment of taxes) was adjusted for inflation with the year of 2000 as base and divided into four categories of Euros (EUR): “< 20 000”, “20 000–35 000”, “35 000–50 000” and “>50 000”. Highest completed education was divided into 4 categories: “Unknown education”, “Public School”, “Craftsman” and “Higher Education”. Area of residence was categorized into 3 categories: “Copenhagen”, “Larger municipalities” covering municipalities with more than 100 000 inhabitants and “Other” covering smaller towns and rural areas.

Statistical approach

We used Cox proportional hazard models [9] to calculate hazard ratios and 95% confidence intervals for the association between the time-dependent retirement status and incidence of MI and HTD. The analysis was based on 18 years (940 weeks) of continuous observation from 1992 to the end of 2009. Participants were followed-up from the week they turned 60 years and until event (incident MI) or censuring due to death, migration, disability pensioning, unemployment, sickness absence of more than 26 weeks, or end of follow up (i.e. completion of 7 years of follow-up), whichever came first. We adjusted the models for baseline measures of sex, ethnicity, disposable income, education level, residence, cohabitation, and year of entering the study. The latter also included adjustment for age as all individuals with identical baseline year also had the same age during the follow up. To identify potentially vulnerable subgroups we also estimated separate models stratified by sex, job-group, area of residence and cohabitation. All statistical analyses were performed using SAS 9.2 (SAS Institute Cary, NC).
Results

Tables 1 shows the baseline characteristics of the population stratified on the overall job-groups. Knowledge workers had the highest income followed by client workers. Eighty-three percent of the client workers were women whereas men constituted more than 82 percent of the knowledge workers and 96 percent of the manual workers. Twenty-five percent of the client workers lived alone which was more than the other groups. Almost all manual workers were had no further education, whereas the opposite was the case for knowledge- and client workers. Manual workers were also to a higher extent settled in rural areas while the percentages of knowledge- and client-workers were higher in the cities. Knowledge workers retired later than both client- and manual workers whom had a similar retirement pattern.

Table 2 shows selected dimensions of the work environment within particular job-groups based on national representative questionnaire data from which the groups were identified. Knowledge work was characterized by relatively lower emotional demands, with physicians as exception, and very low physical demands. Client work was characterised by high emotional demands, relatively high cognitive demands and a medium level of physical demands. Manual work was characterised by high physical demands and low emotional demands compared to other job-groups.

Stratified by selected jobs and job-domains, table 3 shows the estimates of changes in risk of MI and HTD following retirement. There was an overall modest increased risk of MI following retirement (HR = 1.09; 95% CI: 1.05-1.14), however, differences between job domains were modest. The overall HR of HTD following retirement was: 1.34 (95% CI: 1.22-1.48). This increased risk of HTD following retirement was found in all three job-domains with a particularly strong effect among manual workers (HR: 1.86; 95% CI: 1.20-2.89), followed by a modest increased risk among Client Workers (HR =1.37; 95% CI: 1.06-1.77). The effect was lowest among knowledge workers (HR =1.27; 95% CI: 0.83-1.93). Despite comparable cognitive demands the group of knowledge workers was heterogeneous as managers, who constituted the majority of the group, had a relatively low risk (HR =1.06; 95% CI: 0.56-2.01) whereas physicians, academics and engineers had considerably higher risk estimates. This indicates that cognitive demands are insufficient as predictors for risk of HTD following retirement.
Discussion

In this study we found modest increased risk of MI and HTD following retirement in the overall population. Those results are in accordance with previously findings on MI [3,10]. Our national population data allowed sub-analyses of effects within particular domain of the labour-market and in particular job-groups.

Few studies have analysed differences in effects based on job-groups or work-environment pre-retirement. Previous research has shown that perceived work-environment is a modifier for the association between retirement and following health. Westerlund and colleagues [6] showed that the effect of retirement varied according to self-reported work environment factors such as psychological demands, physical demands and job satisfaction where those experiencing highest demands and lowest job-satisfaction experienced the highest benefits of retirement with respect to self-reported health. Nevertheless, in the present study we did not find convincing evidence for work environment modifying the association between retirement and MI

We found the most pronounced increased risk of MI following retirement among knowledge workers whereas estimates for client and manual workers were more in line with the estimate for all workers. Overall the knowledge workers has the highest increased risk of MI following retirement, which was against our hypothesis that relief from occupational stress would result in reduced risk of MI among knowledge workers. Overall the differences between domains were modest and could be explained by consequences of selection into retirement as the models are unadjusted for life-style factors [3] or simply by insufficient statistical power.

With exception of physicians, the stratification on job-groups with different work-environment did not challenge the conclusion that retirement had little effect on risk of MI. An explanation for the similarities across domains could be that retirement simply is not a strong predictor for MI regardless of the work-environment relived from. Thus, the study does not support the notion, that there are individual differences in effect of retirement on risk of MI based on work environment factors. The lower risk of MI following retirement among physicians was not found among other knowledge workers or the client workers with whom physicians also had similarities with respect to emotional demands. Therefore the presented work-environment characteristic is an unlikely explanation of the result.

The study also showed increased risk of HTD following retirement. The effect was strongest among manual workers, weaker among client-workers and almost non-existing among knowledge workers. It was in line with our hypothesis that client- and knowledge workers would have higher benefits from retirement, however we hypothesized and actual reduced risk of HTD following retirement.
which we did not observe. The increase in risk of HTD among manual workers calls for an explanation. All individual job-groups within the domain of manual work were contributing to the increased risk of HTD following retirement. A possible explanation is lack of opportunity to replace rewarding elements of the work similar rewarding activities in retirement. Exercise has shown to be protective against depression [8, 23] and possible lack of comparable exercise in retirement from a physically demanding job will remove such protection. Weight gain has been showed as a possible consequence of retirement [7, 32] whilst obesity is also a risk factor for cardiovascular diseases and MI [22] and depression [31]. It is possible that some workers are protected against obesity before retirement due to the work tasks and relatively more vulnerable afterwards due to inadequate lifestyle. Obesity is associated with socio-economic status with those with lowest status being at highest risk of overweight [26]. Nevertheless, it is still a possibility that our results emerges from workers with low SES developing from bad to worse during retirement. Another speculative explanation regards changes in day-light exposures. Much of the manual work is characterized by being performed outdoor, usually in day-light. As low amount of day-light is a risk factor for seasonal depressive disorders [24] outdoor work may work as a protective mechanism against seasonal depressive disorder and depression, thus removal of such protection may result in an increase in HTD as we observe among the retired manual workers. Thus a speculative explanation for the increase in HTD among manual workers in retirement is removal of protective mechanisms. One or both of these protective mechanisms may contribute to our findings; unfortunately our analysis was not designed to test hypothesis about day-light exposure during work. Mechanisms associated with low socio-economic status are also speculative explanations for the increased risk of HTD among retired manual workers.

With limited opportunity to mobilize financial and educational resources manual workers may be more vulnerable to exposures during the retirement process. However, if that was the case we would expect increased risk of HTD following retirement based on low income regardless of job group. Previous studies did not show such an association [25].

In conclusion the study did not confirm the hypothesis that retirement from knowledge-, client or manual work should have particular influence on the risk of MI following retirement. However, manual workers seem to experience relatively higher risk of HTD in their retirement.

Strengths and limitations

A strength of the study was the national population data yielding a high number of participants free of selection. Another major advantage was the use of register data, with medically certified
outcomes, which gave opportunities to conduct analyses without relying on self-reports vulnerable to dropouts, missing answers, misclassification, and recall errors.

Despite a full population sample size a limitation is the measurement of work environment in the job-groups where data in a single case only consisted of 35 individuals. As our outcomes are relatively rare the statistical power in the single job groups. Thus, potentially interesting job-groups have not been analysed due to a low number of answers in the questionnaire data. Moreover, the national representative questionnaire data has also limited statistical power questionnaire data is only measured at a single point in time despite being used for an analysis including 18 years of follow-up.

Another limitation is the time-to-event method, rendering the study vulnerable to selection-bias when unhealthy individuals retire due to poor health before being hospitalized. This could potentially result in an overestimation of a deleterious effect of retirement. However, as long as vulnerability to diseases affects retirement planning in the same way across job-groups the value of the analysis for comparing job-domains to the overall result remains. In such a case manual workers should be more likely to retire compared to other groups when facing initial depressive symptoms. While selection into retirement may influence estimates for the overall population, we do not find indications that selection into retirement explain the increased risk of HTD following retirement of manual workers.


10) Olesen K, Bonde JP, Madsen, IEH. Rod NH, Rugulies R: Is retirement beneficial for mental health (publication in progress).


13) Jokela et al. From Midlife to Early Old Age - Health Trajectories Associated with Retirement. Epidemiology 2010


Table 1: Population characteristics at baseline (age of 60)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Knowledge Workers</th>
<th>Client Workers</th>
<th>Manual Workers</th>
<th>Full population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency at baseline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disposable Income (EUR)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 20,000</td>
<td>1013 2%</td>
<td>7567 10%</td>
<td>2389 7%</td>
<td>83,636 13%</td>
</tr>
<tr>
<td>20,000 - 35,000</td>
<td>3616 9%</td>
<td>30,933 42%</td>
<td>14,816 46%</td>
<td>213,266 34%</td>
</tr>
<tr>
<td>35,000 - 50,000</td>
<td>7487 18%</td>
<td>24,922 34%</td>
<td>10,445 33%</td>
<td>175,735 28%</td>
</tr>
<tr>
<td>&gt; 50,000</td>
<td>30,243 71%</td>
<td>10,404 14%</td>
<td>4281 13%</td>
<td>148,654 24%</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>34,835 82%</td>
<td>12,852 17%</td>
<td>30,537 96%</td>
<td>349,488 56%</td>
</tr>
<tr>
<td>Female</td>
<td>7524 18%</td>
<td>60,974 83%</td>
<td>1394 4%</td>
<td>271,803 44%</td>
</tr>
<tr>
<td>Cohabitation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living alone</td>
<td>5943 14%</td>
<td>17,650 24%</td>
<td>4994 16%</td>
<td>114,620 18%</td>
</tr>
<tr>
<td>Living with a partner</td>
<td>36,416 86%</td>
<td>56,176 76%</td>
<td>26,937 84%</td>
<td>506,671 82%</td>
</tr>
<tr>
<td>Highest Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public school</td>
<td>3765 9%</td>
<td>16,838 23%</td>
<td>13,277 42%</td>
<td>210,505 34%</td>
</tr>
<tr>
<td>Craftsman</td>
<td>9500 22%</td>
<td>18,821 25%</td>
<td>17,661 55%</td>
<td>243,281 39%</td>
</tr>
<tr>
<td>Higher education</td>
<td>29,094 69%</td>
<td>38,167 52%</td>
<td>993 3%</td>
<td>167,505 27%</td>
</tr>
<tr>
<td>Area of Residence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copenhagen</td>
<td>3582 8%</td>
<td>4834 7%</td>
<td>1794 6%</td>
<td>45,677 7%</td>
</tr>
<tr>
<td>Larger town</td>
<td>4409 10%</td>
<td>7636 10%</td>
<td>2781 9%</td>
<td>59,398 10%</td>
</tr>
<tr>
<td>Smaller town / Rural area</td>
<td>34,368 81%</td>
<td>61,356 83%</td>
<td>27,356 86%</td>
<td>516,216 83%</td>
</tr>
<tr>
<td>Total</td>
<td>42,359 100%</td>
<td>73,826 100%</td>
<td>31,931 100%</td>
<td>621,291 100%</td>
</tr>
</tbody>
</table>
Table 2: Percentage of non-retirees by job-group and age

<table>
<thead>
<tr>
<th>Age*</th>
<th>60</th>
<th>61</th>
<th>62</th>
<th>63</th>
<th>64</th>
<th>65</th>
<th>66</th>
<th>67</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge Work</td>
<td>100</td>
<td>90</td>
<td>86</td>
<td>71</td>
<td>61</td>
<td>54</td>
<td>45</td>
<td>38</td>
</tr>
<tr>
<td>Client Work</td>
<td>100</td>
<td>61</td>
<td>53</td>
<td>34</td>
<td>23</td>
<td>17</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Manual Work</td>
<td>100</td>
<td>68</td>
<td>61</td>
<td>41</td>
<td>30</td>
<td>23</td>
<td>18</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>72</td>
<td>66</td>
<td>48</td>
<td>37</td>
<td>31</td>
<td>25</td>
<td>20</td>
</tr>
</tbody>
</table>

* Measured the week before each birthday

Table 3: Work environment among selected job groups in national representative data

<table>
<thead>
<tr>
<th>Job group</th>
<th>Emotional Demands</th>
<th>Physical Demands</th>
<th>Cognitive Demands</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Score 0-100*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge Work</td>
<td>46</td>
<td>16</td>
<td>76</td>
</tr>
<tr>
<td>Engineer</td>
<td>36</td>
<td>10</td>
<td>75</td>
</tr>
<tr>
<td>Academic</td>
<td>48</td>
<td>13</td>
<td>73</td>
</tr>
<tr>
<td>Physician</td>
<td>61</td>
<td>25</td>
<td>76</td>
</tr>
<tr>
<td>Manager</td>
<td>47</td>
<td>18</td>
<td>78</td>
</tr>
<tr>
<td>Client Work</td>
<td>67</td>
<td>46</td>
<td>72</td>
</tr>
<tr>
<td>Teacher</td>
<td>69</td>
<td>25</td>
<td>76</td>
</tr>
<tr>
<td>Nurse</td>
<td>66</td>
<td>34</td>
<td>71</td>
</tr>
<tr>
<td>Day-care worker</td>
<td>70</td>
<td>44</td>
<td>73</td>
</tr>
<tr>
<td>Nurse aide</td>
<td>62</td>
<td>58</td>
<td>62</td>
</tr>
<tr>
<td>Manual Work</td>
<td>23</td>
<td>66</td>
<td>55</td>
</tr>
<tr>
<td>Carpenter</td>
<td>25</td>
<td>68</td>
<td>58</td>
</tr>
<tr>
<td>Construction worker**</td>
<td>21</td>
<td>68</td>
<td>55</td>
</tr>
<tr>
<td>House painter**</td>
<td>21</td>
<td>65</td>
<td>55</td>
</tr>
<tr>
<td>Postman</td>
<td>24</td>
<td>63</td>
<td>46</td>
</tr>
<tr>
<td>All Workers</td>
<td>41</td>
<td>34</td>
<td>64</td>
</tr>
</tbody>
</table>

Scores from 0-100. High scores indicate high demands.

** Construction workers and house painters have merged emotional demand scores.
Table 4: Adjusted HR's of retired workers compared to active workers of the same strata

<table>
<thead>
<tr>
<th>Job group</th>
<th>Workers at baseline</th>
<th>HTD</th>
<th>MI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Events</td>
<td>No.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No.</td>
</tr>
<tr>
<td>Client Work</td>
<td>64,554</td>
<td>372</td>
<td>1.37</td>
</tr>
<tr>
<td>School teacher</td>
<td>22,576</td>
<td>110</td>
<td>2.12</td>
</tr>
<tr>
<td>Nurse</td>
<td>8,444</td>
<td>59</td>
<td>0.82</td>
</tr>
<tr>
<td>Nursery-teacher</td>
<td>20,860</td>
<td>139</td>
<td>1.28</td>
</tr>
<tr>
<td>Nurses' aide</td>
<td>12,674</td>
<td>64</td>
<td>1.28</td>
</tr>
<tr>
<td>Manual Work</td>
<td>28,050</td>
<td>115</td>
<td>1.86</td>
</tr>
<tr>
<td>Carpenter</td>
<td>6,266</td>
<td>28</td>
<td>1.44</td>
</tr>
<tr>
<td>Construction Worker</td>
<td>13,643</td>
<td>51</td>
<td>2.66</td>
</tr>
<tr>
<td>Postman</td>
<td>4,895</td>
<td>25</td>
<td>2.04</td>
</tr>
<tr>
<td>House painter</td>
<td>3,246</td>
<td>11</td>
<td>1.16</td>
</tr>
<tr>
<td>Knowledge Work</td>
<td>38,373</td>
<td>136</td>
<td>1.27</td>
</tr>
<tr>
<td>Physician</td>
<td>5,504</td>
<td>29</td>
<td>1.93</td>
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