Healthy working life expectancy and the associated health behaviors across sociodemographic groups: evidence from linked survey and registry data

Marit Slootweg
Yuwei Qi
Patricia Ots
Sandra Brouwer
Raun van Ooijen

Netspar

Industry paper 2025-23

Colophon

Industry papers are papers for pension sector professionals. They are published on the Netspar website after approval by the Netspar Editorial Board (EB). The EB checks the papers for both academic quality and accessibility by non-academic professionals. Industry papers are presented for discussion at Netspar events. Representatives from partners in the academic, pension, and insurance sectors are invited to these events.

Netspar Industry Paper 2025-23, April 2026

Acknowledgements
This project was supported by the Network for Studies of Pensions, Aging, and Retirement (Netspar) through the This paper is financially supported by Netspar through the theme project "Health and labor market uncertainty over the lifecycle: the impact on households' risk capacity and retirement income adequacy."
Dit onderzoek wordt mede gefinancierd met de PPS-toeslag van het Ministerie van Economische Zaken en Klimaat vanuit CLICKNL. This research is partly funded with PPS from the Ministry of Economic Affairs and Climate through CLICKNL.
We are grateful for the comments and suggestions by Jeroen van der Vaart, Lieke Beekers, Fanny Tallgren, the Netspar Editorial Board, and participants at the Netspar pension day, the Netspar international pension workshop, and the International Congress on Occupational Health in Marrakesh.

Design Maan
Lay-out Bladvulling
Editor Frans Kooymans

Table of contents

Affiliations

Marit Slootweg – University Medical Center Groningen, University of Groningen
Yuwei Qi – University Medical Center Groningen, University of Groningen
Patricia Ots – University Medical Center Groningen, University of Groningen
Sandra Brouwer – University Medical Center Groningen, University of Groningen
Raun van Ooijen – University Medical Center Groningen, University of Groningen

Abstract

Extending the number of years in employment is crucial for maintaining the sustainability of pension and social security systems. Health substantially influences the ability to extend one's working life, but its impact is unevenly distributed among socioeconomic groups. To shape policies that tackle these disparities, we need better insights using indicators that combine both health and employment. This study estimated healthy working life expectancy (HWLE) — the average number of years expected to be healthy and employed between age 50 and 65 — across sex and educational groups. It also explored the associations between HWLE and health behaviors within these groups.

Using longitudinal data from the Lifelines cohort study (2006-2021), enriched with registry data from Statistics Netherlands, we estimate the HWLE for older workers aged 50-65 (N=21,441). The three states of the multistate model were assigned based on health status, as measured by self-perceived health, and primary source of income as a proxy for employment status. Physical inactivity, smoking, and alcohol consumption were included as covariates. Stratified analyses were conducted by educational levels and sex, in addition to estimates for the entire population.

HWLE was estimated to be 12.7 years. Women had a HWLE that was 0.6 years shorter than that of men. HWLE increased with educational attainment, rising from 12.1 years for those with low education to 12.8 years for those with intermediate education and 13.3 years for those with high education. Lower educated individuals spent more time working while in poor health and outside of the workforce. Educational disparities were more substantial among women than men, though these differences decreased at higher levels of education. Smoking was linked to a shorter HWLE, while both smoking and physical inactivity were associated with longer work duration in poor health. For alcohol consumption we found a small, counter-intuitive association: more alcohol consumption among the general population, but specifically among women, goes with a slightly higher HWLE.

In conclusion, HWLE accounts for approximately 85% of the total working life between age 50 and 65 but is significantly lower for women and individuals with lower educational attainment. Health behaviors at age 50 are linked to HWLE, especially within these vulnerable groups. Strategies to promote sustainable employability require tailored, equitable, and preventive interventions that focus on prolonging healthy working lives while also supporting those in poor health to prevent further deterioration and extend workforce participation. Further research on HWLE, its determinants, and underlying mechanisms has the potential to achieve policy goals for sustainable employment.

Samenvatting

Het vergroten van de arbeidsparticipatie is cruciaal voor de houdbaarheid van het pensioen- en socialezekerheidsstelsel. Omdat gezondheid bepalend is voor langer doorwerken en ongelijk is verdeeld, is meer inzicht nodig in het aantal jaren dat mensen in goede of minder goede gezondheid doorwerken. Met deze inzichten kunnen passende beleidsmaatregelen worden ontwikkeld die ongelijkheden in gezondheid en werkvermogen verkleinen. In dit Industry Paper hebben wij een indicator gebruikt die gezondheid en werk integreert: de gezonde arbeidslevensverwachting (HWLE) in Nederland. HWLE is het aantal jaren dat 50-plussers tot aan 65 jaar zowel gezond als werkzaam blijven. We onderzoeken hoe HWLE samenhangt met gezondheidsgerelateerd gedrag in verschillende sociaaldemografische groepen.

We koppelen gegevens van 21.441 werkenden van 50-65 uit de Lifelines cohortstudie (2006-2021) over zelf-gerapporteerde gezondheid en gezondheidsgerelateerd gedrag aan CBS-registraties over hun arbeidsmarktpositie. HWLE is geschat met een multistatenmodel met drie staten (gezond & werkend, ongezond & werkend, en niet in betaald werk). Lichamelijke inactiviteit, roken, en alcoholgebruik zijn als covariaten voor gezondheidsgerelateerd gedrag opgenomen. De analyses zijn tevens gestratificeerd naar geslacht en opleidingsniveau.

Uit onze resultaten blijkt dat de gemiddelde HWLE 12,7 jaar bedraagt (circa 85% van de resterende werkzame jaren). Voor vrouwen is deze verwachting 0,6 jaar korter dan voor mannen. HWLE neemt toe met opleidingsniveaus (12,1 laag, 12,8 middelbaar, 13,3 hoog); lager opgeleiden brengen relatief meer tijd werkend door in slechte gezondheid of niet in betaald werk. De verschillen naar opleiding zijn groter bij vrouwen dan mannen, hoewel deze ongelijkheden afnemen naarmate het opleidingsniveau stijgt. Roken hangt samen met kortere HWLE en, net als weinig lichaamsbeweging, met langer werken in slechte gezondheid. Voor alcohol zien we een kleine, contra-intuïtieve samenhang: meer drinken gaat in de totale populatie (met name vrouwen) samen met iets hogere HWLE.

Samenvattend omvat HWLE in Nederland circa 85% van de resterende werkzame levensjaren vanaf leeftijd 50 tot 65; vrouwen en lager opgeleiden zijn hierbij kwetsbaarder. Gezondheidsgerelateerd gedrag op 50-jarige leeftijd hangt samen met (on)gezonde arbeidsdeelname, vooral in kwetsbare groepen. Maatwerk en preventieve maatregelen in het beleid rond duurzame inzetbaarheid zijn nodig om ongelijkheden te verkleinen en om inzetbaarheid bij gezondheidsproblemen te ondersteunen. Vervolgonderzoek naar de determinanten en onderliggende mechanismen van HWLE kan beleidsdoelen rond duurzame inzetbaarheid verder versterken.

1. Introduction

The need for more healthy years in employment is increasing. With the aging of the population and increasing old-age dependency ratios, many OECD countries implemented reforms to lengthen working life and foster the labor force participation of older workers [1]. These reforms had a major impact on the length of working lives. In the Netherlands, the average retirement age increased from 61 to 66 between 2006 and 2023, an increase of five years. In other OECD countries, the average retirement age has also increased [2]. Reaching the increased retirement age may be particularly challenging for workers with health problems and may result in an early exit from the labor market [3, 4]. Many known demographical and social determinants predispose people to health adversities and have implications for their employability [5]. These determinants are, however, not randomly dispersed among the population and may result in widening socioeconomic disparities in health and labor force participation [6-8]. To develop policies and interventions to prevent the further widening of inequalities in health and labor force participation, a better understanding of employability among different groups is required [9].

Thus far, key outcome measures for the evaluation of policies on employability mainly focus on employment status, neglecting the central role of health for the success of such policies [5, 10]. Furthermore, pension policies and statutory retirement ages are often based on life expectancy and not on working life expectancy in good health [11]. However, observed increases in measures for sustainable employability are not matching the speed of policies on sustaining employment, such as increased retirement ages [12]. In this context, working life expectancy estimates the expected number of years working-age individuals can spend in employment [13, 14]. Healthy working life expectancy estimates the number of years workers can spend both healthy and in work from a certain age, often from age 50 [15]. Such estimates depend not only on health, but also on the institutional context, including retirement regulations. The implementation of policies that discouraged early retirement and raised the statutory retirement age has made health increasingly relevant for employability within the Netherlands. Therefore, examining healthy working life expectancy in the Netherlands may offer new insights into disparities in sustainable employability by integrating health and employment status.

Since recent international developments of new policies aiming to extend working life, healthy work-life expectancy has been documented for several countries [16]. The initial estimates of healthy working life expectancy for the Netherlands, provided by Lièvre, indicated substantial inequities between men (7.4 years) and women (5.1 years) after age 50. They measured health by examining limitations caused by chronic mental or physical health conditions. De Wind et al. [17] conducted a study among Dutch workers with chronic diseases, estimating working life expectancy in both good and poor self-perceived health

after age 55. They reported an average healthy working life expectancy of 5.2 years for workers suffering from a chronic illness. Furthermore, van der Noordt et al. [12] estimated working life expectancy from age 58 with and without disability from a longstanding limiting illness, which can be regarded as a proxy for health status. Their results indicate that working life expectancy without disability increased from 3.3 to 4.7 as educational attainment improved. Parker et al. [18] conducted a study on healthy working life expectancy from age 50 in the United Kingdom, with health operationalized by assessing the presence of limiting longstanding illness. They estimated healthy working life expectancy stratified by sex, educational attainment, occupation type, deprivation score, and region, revealing inequalities across all groups. Finally, Boissonneault et al. [16] compared countries with various Active Aging Indices [19]. Regardless of the Active Aging Index, men in all countries were found to have longer healthy working life expectancies than women.

When analyzing longitudinal trends and projections of healthy working life expectancy, disparities among groups are evident [16, 19, 20]. At the same, projections in England and Germany indicate that more knowledge is required on the determinants that contribute to the health aspect of working life expectancy [22, 23]. This need for further insight into the determinants of healthy working life is particularly relevant considering the aging population, which implies a higher prevalence of older workers with chronic health conditions that are often linked with health behaviors [24, 25]. Despite this relevance, the associations between a comprehensive set of health behaviors and healthy working life expectancy has not yet been sufficiently explored. Only one study from the United Kingdom has examined this association, finding that healthy working life expectancy is two years shorter for physically inactive individuals, and almost one year shorter for individuals with obesity [25]. However, these findings offer only a partial perspective, as they do not account for differences among socioeconomic groups.

Regarding the relevance of modifiable health behaviors, systematic reviews have shown that physical inactivity is associated with both unemployment and disability benefits [26, 27]. When considering other employability indicators, multiple studies indicate the relevance of health behaviors such as physical inactivity, smoking, alcohol consumption, and healthy weight. For example, Van den Berg et al. [9] found in their systematic review and focus groups that physical inactivity was associated with early retirement. Additionally, Ots et al. reported multiple associations between health behaviors and labor market exit [28]. Smoking and low fruit intake were associated with unemployment and disability benefits, and low vegetable intake with unemployment. Moreover, they reported an association between obesity and disability benefits and between frequent alcohol intake and early retirement. However, no association between physical inactivity and labor market exit was observed [28]. More insight into multiple health behaviors and their contribution to the

extension of healthy working life is needed to implement successful policies that equitably extend healthy working life [29, 30].

In this context, research on healthy working life expectancy and its relationship with a comprehensive set of modifiable health behaviors across sex and educational attainment can offer broader insights into disparities in healthy working life expectancy. This will help us gain a clear understanding of the relationships between health, employment, and their modifiable determinants. This is essential for developing equitable interventions, social security plans, and pension policies that promote sustainable employability and enable individuals to reach the statutory retirement age in good health. This paper, therefore, examines the healthy working life expectancy of workers aged 50 to 65 in the Netherlands, analyzing differences by sex and socioeconomic status, and investigates the relationship with health behaviors as a key determinant of health.

2. Methods

Design and Data

We performed a longitudinal quantitative analysis using data from the Lifelines cohort study, using observations from 2006 to 2021, and linked it at the individual level to employment outcome registry data from Statistics Netherlands. Lifelines is a multi-disciplinary prospective population-based cohort study examining in a unique three-generation design the health and health-related behaviours of 167,729 persons living in the North of the Netherlands. It employs a broad range of investigative procedures in assessing the biomedical, socio-demographic, behavioural, physical and psychological factors which contribute to the health and disease of the general population, with a special focus on multi-morbidity and complex genetics [31]. Data collection started in November 2006 and recruiting of participants occurred through their general practitioners, through family members or by self-registering. The data collection in Lifelines was conducted according to the guidelines in the Declaration of Helsinki, and the Medical Ethics Committee of the University Medical Centre Groningen approved all procedures (2007/152). Lifelines is largely generalizable to the Dutch population. The available data enable us to explore the factors that affect health and their importance on healthy life expectancy across sociodemographic groups. We enriched Lifelines data by incorporating information on the main income source from the Dutch tax registers provided by Statistics Netherlands. This offers us the unique opportunity to investigate transitions in and out of paid employment due to unemployment, disability benefits, social assistance, or early retirement. Data from Statistics Netherlands are available monthly. We used data from the date of enrollment in the Lifelines cohort up until December 2021.

Institutional Setting

In the Netherlands, up to 2006, it was common to retire around the ages of 60 and 61 [32]. On January 1, 2006, early retirement arrangements with favorable tax implications were abolished to boost labor participation among older workers. The early retirement reform did not impact individuals born before January 1, 1950. Starting January 1, 2013, the statutory retirement age gradually increased from 65 to 67 and was linked to life expectancy beginning in 2024. The newly introduced fiscally favorable retirement arrangements, including the 'life course saving arrangement,' were abolished in 2013. As a result of these reforms, the average retirement age increased by almost five years between 2006 and 2023, from 60 years and eleven months to 65 years and eight months [33].

Participants

The study sample is derived from all participants who completed the baseline assessment of the Lifelines cohort study from 2006 to 2013 (N=157,700). Data from Statistics

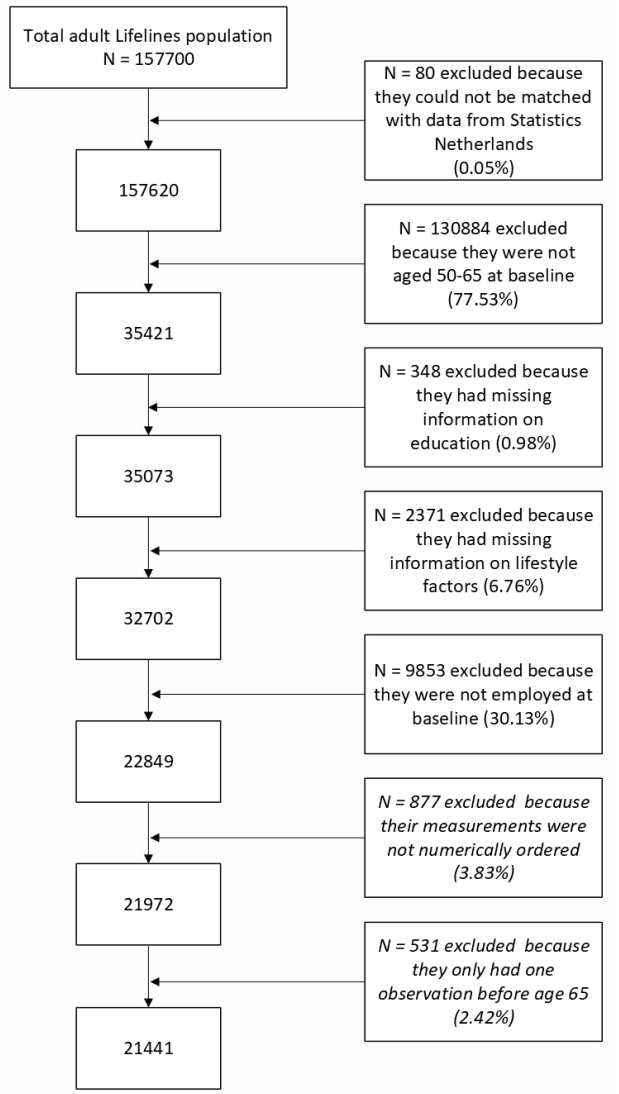

Figure 1: Flowchart of the participants included for analysis

Netherlands enable us to assign combined employment and health states to individuals at various time points, which is essential for estimating healthy working life expectancy. Consequently, individuals were excluded when the Lifelines data could not be aligned with Statistics Netherlands data on the individual level. In line with the literature on healthy working life expectancy, we included individuals aged 50 to 65 who were employed at baseline (N=22,849). Including the baseline assessment, these individuals were tracked for a maximum of five Lifelines waves until 2021. Therefore, only individuals who were 50 years old in 2006 have a follow-up period of 15 years. If we track only those aged 50 in 2006 until they reach 65, the results will reflect the behavior and institutional context of a specific cohort; however, we are interested in the overall healthy working life expectancy for all cohorts aged 50 to 65 at baseline (2006-2013).

Finally, individuals with only one data entry or assessment dates that did not follow the original chronological order of the Lifelines assessment plan were excluded from the

analysis, resulting in a sample of 21,441 individuals. See Figure 1 for a flowchart of participant selection.

Outcome Variable

The primary outcome measure was healthy working life expectancy. This predictive measure reflects the average years spent in paid employment in good health after age 50, up to the statutory retirement age of 65. We estimated this by integrating Lifelines data on self-perceived health (i.e. RAND questionnaire [34]) with data from Statistics Netherlands on the main source of income to determine the participants' employment status (i.e. SECMBUS). Individuals were assigned to a state at each measurement point. Self-perceived health was selected as an indicator for health status, as findings from a meta-analysis reported its relevance for associations with exit from employment [7]. As in previous research [18], for healthy working life expectancy, we distinguished three states that are mutually exclusive:

I. Healthy and in work
II. Not healthy and in work
III. Not in paid employment

'In work' was defined as having a primary source of income from paid employment, self-employment, or serving as a director and major shareholder of a business. The question *"How would you rate your health, generally speaking?"* was evaluated in each Lifelines wave and used to reflect health status. Individuals were categorized as (1) 'healthy' if they respond with excellent, very good, or good, and (2) 'not healthy' if they respond with mediocre or poor. The data properties prevent us from observing multiple transitions between states within a single interval. A transition was observed only when the state at the end of an interval differed from the state at the beginning of that interval.

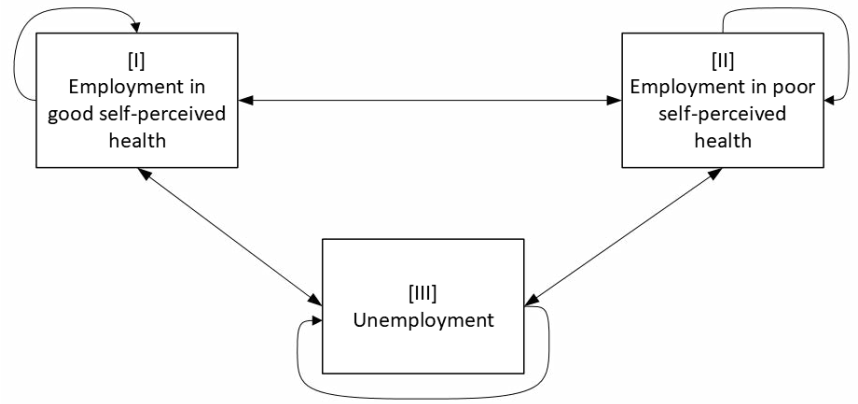

Figure 2: Multistate model for the estimation of healthy working life expectancy.
Permitted *transitions are indicated by arrows.*

In our study, transitions after age 65 were excluded, as this was the legal retirement age in 2006, the starting year of the Lifelines cohort's baseline assessment. We censored observations for individuals who migrated or died before 2021, by excluding them from the sample when the event occurred.

Variables

All variables are self-reported measures from Lifelines, assessed at the baseline wave or during the first visit to one of the Lifelines research centers.

Sociodemographic Groups

Sex and educational attainment were included as indicators of sociodemographic position to identify disparities in achieving a long, healthy working life. *The biological sex* of participants was included as a default question in each assessment. The response options are either male or female. *Educational level* was based on the individual's highest completed level of education and categories were recoded into: (1) 'low' (no education- primary education- lower or preparatory secondary vocational education- junior general secondary education); (2) 'intermediate' (secondary vocational education or work-based learning, senior general secondary education, pre-university secondary education); (3) 'high' (higher vocational education, university education). Given the variety of options under "other" type of education, no results will be presented for this answer category.

Health Behaviors

We incorporated the health behaviors of physical inactivity, smoking, and alcohol consumption to evaluate the association between modifiable factors and employability outcomes. *Physical inactivity* was evaluated using the "Short QUestionnaire to ASsess Health enhancing physical activity" (SQUASH). Participants were classified as *'physically inactive'*, thus unhealthy, when they were active less than five days (answers 0-4) per week, for at least half an hour per day (based on WHO guidelines of 150 mins. of physical activity per week [35]. This was derived from a single question in SQUASH: *"On average, how many days per week do you cycle, do odd jobs, garden, or exercise for at least half an hour?"* [36]. *Smoking* was assessed by classifying participants as (1) 'smokers' if they reported current smoking or smoking in the past month. On the contrary, individuals who did not smoke in the month prior to or during the assessment were labeled as 'non-smokers' (2), indicating healthy behavior. *Alcohol intake* was determined through self-report and classified as 'high' or unhealthy if participants reported consuming alcohol at least four days a week. This classification is preferred to classification of heavy or excessive alcohol use, as problematic alcohol use among the population aged 50 and over is worrying. Problematic

alcohol use refers to a drinking pattern that leads to mental and/or physical health issues or social challenges. The consumed amount in units is not a ruling indicator for diagnosis [37].

Statistical Analyses

Initial restructuring of the data took place using SPSS 25 software [38]. Consecutively, sample matching of the datasets, sample selection and analyses were performed using R 4.1.3 software [39]. Descriptive statistics were obtained to provide insight into the data's characteristics. Descriptive statistics included percentages and frequencies for categorical variables, as well as means and standard deviations for continuous variables.

We used a multistate Markov model as the basis for our analyses. Such a model is based on the assumption that the transition probability to the next state depends solely on individuals' current state, regardless of how long they have been in that state. Given this assumption, left truncation of individuals not directly observed from age 50 is not problematic, since the states preceding their current state do not influence the transition probability to another state. Truncation involves removing or excluding data below a certain value, specifically for those aged under 50 in our study.

The prediction of healthy working life expectancy occurred in several steps. First, we defined a transition matrix that corresponds to the transition model shown in Figure 2. Since transitions can occur in all directions, this led to nine possible transitions. In this multistate model, the transition times between states are interval censored. This means that we assume the exact transition times between these states lie between two observations and that transitions between states may take place several times within an interval. Neither state is an absorbing state, indicating that all states can be entered and exited multiple times. We subsequently created transition frequency tables to assess the transition frequencies between the states of 'Working in good self-perceived health' (state I), 'Working in poor self-perceived health' (state II), and 'Unemployment' (state III), providing insight into how the study population evolved over the follow-up period. Such a table summarizes the total number of times each individual was observed in one of the states I-III, followed by another observation in any state (I-III). These tables, which detail transitions for both the basic model and the models with covariates, as explained in the next section, are available in Appendix I.

Using the data and the transition matrix, we employed maximum likelihood estimation to determine the unknown parameters of our model, including the transition intensities and their confidence intervals. More intuitively, transition intensities represent the probability that a transition to another state will occur within an infinitesimally small time interval. To enhance robustness, we estimated two models and obtained goodness-of-fit figures that show the model's predicted observations in each state for each age, compared to the actual data observations. These figures are presented in Appendix II. First, we fitted a

multistate model to the entire population, where transition intensities were proportionate to age. We also fitted a model in which transition intensities were piecewise dependent on age, estimating separate transition intensities for five-year age intervals and allowing for flexible transition forms within each interval. Based on the goodness-of-fit figures, we proceeded with our analyses using the piecewise constant intervals model with five-year age intervals.

Estimating the transition intensities and deciding on the best-fitting model allowed us to use the predictive features of the multistate model. In a multistate model, healthy working life expectancy can be defined as the estimated total length of stay in the "healthy at work" state (I). The R package msm [40] computes the total length of stay by first obtaining the transition probability matrix, i.e. a matrix of transition probabilities from a given state at the start to another specific state within a time interval. The model uses the transition probability matrix and calculates the integral from the initial time (t0) to the end of the interval (t1) based on the entries at the starting and ending states. This led to the total expected length of stay or healthy working life expectancy. To assess the uncertainty regarding healthy working life expectancy, a bootstrap method was employed: the model simulated 1,000 random vectors from the distribution underlying the maximum likelihood estimates and calculated healthy working life expectancy for each simulation.

Next, estimates of healthy working life expectancies for various health behaviors were obtained for the entire population and across different sociodemographic groups. Since health behavior is rather stable over time [41], we used baseline data on health behaviors and treat these data as individual-specific, constant factors, not changing over follow-up time. After estimating the total length of stay in each state, including health behaviors as a covariate, we estimated multiple models for sex and educational attainment. We created three models for each population group, with the first model including physical inactivity as a covariate. The other two models included smoking and alcohol consumption as covariates, respectively. We again obtained transition frequency tables, estimated the multistate model and its unknown parameters, and ultimately predicted the total length of stay in state I "healthy and in work". These models could only be fitted without numerical overflow when transitions from state 3 to state 2, which were very limited, were excluded from the transition matrix. The simulated models enable us to convey how health behaviors contribute to variations in healthy working life expectancy among different sociodemographic groups.

3. Results

Sample Characteristics

Table 1 presents an overview of the sociodemographic and health behavior characteristics of our study sample at baseline. These characteristics are categorized based on the baseline state of our model, which can be either healthy and in work or unhealthy and in work. More than half of the sample (54%) were women, with a mean age of 54.9 years (SD = 3.85). The sample had a balanced representation of education levels. Regarding health behaviors, both healthy and unhealthy scores of physical activity were equally represented among participants. The prevalence of smoking was 16.3%, while one-third of the population (32.5%) engaged in unhealthy levels of alcohol consumption.

The sociodemographic characteristics of the population reporting good self-perceived health at baseline closely resemble those of the entire sample, as this group constitutes 92.5% of the total. Among those with poor self-perceived health at baseline, there were slightly more women (55.4%), and their education levels were lower than those in the general population (41.1% compared to 34.2%). Within this group, unhealthy patterns of physical activity (54.4% compared to 50.7%) and smoking (20.7% compared to 16.3%) are

Table 1: Baseline characteristics of the employed participants in good and poor self-perceived health and the total sample

	Healthy & at work	Unhealthy & at work	Full population
Demographics, N (%)	19825 (92.5)	1616 (7.5)	21441 (100)
Age in years, M(SD)	54.90 (3.86)	54.90 (3.77)	54.90 (3.85)
50-54	10771 (54.3)	882 (54.6)	11653 (54.3)
55-59	6350 (32.0)	525 (32.5)	6875 (32.1)
60-64	2704 (13.6)	209 (12.9)	2913 (13.6)
Sex, N (%)			
Female	10682 (53.9)	896 (55.4)	11578 (54.0)
Male	9143 (46.1)	720 (44.6)	9863 (46.0)
Education level, N (%)			
Low	6678 (33.7)	664 (41.1)	7342 (34.2)
Intermediate	6753 (34.1)	551 (34.1)	7304 (34.1)
High	6002 (30.3)	369 (22.8)	6371 (29.7)
Other	392 (2.0)	32 (2.0)	424 (2.0)
Health behavior			
Physical inactivity, N (%)			
Healthy	9830 (49.6)	737 (45.6)	10567 (49.3)
Unhealthy	9995 (50.4)	879 (54.4)	10874 (50.7)
Smoking, N (%)			
Non-smoker	16657 (84.0)	1281 (79.3)	17938 (83.7)
Current smoker	3168 (16.0)	335 (20.7)	3503 (16.3)
Alcohol consumption, N (%)			
Healthy (≤ 2 – 3 days/week)	13317 (67.2)	1159 (71.7)	14476 (67.5)
Unhealthy (≥ 4 days/week)	6508 (32.8)	457 (28.3)	6965 (32.5)

more prevalent, while unhealthy alcohol consumption is less common (28.3% compared to 32.5%).

Healthy Working Life Expectancy

Table 2 provides estimates of healthy working life expectancy for the entire population, broken down by sex and education levels. The estimated healthy working life expectancy for the overall population was 12.7 years (95% CI 12.6-12.9), indicating that after age 50, individuals were expected to spend an average of 12.7 years healthy and in work, accounting for approximately 85% of their remaining working life. The estimated time spent unhealthy at work (1.2, 95% CI 1.1-1.3) and not working (1.1, 95% CI 1.0-1.2) was slightly over one year.

Table 2: Total length of stay in each state for the entire population, categorized by sex and education (estimation for 15 years starting at age 50).

	(I) Healthy working life expectancy Y (95% CI)	(II) Unhealthy at work Y (95% CI)	(III) Not working Y (95% CI)
Full population *(N=21441)*	12.7 (12.6-12.9)	1.2 (1.1-1.3)	1.1 (1.0-1.2)
Sex			
Female	12.5 (12.3-12.6)	1.3 (1.2-1.4)	1.3 (1.1-1.4)
Male	13.1 (12.9-13.2)	1.0 (0.9-1.2)	0.9 (0.7-1.0)
Education level			
Low	12.1 (11.8-12.3)	1.4 (1.2-1.7)	1.6 (1.2-1.8)
Intermediate	12.8 (12.6-13.0)	1.2 (1.1-1.4)	1.0 (0.8-1.1)
High	13.3 (13.1-13.5)	1.0 (0.8-1.1)	0.7 (0.6-0.9)
Physical inactivity			
Healthy	12.8 (12.6-12.9)	1.1 (1.0-1.2)	1.2 (1.0-1.3)
Unhealthy	12.7 (12.5-12.8)	1.3 (1.2-1.4)	1.0 (0.9-1.2)
Smoking			
Healthy	12.8 (12.7-13.0)	1.1 (1.0-1.2)	1.0 (0.9-1.2)
Unhealthy	12.3 (12.0-12.5)	1.5 (1.3-1.6)	1.3 (1.1-1.4)
Alcohol consumption			
Healthy	12.6 (12.5-12.8)	1.2 (1.1-1.3)	1.1 (1.0-1.3)
Unhealthy	12.9 (12.8-13.1)	1.1 (1.0-1.2)	1.0 (0.9-1.1)

Socioeconomic Groups

Healthy working life expectancy for women was 12.5 years, compared to 13.1 years for men. The difference was statistically significant because the 95% confidence intervals of these estimates did not overlap (12.3-12.6 compared to 12.9-13.2). Healthy working life expectancy was linearly associated with educational attainment, with 12.1 years (95% CI 11.8-12.3) for low, 12.8 years (95% CI 12.6-13.0) for intermediate, and 13.3 years (95% CI 13.1-13.5) for high education. The estimates for time spent unhealthy at work, as well as for time spent not working, displayed a similar pattern: women and individuals with lower educational attainment spent more time in these states.

Table 3: Total length of stay in each state, stratified by sex and education, associated health behaviors

Women *(N=11578)*	**(I) Healthy working life expectancy** Y (95% CI)	**(II) Unhealthy at work** Y (95% CI)	**(III) Not working** Y (95% CI)
Education level			
Low	11.7 (11.4-12.2)	1.3 (1.1-1.5)	2.0 (1.5-2.3)
Intermediate	12.5 (12.3-12.8)	1.4 (1.2-1.6)	1.1 (0.9-1.3)
High	13.1 (12.8-13.3)	1.1 (1.0-1.4)	0.8 (0.6-1.0)
Physical inactivity			
Healthy	12.6 (12.4-12.8)	1.1 (1.0-1.2)	1.3 (1.1-1.5)
Unhealthy	12.4 (12.2-12.6)	1.4 (1.2-1.5)	1.2 (1.1-1.4)
Smoking			
Healthy	12.6 (12.4-12.8)	1.2 (1.1-1.3)	1.2 (1.0-1.4)
Unhealthy	12.0 (11.6-12.3)	1.5 (1.3-1.7)	1.5 (1.3-1.9)
Alcohol consumption			
Healthy	12.4 (12.2-12.6)	1.3 (1.2-1.4)	1.3 (1.1-1.5)
Unhealthy	12.8 (12.6-13.0)	1.1 (0.9-1.2)	1.1 (0.9-1.3)
Men *(N=9863)*			
Education level			
Low	12.4 (12.1-12.7)	1.5 (1.3-1.9)	1.1 (0.6-1.3)
Intermediate	13.2 (12.9-13.4)	1.0 (0.8-1.3)	0.9 (0.6-1.1)
High	13.5 (13.2-13.8)	0.8 (0.6-1.1)	0.7 (0.3-0.9)
Physical inactivity			
Healthy	13.1 (12.9-13.3)	1.0 (0.8-1.1)	1.0 (0.8-1.1)
Unhealthy	13.1 (12.9-13.3)	1.1 (1.0-1.2)	0.8 (0.7-0.9)
Smoking			
Healthy	13.2 (13.0-13.4)	1.2 (0.9-1.1)	0.8 (0.7-1.0)
Unhealthy	12.7 (12.4-12.9)	1.4 (1.2-1.6)	1.0 (0.8-1.2)
Alcohol consumption			
Healthy	13.1 (12.9-13.2)	1.1 (0.9-1.2)	0.9 (0.7-1.0)
Unhealthy	13.1 (12.9-13.3)	1.0 (0.9-1.2)	0.9 (0.7-1.0)
	(I) Healthy working life expectancy Y (95% CI)	**(II) Unhealthy at work** Y (95% CI)	**(III) Not working** Y (95% CI)
Low education *(N=7342)*			
Physical inactivity			
Healthy	12.1 (11.8-12.4)	1.2 (1.1-1.4)	1.6 (1.4-2.0)
Unhealthy	12.1 (11.8-12.3)	1.4 (1.2-1.6)	1.5 (1.3-1.8)
Smoking			
Healthy	12.2 (12.0-12.5)	1.3 (1.1-1.4)	1.5 (1.3-1.7)
Unhealthy	11.6 (11.2-12.0)	1.6 (1.3-1.8)	1.8 (1.5-2.3)
Alcohol consumption			
Healthy	12.0 (11.8-12.3)	1.4 (1.2-1.5)	1.6 (1.3-1.9)
Unhealthy	12.2 (11.9-12.6)	1.3 (1.1-1.5)	1.5 (1.2-1.9)
Intermediate education *(N=7304)*			
Physical inactivity			
Healthy	12.9 (12.7-13.1)	1.0 (0.9-1.2)	1.1 (0.9-1.3)
Unhealthy	12.8 (12.5-13.0)	1.3 (1.2-1.5)	0.9 (0.8-1.1)
Smoking			
Healthy	12.9 (12.7-13.1)	1.1 (1.0-1.2)	1.0 (0.8-1.1)
Unhealthy	12.5 (12.1-12.8)	1.5 (1.3-1.7)	1.0 (0.8-1.3)
Alcohol consumption			
Healthy	12.8 (12.6-13.0)	1.2 (1.1-1.4)	1.0 (0.8-1.1)
Unhealthy	12.9 (12.6-13.1)	1.1 (0.9-1.2)	1.0 (0.8-1.2)

High education *(N=6371)*			
Physical inactivity			
Healthy	13.3 (13.1-13.5)	0.9 (0.8-1.0)	0.8 (0.6-1.0)
Unhealthy	13.3 (13.1-13.5)	1.0 (0.9-1.2)	0.7 (0.5-0.8)
Smoking			
Healthy	13.3 (13.1-13.5)	0.9 (0.8-1.1)	0.7 (0.6-0.9)
Unhealthy	13.0 (12.6-13.3)	1.2 (0.9-1.4)	0.8 (0.6-1.1)
Alcohol consumption			
Healthy	13.2 (13.0-13.4)	1.0 (0.9-1.1)	0.8 (0.6-1.0)
Unhealthy	13.5 (13.3-13.7)	0.9 (0.7-1.0)	0.6 (0.5-0.8)

Across all educational levels, men had a longer healthy working life expectancy than women, particularly at the intermediate level of educational attainment (Table 3). Women with intermediate education were estimated to spend longer working in poor health compared to men with similar educational attainment. Inequalities between men and women diminished with higher educational attainment across all states. For time spent not working, the substantial differences by sex observed in low educational attainment were not statistically significant for those with intermediate or high educational attainment.

Health Behaviors

Physical Inactivity

When including physical inactivity as a covariate (table 2), the time spent working in poor health was shorter for healthy activity levels (1.1, 95% CI 1.0-1.2) compared to unhealthy levels (1.3, 95% CI 1.2-1.4). This was also true for the subsample of women (table 3), with the estimates for healthy activity levels (1.1, 95% CI 1.0-1.2) being shorter than the average among women (1.3, 95% CI 1.1-1.5) and unhealthy behavior (1.4, 95% CI 1.2-1.5), but not for men. For individuals with intermediate educational attainment, physical inactivity was associated with working longer in poor health (1.0, 95% CI 0.9-1.2 versus 1.3, 95% CI 1.2-1.5). In both the full population and subsamples, estimates of healthy working life expectancy for both healthy and unhealthy levels of physical activity did not significantly differ. Additionally, no significant differences were found in the time spent not working, either within the entire population or within any of the subsamples.

Smoking

The estimated healthy working life expectancy for non-smokers was longer at 12.8 years (95% CI 12.7-13.0) compared to smokers, who had an expectancy of 12.3 years (95% CI 12.0-12.5). Smokers, both men and women, were estimated to have a significantly shorter healthy working life expectancy compared to non-smokers and the average healthy working life expectancy of their subgroup.

Estimates of years spent unhealthy at work were longer for current smokers (1.5, 95% CI 1.3-1.6) than for non-smokers (1.1, 95% CI 1.0-1.2) and the population average (1.2, 95%

CI 1.1-1.3). This means that smokers were estimated to spend significantly longer unhealthy at work, compared to the average population and non-smokers. This association was also observed among women (1.5 for smokers compared to 1.2 for non-smokers and an average of 1.3), men (1.4 for smokers compared to 1.2 for non-smokers and an average of 1.0), and individuals with intermediate education (1.5 for smokers compared to 1.1 for non-smokers and an average of 1.2).

Regarding estimated time spent not working, no significant differences within the full population or its subsamples were found when comparing smokers and non-smokers.

Alcohol Consumption

In terms of alcohol consumption, healthy working life expectancy was estimated to be higher for unhealthy alcohol consumption levels (12.9, 95% CI 12.8-13.1) than for healthy drinking behavior (12.6, 95% CI 12.5-12.8). This was especially observed among women (12.4 for healthy compared to 12.8 for unhealthy alcohol consumption levels, with a group average of 12.5), but it was not observed among men or within educational subgroups. No significant differences were found in the estimated time spent unhealthy at work or not working between unhealthy and healthy drinking behaviors in any of the samples.

4. Discussion

The aim of this study was to gain insights into the healthy working life expectancy of older Dutch workers across various sociodemographic groups and to examine the association with health behaviors. Using data from the Lifelines cohort study, linked to registry data from CBS, we estimated that individuals work an average of 12.7 years in good health, 1.2 years in poor health and spend 1.1 year out of paid employment between age 50-65. Estimates for women were less favorable than for men, especially when categorized by educational levels. Educational attainment was associated with healthy working life expectancy: individuals with lower education had the shortest healthy working life expectancy, those with intermediate education were slightly above average, and individuals with higher education had a 1.2 longer healthy working life expectancy than the lowest group. Health behaviors were more strongly correlated with healthy working life expectancy among women and less educated individuals.

Inequalities in Healthy Working Life Expectancy and the Institutional Context

Our estimates on healthy working life expectancy among adults from age 50 are higher than those from Lièvre et al. in 2007 [15] (12.7 vs ±6.3 years), which can be attributed to the fact that our analysis only included individuals working at baseline, which implies a better initial health status (also known as the healthy-worker effect). Moreover, our study was conducted using data from more than a decade later [21]. Before 2006, favorable early retirement arrangements made retiring around the age of 60 to 61 common in the Netherlands. The abolition of the arrangements impacted individuals aged 50 to 56 in 2006. More than half of our population was of this age during the sample recruitment period, meaning they were born between 1951 and 1963. This sample composition corresponds to a statutory retirement age well above 65 years (ranging from 65 years and 9 months to 67 years and 3 months). Furthermore, the average retirement age for this population increased substantially, which has converged to an about one-year difference between with the statutory retirement age, coming from a four-year difference in 2006. These factors together explain the higher estimates for healthy working life expectancy. In addition, estimates for time spent unhealthy and in work were higher in the study by Parker [18] (1.8 versus 1.2), which can be explained by the fact that they estimated this as part of total life expectancy after age 50 instead of only the available years up until the statutory retirement.

The differences in healthy working life expectancy between women (12.5) and men (13.1) are much smaller compared to studies from other countries or periods. For example, Lièvre, also focusing on the Netherlands, [15] found a difference of 2.3 years (5.1 for women, 7.4 for men) over the period between 1995-2001, Parker and Lynch estimated the difference between men and women between 1.5 and 2.5 years between 2002-2013 [18, 23].

It is known that in recent decades, traditional household roles have shifted, and pension systems increasingly discouraged early retirement for women [11]. Together, this resulted in more work participation by women, increasing their healthy working life expectancy [16, 17, 23]. However, after accounting for educational attainment and health behaviors, our findings indicate that women fare less favorably than men. Therefore, attention is still needed to mitigate these inequalities by sex.

Focusing on education, we found that healthy working life expectancy varies significantly between those with different levels of educational attainment. In line with Parker et al [18], we also found a linear pattern of healthy working life expectancy increasing over educational attainment. This means that individuals with lower education levels spend a greater portion of their working lives in poor health or inactive in the workforce for various reasons. Age stratification did not indicate that our findings are skewed by imbalances in educational attainment per age group. A possible explanation for our observed pattern is that workers with lower educational attainment have much higher risks of exiting from the workforce due to disability benefits caused by poorer health levels [42], and workers with a higher educational background have more possibilities to voluntarily exit the labor market compared to those with intermediate education levels [43]. Educational attainment thus unevenly predisposes individuals to health and labor market challenges.

Healthy Working Life Expectancy and Health Behavior

A unique aspect of this study was evaluating the relationship between a comprehensive range of health behaviors and healthy working life expectancy, taking into account sex and educational attainment. Our results indicate that unhealthy behaviors, such as physical inactivity and smoking, are associated with working longer in poor health, with smoking also associated with a shorter healthy working life expectancy. This is presumably due to chronic diseases, where people with long-term illness are encouraged to work and not all chronically ill individuals perceive themselves as unhealthy [17]. We found that moderate alcohol consumption is associated with a slightly longer healthy working life expectancy for women. We suspected this might be driven by educational attainment, but we did not notice an association between alcohol consumption and healthy working life expectancy within one of the subsamples by educational attainment. Adittionally, we found that particularly among women and low educated individuals, more health behaviours showed significant within-group differences in working life estimates compared other groups.

Strengths and Limitations

This study has several strengths, foremost among them being the provision of the first estimates of healthy working life expectancy for the Dutch population in the 21st century. The findings of this study are derived from data collected from the Lifelines cohort in the

northern provinces of the Netherlands. This cohort was initiated for research on the mechanisms behind the development of chronic illnesses, which is presumably a driving factor of sustainable employment [17]. Thus, the Lifelines cohort serves as a very suitable data source for our estimation. By thoughtfully selecting a sample that represents our population of interest, the risk of selection bias is likely to be low. Furthermore, Lifelines is a large and stable cohort that includes repeated measurements of self-perceived health and potential determinants over 15 years. Linking self-perceived health status to employment status was possible within the same month of assessment, enhancing the accuracy of the transition intensities. Moreover, the Lifelines cohort includes data on various variables and multiple perspectives, offering promising insights for future research on healthy working life expectancy. Finally, we integrated insights from both epidemiology and econometric methods to offer interdisciplinary perspectives on measuring healthy working life expectancy, effectively bridging the two fields.

This study also has several limitations. First of all, a study on the representativeness of the Lifelines cohort found that low educational attainment and unemployment, as well as smoking, are underrepresented in the cohort, in comparison with the general population of the Northern Netherlands [44]. This may suggest that our results slightly overestimate healthy working life expectancy and underestimate the association between smoking and the duration of working life. Furthermore, the majority of Lifelines participants hold Dutch nationality and have an East or West European background (97%), reflecting the demographic composition of the northern Netherlands. This complicates the generalizability to other populations and regions within the Netherlands and abroad that are more diverse in nationality and ethnicity. Second, health status was operationalized based on a self-assessment using only one item. This was supported by the notion that other health measures, such as medication use, complicate the classification of individuals into healthy or unhealthy states. However, the current approach still leaves us somewhat uncertain about the significance of the growing prevalence of chronic health conditions. Nonetheless, Parker and colleagues obtained similar estimates in their sensitivity analysis, regardless of when health was operationalized by assessing limitations from longstanding illness compared to self-perceived health [18]. Finally, the three mutually exclusive states of our model were based on activity in the labor market. We gathered data from the Statistics Netherlands dataset regarding reasons for economic inactivity and summarized it into a dichotomous state of either working or not working. This prevents us from analyzing the differences between voluntary and involuntary exits from the labor market.

Societal Relevance and Implications

This study contributes to the existing literature on healthy working life expectancy by examining the association between various health behaviors and healthy working life expectancy for different sociodemographic groups. Focusing on the Netherlands, our findings respond directly to the recommendations of the Health Council of the Netherlands, expressing the need to monitor the health of the working population and socioeconomic inequalities in this regard [45]. In light of recent developments in the Netherlands regarding a new pension scheme and the coalition agreement's emphasis on multidisciplinary, evidence-based, and small-scale interventions for healthy aging, the innovative insights from this industry paper are valuable for shaping pension policy. Additionally, the findings from this study can enhance the estimation and awareness of participants' risk capacity in a pension fund [46] by considering health indicators alongside labor participation and differentiating between sociodemographic groups. When labor market uncertainty is high, as indicated by a shorter healthy working life expectancy, pension funds may choose to pursue lower investment risk.

The findings of this study also have implications for health and social security policies. Our findings indicate that estimates of healthy working life expectancy and their relationship with health determinants can offer valuable insights for policy development. To address health and employment inequalities and improve the number of healthy years in the workforce, a dual approach is necessary. First, preventive public health interventions could improve individual health throughout their lifetime, benefiting various aspects of life. Second, interventions to facilitate workers with poor health are required to prevent early exit from the labor market [7, 47] and the drop in income that this is associated with [48].

For future research, it is important to continue to conduct studies on social determinants of health and their relevance for healthy employability [25]. Studies that incorporate meso- or macro-level social determinants, such as working conditions and regional characteristics, are a valuable addition to our findings. Furthermore, we recommend that future researchers use duration-dependent models that consider multiple exit routes. Such models can inform policymakers about the duration and patterns of trajectories leading to (early) unemployment, which can be addressed in social policies. Insights from data collected within a country's current institutional context are particularly significant, as they facilitate knowledge translation into relevant policy actions. These insights are valuable for gradually developing and improving policies that lead to an equitable increase in healthy years of employment.

5. Conclusion

In conclusion, this study found that the healthy working life expectancy of the Dutch population encompasses approximately 85% of their remaining working life from age 50-65, after which individuals, on average, work just over one year in poor health and spend one year out of paid employment. Women and individuals with lower education levels face greater disadvantages in healthy employment and its consequences compared to men and those with higher education. Inequalities between men and women are particularly pronounced at low levels of education and decrease with increasing educational attainment. Health behaviors contribute to the mechanisms that shape healthy years in employment; however, addressing additional social determinants is likely necessary to further expand healthy working life expectancy.

References

1. Hinrichs K. Recent pension reforms in Europe: More challenges, new directions. An overview. Social Policy & Administration. 2021;55(3):409-22.
2. Börsch-Supan A, Coile C. Introduction and Summary, "Social Security Programs and Retirement Around the World: The Effects of Reforms on Retirement Behavior". In: Research NBoE, editor. Social Security Programs and Retirement Around the World: The Effects of Reforms on Retirement Behavior. Chicago: University of Chicago Press; 2023.
3. Reeuwijk KG, van Klaveren D, van Rijn RM, Burdorf A, Robroek SJ. The influence of poor health on competing exit routes from paid employment among older workers in 11 European countries. Scandinavian journal of work, environment & health. 2017:24-33.
4. Ooijen R, Brouwer S. Prolongation of working life and its effect on work disability and retirement income: evidence from register data in the Netherlands. Network for Studies on Pensions, Aging and Retirement. 2025. Available from: https://www.netspar.nl/wp-content/uploads/Netspar-Industry-Paper-2025-09-WEB.pdf
5. Shiri R, Hiilamo A, Lallukka T. Indicators and determinants of the years of working life lost: a narrative review. Scandinavian journal of public health. 2021;49(6):666-74.
6. Kang YJ, Kang M-Y. Chronic diseases, health behaviors, and demographic characteristics as predictors of ill health retirement: findings from the Korea Health Panel Survey (2008–2012). PloS one. 2016;11(12):e0166921.
7. Van Rijn RM, Robroek SJ, Brouwer S, Burdorf A. Influence of poor health on exit from paid employment: a systematic review. Occupational and environmental medicine. 2014;71(4):295-301.
8. Kuitto K, Helmdag J. Extending working lives: How policies shape retirement and labour market participation of older workers. Social Policy & Administration. 2021;55(3):423-39.
9. van den Berg TI, Elders LA, Burdorf A. Influence of health and work on early retirement. Journal of occupational and environmental medicine. 2010;52(6):576-83.
10. Parker M, Bucknall M, Jagger C, Wilkie R. Extending working lives: a systematic review of healthy working life expectancy at age 50. Social Indicators Research. 2020;150(1):337-50.
11. Axelrad H, Mahoney KJ. Increasing the pensionable age: What changes are OECD countries making? What considerations are driving policy? Open Journal of Social Sciences. 2017;5(7):56-70.
12. van der Noordt M, van der Pas S, van Tilburg TG, van den Hout A, Deeg DJ. Changes in working life expectancy with disability in the Netherlands, 1992–2016. Scandinavian Journal of Work, Environment & Health. 2019;45(1):73-81.
13. Hoem JM. A Markov chain model of working life tables. Scandinavian Actuarial Journal. 1977;1977(1):1-20.
14. Burdorf A, Fernandes RC, Robroek SJ. Health and inclusive labour force participation. The Lancet. 2023;402(10410):1382-92.
15. Lièvre A, Jusot F, Barnay T, Sermet C, Brouard N, Robine J, et al. Healthy working life expectancies at age 50 in Europe: a new indicator. Journal of Nutrition Health and Aging. 2007;11(6):508.
16. Boissonneault M, Rios P. Changes in healthy and unhealthy working-life expectancy over the period 2002-17: a population-based study in people aged 51-65 years in 14 OECD countries. Lancet Healthy Longev. 2021;2(10):e629-e38.
17. de Wind A, van der Noordt M, Deeg DJ, Boot CR. Working life expectancy in good and poor self-perceived health among Dutch workers aged 55–65 years with a chronic disease over the period 1992–2016. Occupational and environmental medicine. 2018;75(11):792-7.
18. Parker M, Bucknall M, Jagger C, Wilkie R. Population-based estimates of healthy working life expectancy in England at age 50 years: analysis of data from the English Longitudinal Study of Ageing. The Lancet Public Health. 2020;5(7):e395-e403.

19. United Nations Economic Commission for Europe. Active Ageing Index Analytical report. Geneva; 2019.
20. Laaksonen M, Elovainio M, Kainulainen S, Leinonen T, Jääskeläinen T, Rissanen H, et al. Changes in healthy and unhealthy working life expectancies among older working-age people in Finland, 2000–2017. European journal of public health. 2022;32(5):729-34.
21. Loichinger E, Weber D. Trends in working life expectancy in Europe. Journal of aging and health. 2016;28(7):1194-213.
22. Heller C, Sperlich S, Tetzlaff F, Geyer S, Epping J, Beller J, et al. Living longer, working longer: analysing time trends in working life expectancy in Germany from a health perspective between 2002 and 2018. Eur J Ageing. 2022;19(4):1263-76.
23. Lynch M, Bucknall M, Jagger C, Wilkie R. Projections of healthy working life expectancy in England to the year 2035. Nature Aging. 2022;2(1):13-8.
24. Alavinia SM, Burdorf A. Unemployment and retirement and ill-health: a cross-sectional analysis across European countries. Int Arch Occup Environ Health. 2008;82(1):39-45.
25. Lynch M, Bucknall M, Jagger C, Kingston A, Wilkie R. Demographic, health, physical activity, and workplace factors are associated with lower healthy working life expectancy and life expectancy at age 50. Scientific Reports. 2024;14(1):5936.
26. Neovius K, Johansson K, Rössner S, Neovius M. Disability pension, employment and obesity status: a systematic review. Obesity Reviews. 2008;9(6):572-81.
27. Robroek SJ, Reeuwijk KG, Hillier FC, Bambra CL, van Rijn RM, Burdorf A. The contribution of overweight, obesity, and lack of physical activity to exit from paid employment: a meta-analysis. Scandinavian journal of work, environment & health. 2013:233-40.
28. Ots P, van Zon SK, Schram JL, Burdorf A, Robroek SJ, Hengel KMO, et al. The influence of unhealthy behaviours on early exit from paid employment among workers with a chronic disease: a prospective study using the Lifelines cohort. Preventive medicine. 2020;139:106228.
29. Dudel C. Healthy and unhealthy working-life expectancy: opportunities and challenges. Lancet Healthy Longev. 2021;2(10):e604-e5.
30. Centraal Bureau voor de Statistiek. Arbeidsparticipatie naar leeftijd en geslacht: Centraal Bureau voor de Statistiek; 2023. Available from: https://www.cbs.nl/nl-nl/visualisaties/dashboard-arbeidsmarkt/werkenden/arbeidsparticipatie-naar-leeftijd-en-geslacht#:~:text=In%20de%20periode%202013%2D2021,(%2B14%2C2%20procentpunt)
31. Scholtens S, Smidt N, Swertz M, Bakker S, Dotinga A, Vonk J, et al. LifeLines, a three-generation cohort study and biobank. International Journal of Epidemiology. 2015;44(4):1172-80.
32. Centraal Bureau voor de Statistiek. Pensioenleeftijd in 2021 ruim 4 jaar hoger dan in 2006: Centraal Bureau voor de Statistiek; 2022. Available from: https://www.cbs.nl/nl-nl/nieuws/2022/16/pensioenleeftijd-in-2021-ruim-4-jaar-hoger-dan-in-2006#:~:text=Net%20als%20in%202020%20bedroeg,pensioen%20ging%20is%20sindsdien%20gedaald
33. Centraal Bureau voor de Statistiek. Pensioenleeftijd werknemers nadert 66 jaar: Centraal Bureau voor de Statistiek; 2024. Available from: https://www.cbs.nl/nl-nl/nieuws/2024/18/pensioenleeftijd-werknemers-nadert-66-jaar#:~:text=Bijna%20drie%20kwart%20van%20de,dan%20ook%20steeds%20verder%20op.
34. Hays RD, Morales LS. The RAND-36 measure of health-related quality of life. Annals of medicine. 2001;33(5):350-7.
35. World Health Organization. Global recommendations on physical activity for health. Geneva: World Health Organization; 2010.
36. Wendel-Vos GW, Schuit AJ, Saris WH, Kromhout D. Reproducibility and relative validity of the short questionnaire to assess health-enhancing physical activity. Journal of clinical epidemiology. 2003;56(12):1163-9.
37. Boomsma L, Drost I, Larsen I, Luijkx J, Meerkerk G, Valken N, et al. NHG-Standaard Problematisch alcoholgebruik (derde herziening). Huisarts en Wetenschap. 2014;57(12):638-46.

38. IBM Corporation. IBM SPSS statistics for windows. 25 ed. Armonk, NY: IBM corporation; 2017.
39. R Core Team. R: A language and environment for statistical computing. In: Foundation for Statistical Computing V, Austria, editor. 2013.
40. Jackson C. Multi-state models for panel data: the msm package for R. Journal of statistical software. 2011;38:1-28.
41. Mulder M, Ranchor AV, Sanderman R, Bouma J, van den Heuvel WJ. The stability of lifestyle behaviour. International journal of epidemiology. 1998;27(2):199-207.
42. Schuring M, Schram JL, Robroek SJ, Burdorf A. The contribution of health to educational inequalities in exit from paid employment in five European regions. Scandinavian journal of work, environment & health. 2019;45(4):346-55.
43. Bloemen HG. The effect of private wealth on the retirement rate: an empirical analysis. Economica. 2011;78(312):637-55.
44. Klijs B, Scholtens S, Mandemakers JJ, Snieder H, Stolk RP, Smidt N. Representativeness of the LifeLines cohort study. PloS one. 2015;10(9):e0137203.
45. Van Der Mark-Reeuwijk KG, Weggemans RM, Bültmann U, Burdorf A, Deeg DJ, Geuskens GA, et al. Health and prolonging working lives: an advisory report of the Health Council of The Netherlands. Scandinavian journal of work, environment & health. 2019;45(5):514-9.
46. Alessie R, Knoef M, Paz-Pardo G, Van Ooijen R. Measuring risk capacity based on lifetime earnings and total wealth portfolios in the Netherlands. Network for Studies on Pensions, Aging and Retirement. 2025. Available from: https://www.netspar.nl/en/knowledge-hub/measuring-risk-capacity-based-on-lifetime-earnings-and-total-wealth-portfolios-in-the-netherlands/
47. Gurgel do Amaral GS, Ots P, Brouwer S, van Zon SK. Multimorbidity and exit from paid employment: the effect of specific combinations of chronic health conditions. European Journal of Public Health. 2022;32(3):392-7.
48. Yu P, Couch KA. Work-limiting health, earnings, and employment: an analysis with SIPP data. Applied Economics. 2020;52(12):1327-48.

Appendix I – Transition frequencies

Transitions from and to state 999 are censored transitions in the estimation of healthy working life expectancy, as this code denotes the absence of a state. These transitions are not reported, due to output regulations of Statistics Netherlands.

Full population				
Transitions from state		I Healthy in work	II Unhealthy in work	III Unemployed
	I	46786	2631	3642
	II	2057	2137	622
	III	539	57	2875

Women				
Transitions from state		I Healthy in work	II Unhealthy in work	III Unemployed
	I	25357	1562	2088
	II	1203	1210	370
	III	270	33	1706

Men				
Transitions from state		I Healthy in work	II Unhealthy in work	III Unemployed
	I	21595	1071	1556
	II	862	946	251
	III	270	25	1194

Low education level				
Transitions from state		I Healthy in work	II Unhealthy in work	III Unemployed
	I	14855	978	1489
	II	794	825	260
	III	219	20	1307

Intermediate education level				
Transitions from state		I Healthy in work	II Unhealthy in work	III Unemployed
	I	16517	888	1092
	II	692	783	188
	III	180	22	827

High education level				
Transitions from state		I Healthy in work	II Unhealthy in work	III Unemployed
	I	14689	713	988
	II	539	515	155
	III	132	16	707

Appendix II – Goodness-of-fit figures

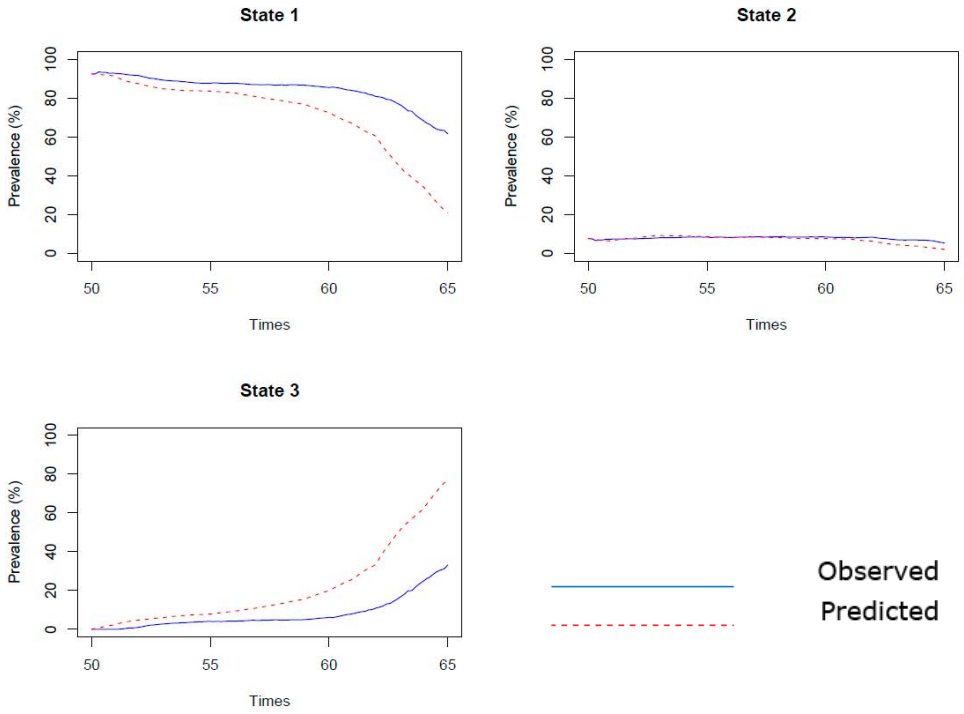

Figure 3: Goodness-of-fit plot from the observed and predicted prevalence of the PCI model (state 1 = HWLE, state 2 = working in poor health, state 3 = not in work)

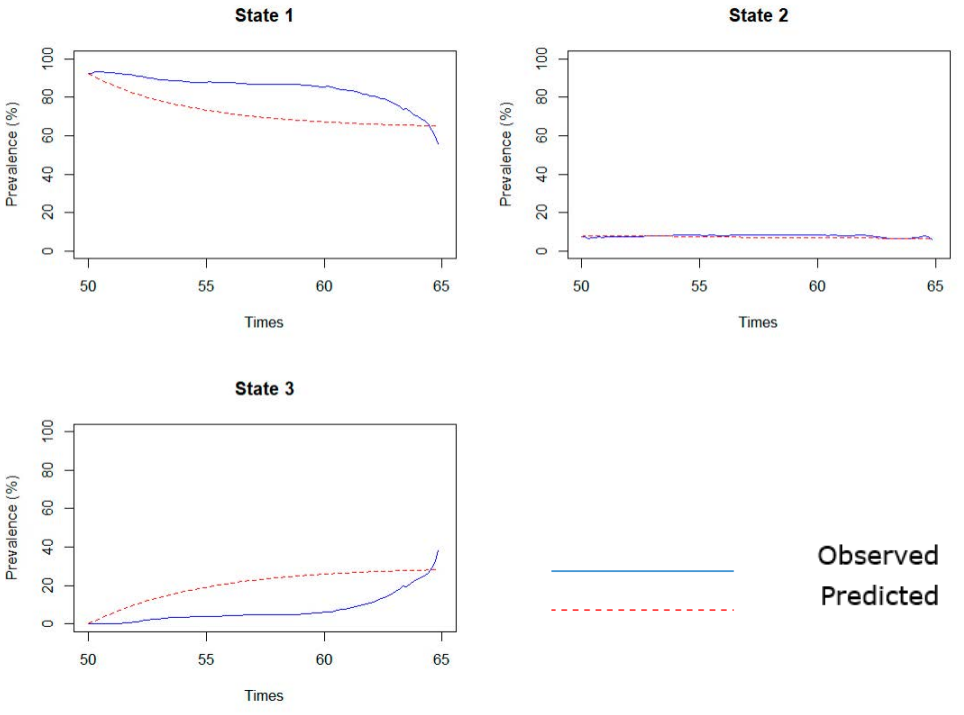

Figure 4: Goodness-of-fit plot from the observed and predicted prevalence of a general multistate model (state 1 = HWLE, state 2 = working in poor health, state 3 = not in work)

Network for Studies on
Pensions, Aging and Retirement

This is a publication of Netspar
April 2026

T +31 13 466 2109
E info@netspar.nl

netspar.nl