# Trends across 20 years in multiple indicators of functioning among older adults in the Netherlands

Erik J. Timmermans[1], Emiel O. Hoogendijk[1], Marjolein I. Broese van Groenou [2],
Hannie C. Comijs[3], Natasja M. van Schoor[1], Fleur C.F. Thomése[2], Marjolein Visser[4],
Dorly J.H. Deeg[1], Martijn Huisman[1,2]

1 Department of Epidemiology and Biostatistics, Amsterdam Public Health Research Institute, Amsterdam UMC – Location VU University Medical Center, Amsterdam, The Netherlands
2 Department of Sociology, Faculty of Social Sciences, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands
3 Department of Psychiatry, Amsterdam Public Health Research Institute, Amsterdam UMC – Location VU University Medical Center/GGZ inGeest, Amsterdam, The Netherlands
4 Department of Health Sciences, Faculty of Science, Amsterdam Public Health Research Institute, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands

Correspondence: Erik J. Timmermans, Department of Epidemiology and Biostatistics, Amsterdam Public Health Research Institute, Amsterdam UMC – Location VU University Medical Center, De Boelelaan 1089A, 1081HV Amsterdam, The Netherlands, Tel: +31 (0) 20 4448187, e-mail: ej.timmermans@vumc.nl

**Background:** Monitoring of trends in functioning of older adults provides indispensable information for health care policy. This study examined trends in multiple indicators of functioning among Dutch older adults across a period of 20 years. **Methods:** Data from the Longitudinal Aging Study Amsterdam were used. We included 10 870 observations of 3803 respondents aged 64–84 years across seven waves (1992–12) and 931 observations of 603 respondents aged 85–94 years across four waves (2001–12). At each wave, 8 indicators of functioning were measured: multimorbidity, severe functional limitations, depression, anxiety, cognitive impairment, physical inactivity, loneliness and social isolation. In addition, a sum score (range: 0–8) of these indicators was calculated, with a score of $\geq 5$ indicating 'multiple problems.' Trends in functioning over time were assessed using Generalized Estimating Equation analyses. **Results:**  In the 64-84-years-olds, the prevalence of multimorbidity increased over time [OR(year) = 1.06, 95% CI = 1.05–1.06], whereas the prevalence of the other indicators decreased [i.e. cognitive impairment, physical inactivity (in women) and loneliness (in women)] or remained stable [i.e. severe functional limitations, depression, anxiety, physical inactivity (in men), loneliness (in men) and social isolation]. In the 85-94-year-olds, the prevalence of severe functional limitations increased over time [OR(year) = 1.08, 95% CI = 1.02–1.13], whereas the prevalence of the other indicators remained stable. In both age groups, the prevalence of 'multiple problems' remained stable. **Conclusion:** : Unfavorable trends were observed in multimorbidity among 64-84-years-olds and in severe functional limitations among 85-94-year-olds. Favorable trends were found in cognitive impairment, physical inactivity (in women) and loneliness (in women) among 64–84-years-olds.

## Introduction

Life expectancy in most developed countries has increased continuously over recent decades. More people survive to old age, and people in old age live longer.[1,2] Because, in general, aging is accompanied by an increasing risk of physical, mental and cognitive decline, an increased number of older adults may put pressure on our health care and welfare systems.[3] Monitoring of trends in health and functioning of older adults at the population level provides indispensable information for health care policy, as they reflect the challenges and results of long-term policy.[4,5] Trend studies may help to verify policymakers' assumptions about developments in health and functioning of older adults, and provide information that could be used by policymakers for projections regarding future health care use.[4]

The improvement in life expectancy may be attributed to better life course conditions of subsequent generations, as well as to substantial improvements in medical care and advances in diagnostic tools over time.[6] For instance, previous studies have shown that educational attainment and concomitant social status have increased in subsequent generations.[6,7] Furthermore, more recent generations of older adults have been exposed less to unfavorable

conditions,[6] such as infectious diseases in childhood[8] and smoking in adulthood.[9] In addition, improvements in medical care and better diagnostic tools enable earlier diagnosis and better treatments of diseases.[6,10]

It is not self-evident that the increase in life expectancy is accompanied by positive developments in health and functioning among older adults. Previous research in older adults mainly focused on trends in multimorbidity and functional limitations over time and showed mixed results.[11–14] For instance, a study by Lafortune and Balestat including data from 12 Organization for Economic Cooperation and Development countries showed that the prevalence of severe disability is rising in some countries and falling in others, with no clear overall trend.[13] Previous research on trends in other indicators of functioning among older adults, such as depression,[15,16] anxiety,[15,17] cognitive impairment,[18,19] physical inactivity,[20,21] loneliness[22,23] and social isolation[24,25] also revealed mixed results. It has been suggested that the inconsistencies in the findings across studies could be explained by differences in policy across countries as well as by methodological differences, such as differences in age groups, sampling frames, definitions of outcome measures and methods of data collection.[14] In particular, research on trends in indicators of social functioning is limited. However, it is

important to examine trends in these indicators as they could compensate for negative trends in other indicators.[26]

Most studies on trends in functioning of older adults have focused on specific indicators, studied one at a time.[19] However, problems in functioning are often interrelated and exist simultaneously in old age. In particular, the accumulation of problems across different domains of functioning increases the demand for curative and long-term care among older adults.[19] Policymakers should particularly have the vulnerable older adults with multiple problems on their radar. This requires information about trends in multiple indicators of functioning among older adults assessed simultaneously over time.

This study extends previous research by examining time trends in multiple indicators of functioning, including problems in physical, cognitive, mental and social functioning, among 64–84-years-olds as well as among 85–94-years-olds in the Netherlands. It is hypothesized that the prevalence of the individual indicators of functioning decreased over time in both age groups due to the fact that subsequent generations of older adults have been exposed to better life course conditions and medical care.[6,10] For this reason, it is also expected that the prevalence of the absence of problems increased over time as many people will reach old age in good health and the onset of health problems is delayed until a higher age. In particular, it is expected that this increase will be most visible in 64–84-years-olds. In addition, it is hypothesized that the prevalence of 'multiple problems' increased over time due to increases in life expectancy and concomitant aging of the population, which is related to multiple problems in functioning.[3,19] It is expected that this increase will be most visible in 85–94-years-olds.

## Methods

### Design and study sample

Data from the Longitudinal Aging Study Amsterdam (LASA) were used in this study. The Longitudinal Aging Study Amsterdam is an ongoing, prospective cohort study in the Netherlands on the determinants, trajectories and consequences of physical, cognitive, emotional and social functioning in older adults.[27,28] Sampling, response and procedures are described in detail elsewhere.[28] In summary, a random sample of older men and women (55–85 years), stratified by age and sex, was drawn from the population registries of eleven municipalities across three culturally distinct regions in the Netherlands, thereby representing variation in religious background and urbanicity. The baseline data collection was conducted in 1992/93 and the baseline sample included 3107 respondents. Since then, follow-up measurements have been conducted approximately every 3 years. Additional respondents (n = 1002; 55–64 years) were recruited from the same sampling frame in 2002/03. Data were collected in main face-to-face, computer assisted interviews. In addition, respondents were asked to participate in a medical interview, entailing a separate visit to administer clinical measurements and ask additional questions. The LASA study has been approved by the Ethical Review Board of the VU University medical center.

For this study, data from 64 to 84 years olds were used, including data from Wave 1992/93, Wave 1995/96, Wave 1998/99, Wave 2001/02, Wave 2005/06, Wave 2008/09 and Wave 2011/12. In addition, data from 85 to 94 years old were used, including data from Wave 2001/02 to Wave 2011/12. In LASA, Wave 2001/02 is the first measurement wave at which data were available for the full age range of 85–94-years-olds. At each wave, observations from 'new' respondents (i.e. those who turned 64 or 85 years old) were included in the analyses. A total of 10 870 observations of 3803 respondents aged 64–84 years across seven waves were included. Furthermore, a total of 931 observations of 603 respondents aged 85–94 years across four waves were included in this study. For some 64–84-years-olds

(n = 70) and 85–94-years-olds (n = 135), the data on multimorbidity, severe functional limitations and depression were collected using telephone interviews with respondents or proxies, because these were unable to complete a face-to-face interview. In the telephone interviews, data on multimorbidity, severe functional limitations and depression were assessed in the same way as in the main face-to-face interview. In the telephone interviews, data on cognitive impairment and loneliness were assessed using abbreviated questionnaires and could therefore not be included in the analyses. Data on anxiety, physical inactivity and social isolation were not collected in the telephone interviews.

### Indicators of functioning

The number of chronic diseases was measured through self-reports of the following nine chronic diseases that lasted for at least 3 months, or diseases for which the participants had been treated or monitored by a physician: chronic nonspecific lung disease, cardiovascular diseases, peripheral artery diseases, diabetes mellitus, stroke, arthritis, cancer, hypertension and one other disease. Multimorbidity was defined as present when participants had two or more chronic diseases.[29]

Functional limitations were assessed as the self-reported degree of difficulty or need of help with performing the following activities of daily living: climbing stairs, walking 5 min outdoors without resting, getting up and sitting down in a chair, dressing and undressing oneself, using own or public transportation and cutting one's own toenails.[30] Severe functional limitations were considered as present when participants indicated that they could not perform at least one of these activities at all or without help.

Depressive symptoms were measured using the Center for Epidemiologic Studies Depression Scale (CES-D).[31] The CES-D is a 20-item self-report scale ranging from 0 to 60. A clinically relevant level of depressive symptoms was defined as present when participants had a CES-D score of 16 or higher.[31]

Anxiety symptoms were examined by the Hospital Anxiety and Depression Scale—Anxiety scale (HADS-A).[32] The HADS-A is a seven-item self-report questionnaire. The scale ranges from 0 to 21. Anxiety was considered as present when participants had a HADS-A score of 8 or higher.[33]

General cognitive functioning was measured using the Mini-Mental State Examination (MMSE).[34,35] The MMSE is a 23-item global cognitive function test. The MMSE score ranges from 0 to 30. Cognitive impairment was defined as present when participants had a MMSE-score of 23 or lower.[35]

Physical activity was measured using the LASA Physical Activity Questionnaire (LAPAQ).[36] The LAPAQ covers frequency and duration of various activities during the previous 2 weeks. Activities include walking outside, cycling, gardening, light and heavy household work and a maximum of two sports. According to the physical activity recommendations of the World Health Organization, older adults should do at least 150 min of moderate intensity aerobic physical activity or at least 75 min of vigorous intensity aerobic physical activity throughout the week or an equivalent combination of moderate and vigorous intensity activity.[37] A physically inactive lifestyle was considered as present when participants spent less than 150 min/week on moderate to vigorous physical activities (i.e. walking outside, cycling, heavy household work and sports).

Loneliness was assessed using the De Jong-Gierveld Loneliness Scale.[38] This scale ranges from 0 to 11. Loneliness was considered as present when participants had a score of 3 or higher.[38]

Social isolation was defined as present when participants indicated that they had no daily contact with anyone from their personal social network. Participants who live together with a partner or someone else were considered as not socially isolated.

**Table 1** Characteristics of the 64–84-years-olds and the weighted prevalence of the eight indicators of functioning and sum score measures among this group at each measurement wave[a,b,c,d]

|  | Measurement waves | | | | | | |
|---|---|---|---|---|---|---|---|
|  | 1992/93<br>*n* = 2199 | 1995/96<br>*n* = 1773 | 1998/99<br>*n* = 1553 | 2001/02<br>*n* = 1366 | 2005/06<br>*n* = 1381 | 2008/09<br>*n* = 1323 | 2011/12<br>*n* = 1275 |
| Characteristics |  |  |  |  |  |  |  |
| Age in years [mean (SD)] | 74.9 (6.1) | 74.2 (6.1) | 73.9 (6.1) | 73.6 (5.7) | 73.2 (6.0) | 73.4 (6.0) | 73.3 (5.9) |
| Sex (female) (%) | 51.1 | 53.1 | 55.6 | 56.6 | 55.9 | 55.6 | 55.8 |
| Educational level in years [mean (SD)] | 8.5 (3.3) | 8.8 (3.3) | 9.0 (3.2) | 9.2 (3.2) | 9.6 (3.3) | 9.9 (3.4) | 10.2 (3.4) |
| Indicators of functioning |  |  |  |  |  |  |  |
| Multimorbidity (%) | 43.6 | 52.2 | 58.3 | 58.9 | 62.3 | 64.4 | 67.8 |
| Severe functional limitations (%) | 31.0 | 30.4 | 27.4 | 25.7 | 27.6 | 25.2 | 24.6 |
| Depression (%) | 15.8 | 15.1 | 16.6 | 15.6 | 15.6 | 12.5 | 13.1 |
| Anxiety (%) | 9.1 | 8.9 | 9.9 | 8.8 | 10.0 | 8.7 | 8.9 |
| Cognitive impairment (%) | 12.4 | 11.0 | 8.1 | 7.7 | 7.4 | 5.7 | 4.6 |
| Physical inactivity (%) | 33.8 | 35.5 | 32.7 | 31.3 | 31.6 | 29.0 | 26.8 |
| Loneliness (%) | 33.9 | 35.4 | 35.3 | 33.3 | 30.3 | 29.2 | 28.5 |
| Social isolation (%) | 15.3 | 14.9 | 15.5 | 15.4 | 13.0 | 14.0 | 14.6 |
| Sum score measures |  |  |  |  |  |  |  |
| Sum score (0–8) [mean (SD)] | 1.8 (1.7) | 2.0 (1.6) | 2.0 (1.6) | 1.9 (1.5) | 1.9 (1.5) | 1.8 (1.5) | 1.8 (1.5) |
| Absence of problems (%) | 25.0 | 19.1 | 17.7 | 17.8 | 19.7 | 19.5 | 17.7 |
| Multiple problems (%) | 8.5 | 9.2 | 8.3 | 7.1 | 7.1 | 6.9 | 5.4 |

*n*, number of observations; SD, standard deviation.

a: Means and standard deviations are presented for normally distributed continuous variables. Frequencies and proportions are presented for categorical variables.

b: The total number of 64–84-years-olds is 3803. In this group, the total number of observations is 10 870. The number of observations may vary for some indicators, because of missing values.

c: For the analyses regarding the sum score measures, only 64–84-years-olds ($n_{participants}$ = 3539, $n_{observations}$ = 9264) with full data on the indicators were included.

d: The prevalence of the indicators is weighted to the age and sex distribution at wave 2001/02.

## Sum score measures

At each wave, a sum score (range: 0–8) of the 8 indicators of functioning was calculated. Absence of problems was defined as present when participants had a sum score of 0. 'Multiple problems' were considered as present when participants had a sum score of 5 or higher. By using the cut-off point of 5, we selected participants with problems on the majority of indicators and with problems in multiple domains of functioning (i.e. covering physical, cognitive, mental and social functioning).

## Time indicator

For the trend analyses in the 64–84-years-olds, a time indicator was constructed, representing the time in years between the first and subsequent waves from 1992/93. For the trend analyses in the 85–94-years-olds, a second time indicator was constructed, representing the time in years between the first and subsequent waves from 2001/02.

## Covariates

Age in years and sex (0 = men, 1 = women) were included as covariates in the analyses. In addition, the highest educational level attained in years (range: 5–18 years) was included as covariate in the analyses to examine to what extent an increased level of education has contributed to the observed trends.

## Statistical analyses

At all waves, the prevalence of each individual indicator and sum score measure was assessed. To adjust for differences in the distributions of age and sex across the various waves, the data on each indicator and sum score measure were weighted to the age and sex distribution of the mid-wave of the observation period (i.e. 64–84-years-olds: Wave 2001/02; 85–94-years-olds: Wave 2008/09). Weights were calculated per sex and 5-year age category.

Generalized Estimating Equations (GEEs) modeling was used to assess whether the observed trends in each individual indicator and the observed trends in the sum score measures were statistically significant over time. For the analyses regarding the sum score measures, only participants with full data on the indicators were included. In all GEE-analyses, a six-dependent (64–84-years-olds) and a three-dependent (85–94-years-olds) correlation structure were used to account for the dependency of repeated observations within participants. The unstandardized regression coefficients that were obtained from the GEE-analyses show the average annual change in the continuous sum score measure. In cases where the outcome measure was binary we used the logit link function. The odds ratios that were obtained from the GEE-analyses show the average annual change in prevalence of the various indicators of functioning.

To examine whether the trends differed between men and women in both age groups, an interaction term between sex and time was added to the fully adjusted model. The interaction term was considered as statistically significant at a *P* values below 0.10.[39] If the interaction term was statistically significant, stratified analyses were conducted and results were presented for men and women separately. All trend-analyses were adjusted for age and sex (Model 1) and additionally adjusted for educational level (Model 2). The sex-stratified analyses were adjusted for age (Model 1) and additionally adjusted for educational level (Model 2).

Pre-planned sensitivity analyses were conducted to examine trends in multimorbidity, severe functional limitations and depression among 64–84 and 85–94-years-olds, while excluding those of which data were collected using telephone interviews.

Level of significance was set to $\alpha$ = 5.0%. All analyses were performed in IBM SPSS Statistics (Version 22.0; IBM Corp, Armonk, New York, USA).

**Table 2** Characteristics of the 85–94-years-olds and the weighted prevalence of the eight indicators of functioning and sum score measures among this group at each measurement wave[a,b,c,d]

| | Measurement waves | | | |
|---|---|---|---|---|
| | 2001/02<br>*n* = 308 | 2005/06<br>*n* = 226 | 2008/09<br>*n* = 198 | 2011/12<br>*n* = 199 |
| Characteristics | | | | |
| Age in years [mean (SD)] | 88.8 | 89.0 | 89.2 | 88.7 |
| | (2.6) | (2.7) | (2.9) | (2.7) |
| Sex (female) (%) | 62.0 | 62.8 | 65.2 | 65.8 |
| Educational level in years [mean (SD)] | 8.4 (3.5) | 8.7 (3.3) | 8.8 (3.1) | 9.1 (2.9) |
| Indicators of functioning | | | | |
| Multimorbidity (%) | 70.1 | 68.0 | 76.1 | 76.3 |
| Severe functional limitations (%) | 73.8 | 75.9 | 80.9 | 78.6 |
| Depression (%) | 26.5 | 21.2 | 25.0 | 20.4 |
| Anxiety (%) | 12.9 | 10.1 | 7.2 | 9.6 |
| Cognitive impairment (%) | 33.5 | 28.6 | 27.5 | 20.5 |
| Physical inactivity (%) | 70.8 | 67.9 | 71.5 | 66.7 |
| Loneliness (%) | 53.6 | 48.5 | 47.7 | 50.0 |
| Social isolation (%) | 33.0 | 31.9 | 25.5 | 26.7 |
| Sum score measures | | | | |
| Sum score (0–8) [mean (SD)] | 3.6 (1.7) | 3.4 (1.7) | 3.5 (1.5) | 3.3 (1.5) |
| Absence of problems (%) | 4.0 | 1.6 | 0.8 | 1.7 |
| Multiple problems (%) | 31.2 | 23.8 | 23.8 | 24.4 |

*n*, number of observations; SD, standard deviation.

a: Means and standard deviations are presented for normally distributed continuous variables. Frequencies and proportions are presented for categorical variables.

b: The total number of 85–94-years-olds is 603. In this group, the total number of observations is 931. The number of observations may vary for some indicators, because of missing values.

c: For the analyses regarding the sum score measures, only 85–94-years-olds ($n_{participants}$ = 377, $n_{observations}$ = 549) with full data on the indicators were included.

d: The prevalence of the indicators is weighted to the age and sex distribution at wave 2008/09.

## Results

### Characteristics of 64–84-years-olds

The characteristics of the 64–84-years-olds at each wave are presented in table 1. Across all observations, the average age was 73.9 (SD = 6.0) years, the average proportion of women was 54.5%, and the average level of education attained in years was 9.2 (SD = 3.4). The weighted prevalence of the 8 indicators of functioning and the sum score measures among 64–84-years-olds at each wave are also presented in table 1. The estimated prevalence of the individual indicators of functioning and the sum score measures among 64–84-years-olds, adjusted for age and sex, are graphically presented in Supplementary file S1.

### Characteristics of 85–94-years-olds

The characteristics of the 85–94-years-olds at each wave are presented in table 2. Across all observations, the average age was 88.9 (SD = 2.7) years, the average proportion of women was 63.7%, and the average level of education attained in years was 8.7 (SD = 3.3). The weighted prevalence of the 8 indicators of functioning and the sum score measures among 85–94-years-olds at each wave are also presented in table 2. The estimated prevalence of the individual indicators of functioning and the sum score measures among 85–94-years-olds, adjusted for age and sex, are graphically presented in Supplementary file S1.

### Trends in the individual indicators of functioning among 64–84-years-olds

After adjustment for age, sex and educational level, a statistically significant increasing trend in the prevalence of multimorbidity between 1992/93 and 2011/12 was observed among 64–84-years-olds [OR(year) = 1.06, 95% CI = 1.05–1.07] (table 3; Model 2).

Furthermore, the fully adjusted model showed a significant decreasing trend in cognitive impairment [OR(year) = 0.98, 95% CI = 0.96–0.99] among 64–84-years-olds. In this age group, the trends in physical inactivity (*P*-value$_{interaction}$ = 0.001) and loneliness (*P*-value$_{interaction}$ = 0.02) differed by sex. Significant decreasing trends were observed in physical inactivity and loneliness in women [OR(year)$_{physical\_activity}$ = 0.98, 95% CI = 0.97–0.99; OR(year)$_{loneliness}$ = 0.99, 95% CI = 0.98–1.00], but not in men [OR(year)$_{physical\_activity}$ = 1.00, 95% CI = 0.99–1.01; OR(year)$_{loneliness}$ = 1.00, 95% CI = 0.99–1.01] (table 3; Model 2). After adjustment for all covariates, the trends in all other indicators were stable over time in this age group (table 3; Model 2).

### Trends in the individual indicators of functioning among 85–94-years-olds

A significant increasing trend in the prevalence of severe functional limitations between 2001/02 and 2011/12 was observed among 85–94-years-olds after adjustment for all covariates [OR(year) = 1.09, 95% CI = 1.03–1.14] (table 3; Model 2). An age- and sex-adjusted decreasing trend in the prevalence of cognitive impairment was observed [OR(year) = 0.95, 95% CI = 0.90–0.99] (table 3; Model 1 and Supplementary file S1). After additional adjustment for educational level, the decreasing trend in cognitive impairment was only marginally statistically significant [OR(year) = 0.95, 95% CI = 0.91–1.00] (table 3; Model 2). In this age group, the trend in anxiety differed by sex (*P*-value$_{interaction}$ = 0.04). An increasing and decreasing trend in anxiety was observed in men [OR(year) = 1.10, 95% CI = 0.98–1.23] and women [OR(year) = 0.92, 95% CI = 0.83–1.02], respectively, but both trends were not statistically significant (table 3; Model 2). After adjustment for age, sex and educational level, the trends in all other indicators were stable over time in this age group (table 3; Model 2).

**Table 3** Trends in the prevalence of the eight indicators of functioning over time among 64–84-years-olds (1992/93–2011/12) and 85–94-years-olds (2001/02–2011/12)[a]

| | 64–84-years-olds | | 85–94-years-olds | |
|---|---|---|---|---|
| | Model 1 | Model 2 | Model 1 | Model 2 |
| | OR(year) (95% CI) | OR(year) (95% CI) | OR(year) (95% CI) | OR(year) (95% CI) |
| Indicators of functioning | | | | |
| Multimorbidity | 1.06 (1.05–1.06)*** | 1.06 (1.05–1.07)*** | 1.03 (0.99–1.08) | 1.04 (0.99–1.08) |
| Severe functional limitations | 0.99 (0.98–1.00)** | 1.00 (0.99–1.01) | 1.08 (1.02–1.13)** | 1.09 (1.03–1.14)** |
| Depression | 0.99 | 1.00 | 1.00 | 1.01 |
| | (0.98–1.00) | (0.99–1.01) | (0.96–1.05) | (0.96–1.06) |
| Anxiety | 1.00 (0.99–1.01) | 1.01 (1.00–1.02) | – | – |
| Men | – | – | 1.09 (0.98–1.23) | 1.10 (0.98–1.23) |
| Women | – | – | 0.91 (0.83–1.00) | 0.92 (0.83–1.02) |
| Cognitive impairment | 0.96 (0.95–0.97)*** | 0.98 (0.96–0.99)*** | 0.95 (0.90–0.99)* | 0.95 (0.91–1.00) |
| Indicators of functioning | | | | |
| Physical inactivity | – | – | 1.00 (0.95–1.06) | 1.00 (0.95–1.06) |
| Men | 1.00 (0.99–1.01) | 1.00 (0.99–1.01) | – | – |
| Women | 0.98 (0.97–0.99)*** | 0.98 (0.97–0.99)*** | – | – |
| Loneliness | – | – | 1.00 (0.93–1.09) | 0.98 (0.93–1.03) |
| Men | 1.00 (0.99–1.01) | 1.00 (0.99–1.01) | – | – |
| Women | 0.99 (0.98–0.99)** | 0.99 (0.98–1.00)** | – | – |
| Social isolation | 1.00 (0.99–1.01) | 0.99 (0.98–1.00) | 0.97 (0.92–1.02) | 0.96 (0.92–1.02) |

CI, confidence interval; OR, odds ratio.

a: In Model 1, the trends over time are adjusted for age and sex. In Model 2, the trends over time are additionally adjusted for educational level. The sex-stratified trend analyses in 64–84-years-olds (physical inactivity and loneliness) and 85–94-years-olds (anxiety) are adjusted for age (Model 1) and additionally adjusted for educational level (Model 2).

*: $P < 0.05$, **: $P < 0.01$, ***: $P < 0.001$.

**Table 4** Trends in the sum score, prevalence of the absence of problems, and prevalence of 'multiple problems' over time among 64–84-years-olds (1992/93–2011/12) and 85–94-years-olds (2001/02–2011/12)[a,b]

| | Sum score (range = 0–8) | Absence of problems (sum score = 0) | Multiple problems (sum score $\geq$5) |
|---|---|---|---|
| **64–84-years-olds** | | | |
| | B(year) (95% CI) | OR(year) (95% CI) | OR(year) (95% CI) |
| Model 1 | – | 0.98 (0.97–0.99)*** | 0.98 (0.97–1.00)* |
| Men | 0.012 (0.006–0.019)*** | – | – |
| Women | −0.004 (−0.011–0.003) | – | – |
| Model 2 | – | 0.97 (0.96–0.98)*** | 0.99 (0.98–1.00) |
| Men | 0.016 (0.009–0.023)*** | – | – |
| Women | 0.001 (−0.006–0.009) | – | – |
| **85–94-years-olds** | | | |
| Model 1 | – | 0.85 (0.69–1.04) | 0.98 (0.93–1.04) |
| Men | 0.059 (0.003–0.115)* | – | – |
| Women | −0.030 (−0.075–0.015) | – | – |
| Model 2 | – | 0.84 (0.68–1.04) | 1.05 (0.96–1.16) |
| Men | 0.060 (0.004–0.116)* | – | – |
| Women | −0.021 (−0.066–0.023) | – | – |

B, unstandardized regression coefficient; CI, confidence interval; OR, odds ratio.

a: For these analyses, only 64–84-years-olds ($n_{participants}$ = 3539, $n_{observations}$ = 9264) and 85–94-years-olds ($n_{participants}$ = 377, $n_{observations}$ = 549) with full data on the indicators were included.

b: In Model 1, the trends over time are adjusted for age and sex. In Model 2, the trends over time are additionally adjusted for educational level. The sex-stratified trend analyses in 64–84 and 85–94-years-olds (sum score measure) are adjusted for age (Model 1) and additionally adjusted for educational level (Model 2).

*: $P < 0.05$, ***: $P < 0.001$.

## Trends in the sum score measures among 64–84-years-olds

The trend in average sum score differed by sex in 64–84-years-olds ($P$-value$_{interaction}$ = 0.01). In this age group, the average sum score significantly increased between 1992/93 and 2011/12 in men [B(year) = 0.016, 95% CI = 0.009–0.023], but not in women [B(year) = 0.001, 95% CI = −0.006 to 0.009] (table 4; Model 2). After adjustment for all covariates, a significant decreasing trend in the prevalence of the absence of problems was found among 64–84-years-olds [OR(year) = 0.97, 95% CI = 0.96–0.98] (table 4; Model

2). After adjustment for age, sex and educational level, a stable trend was observed in the prevalence of 'multiple problems' in this age group [OR(year) = 0.99, 95% CI = 0.98–1.00] (table 4; Model 2).

## Trends in the sum score measures among 85–94-years-olds

The trend in average sum score differed by sex in 85–94-years-olds ($P$-value$_{interaction}$ = 0.01). In this age group, the average sum score significantly increased between 2001/02 and 2011/12 in men [B(year) = 0.060, 95% CI = 0.004–0.116], but not in women

[B(year) = −0.021, 95% CI = −0.066 to 0.023] (table 4; Model 2). The fully adjusted models showed stable trends in the prevalence of absence of problems [OR(year) = 0.84, 95% CI = 0.68–1.04] and 'multiple problems' [OR(year) = 1.05, 95% CI = 0.96–1.16] among 85–94-years-olds (table 4; Model 2).

### Sensitivity analyses

The sensitivity analyses, in which the trends in multimorbidity, severe functional limitations and depression were examined among 64–84 and 85–94-years-olds, while excluding those of which data were collected using telephone interviews, revealed similar results as observed in the main analyses, except regarding one finding. A decreasing trend in the prevalence rate of severe functional limitations among 64–84-years-olds was observed (OR = 0.98, 95% CI = 0.97–0.99), which remained statistically significant in the fully adjusted model (OR = 0.99, 95% CI = 0.98–1.00).

## Discussion

This study examined trends in multiple indicators of functioning among Dutch older adults. The findings show that the prevalence of multimorbidity increased over time among 64–84-years-olds. However, the prevalence of all other indicators decreased or remained stable over time. In the 85–94-years-olds, the prevalence of severe functional limitations increased over time, whereas the prevalence of all other indicators remained stable over time. In both age groups, the prevalence of 'multiple problems' remained stable over time.

The increasing trend in the prevalence rate of multimorbidity among 64–84-years-olds could be interpreted as a negative trend. However, it should be noted that the increased prevalence rate of multimorbidity over time is related to significant improvements in medical care and diagnostic tools.[6,10] Due to improvements in medical care, older adults, in particular those with two or more fatal chronic diseases, live longer on average. In addition, more screening and better diagnostic tools enable earlier diagnoses of diseases. Consequently, the prevalence of multimorbidity can be expected to increase over time.[6,19]

The results were suggestive of a decreasing trend in the prevalence of severe functional limitations between 1992/93 and 2011/12 among 64–84-years-olds, whereas an increasing trend in severe functional limitations was found among 85–94-years-olds between 2001/02 and 2011/12. These findings suggest that there might be a postponement of severe functional limitations into older ages. This is in line with a previous Dutch study by Bruggink et al.[40], who used nation-wide registry data from Statistics Netherlands.

The stable and unfavorable trends observed in 64–84 and 85–94-years-olds imply a relative increase in the need for care. Given that the absolute number of older adults will increase in the next decades, these findings suggest an increasing demand for professional and informal care in the near future. Although the findings of this study show that the prevalence of most indicators of functioning decreased or remained stable over time in both age groups, the findings also suggest that there remains substantial room for improvements. The prevalence of some indicators is high in absolute terms. For instance, still a third of the 64–84-years-olds suffer from loneliness and two-thirds of the 85–94-years-olds have a physically inactive lifestyle. Implementation of effective interventions on loneliness and physical inactivity in older adults therefore remains urgent.

Ideally, it would be best to use a multiple cross-sectional design for trend studies, as data can be analyzed from independent samples at each individual measurement wave, without data from the same individuals at different measurement waves. However, LASA is the only data-source in the Netherlands that enables to examine trends in the eight indicators of interest among older adults across a time frame of 20 years. Strength of this study is that all data were collected using the same standardized procedures and set of measurements during the full study period, offering good conditions for trend research.

Some limitations have to be acknowledged as well. In this study, the number of 85–94-years-olds was fairly small and, consequently, the stratified analyses in this age group may have led to trend estimates with only limited precision. Furthermore, participants in the telephone interviews could not be included in the analyses regarding the sum score measures, because they had no full data available on all indicators. However, the findings of the sensitivity analyses suggest that excluding participants of which data were collected using telephone interviews did not substantially change the results.

Future studies could focus on factors that possibly explain the observed trends over time, such as lifestyle and individual-level socio-economic position. Future trend research on multiple indicators of functioning is also needed across different countries to place the current results in an international context.

## Supplementary data

Supplementary data are available at *EURPUB* online.

## Funding

---

## Key points

- This study extends previous research by examining trends in multiple indicators of functioning, including problems in physical, cognitive, mental and social functioning, among older adults assessed simultaneously over time in the Netherlands.
- In the 64–84-years-olds, the prevalence of multimorbidity increased over time, whereas the prevalence of the other indicators decreased [i.e. cognitive impairment, physical inactivity (in women) and loneliness (in women)] or remained stable [i.e. severe functional limitations, depression, anxiety, physical inactivity (in men), loneliness (in men) and social isolation].
- In the 85–94-years-olds, the prevalence of severe functional limitations increased over time, whereas the prevalence of the other indicators remained stable.
- In both age groups, the prevalence of 'multiple problems' (i.e. having ≥5 out of 8 problems) remained stable over time.
- Given that the absolute number of older adults will increase in the next decades, these findings suggest an increasing demand for professional and informal care in the near future.

## References

1 Christensen K, Doblhammer G, Rau R, et al. Ageing populations: the challenges ahead. *Lancet* 2009;374:1196–208.

2 Lutz W, Sanderson W, Scherbov S. The coming acceleration of global population ageing. *Nature* 2008;451:716–9.

3 Robine J-M, Jagger C, Crimmins EM. Healthy longevity, Part 3: are we living longer healthier? *Annu Rev Gerontol Geriatr* 2013;33:259.

4 Parker MG, Thorslund M. Health trends in the elderly population: getting better and getting worse. *Gerontologist* 2007;47:150–8.

5   Spillman BC. Changes in elderly disability rates and the implications for health care utilization and cost. *Milbank Q* 2004;82:157–94.

6   Deeg DJH, Van Vliet M, Kardaun J, et al. Understanding the mortality decline at old age. Improved life course or improved present period? *Annu Rev Gerontol Geriatr* 2013;33:261–91.

7   Huisman M, Kunst AE, Anderson O, et al. Socioeconomic inequalities in mortality among the elderly in eleven European countries. *J Epidemiol Community Health* 2004;55:895–904.

8   Bengtsson T, Lindström M. Childhood misery and disease in late life: the effects on mortality in old age of hazards experienced in early life, southern Sweden, 1760–1894. *Popul Stud* 2000;54:263–77.

9   Nusselder WJ, Franco OH, Peeters A, et al. Living healthier for longer: comparative effects of three heart-healthy behaviors on life expectancy with and without cardiovascular disease. *BMC Public Health* 2009;9:487.

10  Ahacic K, Parker MG, Thorslund M. Mobility limitations 1974–1991: period changes explaining improvement in the population. *Soc Sci Med* 2003;57:2411–22.

11  Crimmins EM, Saito Y. Change in the prevalence of diseases among older Americans: 1984–1994. *Demogr Res* 2000;3:1–20.

12  Freedman VA, Martin LG, Schoeni RF. Recent trends in disability and functioning among older adults in the United States: a systematic review. *JAMA* 2002;288:3137–46.

13  Lafortune G, Balestat G. 2007. *Trends in Severe Disability Among Elderly People: Assessing the Evidence in 12 OECD Countries and the Future Implications* (OECD Health Working Papers No. 26). Paris, France: Organization for Economic Co-operation and Development (OECD).

14  Van Gool CH, Picavet HSJ, Deeg DJH, et al. Trends in activity limitations: the Dutch older population between 1990–2007. *Int J Epidemiol* 2011;40:1056–67.

15  Baxter AJ, Scott KM, Ferrari AJ, et al. Challenging the myth of an "epidemic" of common mental disorders: trends in the global prevalence of anxiety and depression between 1990 and 2010. *Depress Anxiety* 2014;31:506–16.

16  Jeuring HW, Comijs HC, Deeg DJH, et al. Secular trends in the prevalence of major and subthreshold depression among 55–64 year olds over 20 years. *Psychol Med* 2017;48:1824–34.

17  De Graaf R, Ten Have M, Van Gool C, et al. Prevalence of mental disorders and trends from 1996 to 2009. Results from the Netherlands Mental Health Survey and Incidence Study-2. *Soc Psychiatry Psychiatr Epidemiol* 2012;47:203–13.

18  Christensen K, Thinggaard M, Oksuzyan A, et al. Physical and cognitive functioning of people older than 90 years: a comparison of two Danish cohorts born 10 years apart. *Lancet* 2013;382:1507–13.

19  Meinow B, Kåreholt I, Thorslund M, et al. Complex health problems among the oldest old in Sweden: increased prevalence rates between 1992 and 2002 and stable rates thereafter. *Eur J Ageing* 2015;12:285–97.

20  Midlöv P, Leijon M, Sundquist K, et al. The longitudinal exercise trend among older Swedes aged 53–84 years—a 16-year follow-up study. *BMC Public Health* 2014;14:1327.

21  Reinders I, Van Schoor NM, Deeg DJH, et al. Trends in lifestyle among three cohorts of adults aged 55–64 years in 1992/1993, 2002/2003 and 2012/2013. *Eur J Public Health* 2017;28:564–70.

22  Dykstra PA, Van Tilburg TG, De Jong-Gierveld J. Changes in older adult loneliness. Results from a seven-year longitudinal study. *Res Aging* 2005;27:725–47.

23  Honigh-de Vlaming R, Haveman-Nies A, Bos-Oude Groeniger I, et al. Determinants of trends in loneliness among Dutch older people over the period 2005–2010. *J Aging Health* 2014;26:422–40.

24  McPherson M, Smith-Lovin L, Brashears ME. Social isolation in America: changes in core discussion networks over two decades. *Am Sociol Rev* 2006;71:353–75.

25  Suanet B, Huxhold O. Cohort difference in age-related trajectories in network size in old age: are networks expanding? *J Gerontol B Psychol Sci Soc Sci* 2018; https://doi.org/10.1093/geronb/gbx166.

26  Bisschop MI, Kriegsman DM, Beekman ATF, Deeg D. Chronic diseases and depression: the modifying role of psychosocial resources. *Soc Sci Med* 2004;59:721–33.

27  Hoogendijk EO, Deeg DJH, Poppelaars JL, et al. The Longitudinal Aging Study Amsterdam: cohort update 2016 and major findings. *Eur J Epidemiol* 2016;31:927–45.

28  Huisman M, Poppelaars JL, Van der Horst MHL, et al. Cohort profile: the Longitudinal Aging Study Amsterdam. *Int J Epidemiol* 2011;40:868–76.

29  Galenkamp H, Huisman M, Braam AW, et al. Disease prevalence based on older people's self-reports increased, but patient-general practitioner agreement remained stable, 1992–2009. *J Clin Epidemiol* 2014;67:773–80.

30  Bisschop MI, Kriegsman DM, Van Tilburg TG, et al. The influence of differing social ties on decline in physical functioning among older people with and without chronic diseases: the Longitudinal Aging Study Amsterdam. *Aging Clin Exp Res* 2003;15:164–73.

31  Radloff LS. The CES-D Scale: a self-report depression scale for research in the general population. *Appl Psychol Meas* 1977;3:385–401.

32  Zigmond A, Snaith RP. The hospital anxiety and depression scale. *Acta Psychiatr Scand* 1983;67:361–70.

33  Snaith RP. The hospital and depression scale. *Health Qual Life Outcomes* 2003;1:29.

34  Folstein MF, Folstein SE, McHugh PR. 'Minimental state': a practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 1975;12:189–98.

35  Tombaugh TN, McIntyre NL. The Mini Mental State Examination: a comprehensive review. *J Am Geriatr Soc* 1992;40:922–35.

36  Stel VS, Smit JH, Pluijm SM, et al. Comparison of the LASA Physical Activity Questionnaire with a 7-day diary and pedometer. *J Clin Epidemiol* 2004;57:252–8.

37  World Health Organization. 2010. *Global Recommendations on Physical Activity for Health*. Geneva, Switzerland: WHO Press.

38  De Jong-Gierveld J, Van Tilburg TG. *Manual of the Loneliness Scale 1999*. 1999. Available at: http://home.fsw.vu.nl/TG.van.Tilburg/manual_loneliness_scale_1999.html (15 June 2017, date last update; 17 August 2018, date last accessed)

39  Aiken LS, West SG. 1991. *Multiple Regression: Testing and Interpreting Interactions* Thousand Oaks, CA: SAGE Publications, Inc.

40  Bruggink J-W, Garssen J, Lodder B, et al. Trends in gezonde levensverwachting [In Dutch]. [In English: trends in healthy life expectancy]. *Bevolkingstrends* 2009;57:60–6.