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Trajectories in Functional Limitations and Cognitive Decline among a Dutch sample aged 75 and older

Abstract

Objective: The purpose of this study is twofold: first, to identify trajectories in cognitive and physical functioning of Dutch older adults, second, to investigate the main characteristics associated with the identified trajectories.

Methods: Data came from 574 Dutch adults aged 75+, collected in five nine-month measurement waves conducted between 2015 and 2018 for the Longitudinal Aging Study Amsterdam. Using Group Based Trajectory Modelling with mortality jointly estimated, we explored trajectories using a scale composed of 6 Activities of Daily Living (ADL) as a measure of physical functioning, and a short version of the mini mental status examination (sMMSE) or the IQCODE as a measure of cognitive functioning.

Results: Five trajectories in physical functioning were identified: ‘high’, ‘moderate’, ‘steeply declining’, ‘gradually declining’, and ‘continuously low’. Low or declining physical functioning were found among people that were old, low educated, lived in an institution and had diabetes or cerebrovascular accidents. For cognitive functioning four trajectories were identified: a ‘high’, ‘moderate’, ‘declining’, and ‘low’ trajectory. Old age, low education, living in an institution, and heart- and lung diseases were associated with continuously low or declining cognitive functioning. Mortality risks were highest among those experiencing continuously low functioning trajectories.

Conclusion: This study identified trajectories comparable to previous studies that used longer time intervals, showing the consistent presence of heterogeneity in both physical and cognitive trajectories. Co-modelling mortality lead to bigger group sizes for the more adverse trajectories. In conclusion, age, living in an institution, education, and specific chronic diseases should be the predictors policymakers use for future care planning and identifying people at risk for adverse functioning.

Introduction

Western societies are aging rapidly, with both an increase in the number of young older adults (aged 65 to 75) and the number of oldest-old (aged 80 and older) (World Health Organization 2015). For some older adults this increased longevity goes hand in hand with chronic disease, functional limitations, and cognitive decline (Centraal Bureau voor de Statistiek 2019; Crimmins and Beltrán-Sánchez 2011; Deeg et al. 2018; Heger and Kolodziej 2016; Rijksinstituut voor Volksgezondheid en Milieu 2018). But ageing does not appear to be debilitating to all, and some older adults reach high age while maintaining good physical and cognitive functioning (Kok et al. 2015). In other words, there is considerable heterogeneity in health and functioning in old age. Exploring this heterogeneity is a fundamental task of gerontological research.

A longitudinal approach is best suited to investigate the different functional trajectories that emerge among older adults since health is dynamic and not static. Previous studies usually identified between two and nine trajectories of physical or cognitive functioning, depending on various aspects of study design, such as the indicator of functioning that is examined, the sample size and density of observation points (Comijs et al. 2004; Deeg 2005; Gill et al. 2013; Han et al. 2013; Hu et al. 2019a; Kingston et al. 2015; Kok et al. 2015; Martin, Zimmer, and Lee 2017; Min 2018; Nusselder, Looman, and Mackenbach 2005; Proust and Jacqmin-Gadda 2005; Taylor and Lynch 2011; Terrera et al. 2010; Timmermans et al. 2018). Studies focussing on older populations tend to be consistent in that they report no recovery, but do report decline (van Houwelingen et al. 2014; Kingston et al. 2015; Lafortune et al. 2009), despite this wide variety in the number of trajectories observed,

The best approach to gain a more comprehensive understanding of the heterogeneity in trajectories of functioning in older adults may be to triangulate

findings from multiple studies that vary in key aspects of study design. Existing studies of functional limitations in Dutch older adults focused on relatively young samples (~mean age 70) and used relatively long time intervals of 3 years (Deeg 2005; van Houwelingen et al. 2014; Kok et al. 2015; Timmermans et al. 2018) to assess trajectories of limitations. A limited number studies investigated trajectories of cognition among older Dutch adults, but the ones that did, tended to exclude dementia at baseline (Comijs et al. 2004; Kok et al. 2015). In the current study, we investigate heterogeneity in functional limitations and cognitive functioning among Dutch older adults. Our approach differs from previous work in a number of aspects of the study design. Firstly, we examine changes in functioning across relatively short time intervals of nine months, which may be more sensitive to a meaningful change than studies using longer follow-up periods. Secondly, we focus on a sample of participants aged 75 years and older, which is where we expect the most changes in functioning to occur. Finally, we incorporate information on mortality risk in our estimates of trajectories to account for bias in estimated group sizes caused by nonselective attrition caused by mortality (Haviland, Jones, and Nagin 2011). This approach allows for building on the assumption that attrition due to mortality is related to the previous health status of participants. Studies that did not model mortality in effect made the assumption that decease occurred at random (Haviland et al. 2011). In addition, we explore differences in several key characteristics of older adults between each of the observed trajectories. Our research question is as follows: Which trajectories in functional limitations and cognitive functioning can be identified in Dutch adults aged 75 and older in a period of three years? And how are age, gender, SES, and chronic diseases associated with these trajectories?

Methods

Design and study sample

This study used data from the LASA 75-PLUS-study, an ancillary study of the Longitudinal Aging Study Amsterdam (LASA). LASA is an ongoing longitudinal population-based study of older adults (aged 55+) in the Netherlands (Hoogendijk et al. 2016). The baseline sample was drawn from eleven municipal registries in 1992, stratified by age and sex, and contained 3107 men and women aged 55-84 years (born between 1908 and 1937). In 2002 and 2012 additional cohorts were sampled of respectively 1002 and 1032 men and women born between either 1938 and 1947, or 1948 and 1957. The baseline response rate and cooperation rate were 60% and 62% for the first cohort. For the second and third cohort the cooperation rates were 62% and 63% (Hoogendijk et al. 2016, 2019). The data were mainly collected by trained interviewers in face-to-face, computer-assisted interviews. In cases where respondents refused or were not able to complete the full interview, either an abbreviated face-to-face interview, or a 15-minutes telephone interview (with a proxy or the respondent) was conducted. Further details concerning data collection are described in cohort profile papers (Hoogendijk et al. 2019; Huisman et al. 2011).

For the ancillary 75-PLUS-study, three additional nine-monthly measurement waves were conducted between measurement wave 2015/16 and measurement wave 2018/19. All LASA-participants who were born before 1941 were asked to participate in the ancillary study (N=686), of whom 601 eventually participated in 75-PLUSI. For this study we used these three nine-monthly measurements: 75-PLUSI, 75-PLUSII (N=550) and 75-PLUSIII (N=507), together with data from the preceding (2015/16) and subsequent (2018/19) regular LASA waves (N=473). Table 1 shows the number of participants included in each wave.

Table 1 about here

Dependent Variables

Functional Limitations

Functional limitations are restrictions in performing physical or mental tasks, that usually result in limitations in the performance of activities of daily living (ADL). We used ADL-indicators of respondents' ability to perform the following six tasks: (1) dressing or undressing themselves, (2) standing up from or sitting down in a chair, (3) cutting own toenails, (4) using own or public transport, (5) climb a flight of stairs, and (6) walk 5 minutes outdoors without resting. The response categories ranged from '1' not able at all, to '5' very able. The responses to the ADL-items were summed to the 'functional-limitations-scale', that ranged from 6 to 30, with higher scores indicating higher levels of functioning.

Cognitive Decline

The degree of cognitive decline was assessed using either the sMMSE, a short 8-item version of the Mini-Mental State Examination (MMSE) (Folstein, Folstein, and McHugh 1975), in which functioning in the following domains was tested: orientation in time and place, registration of words, attention and calculation measured by either subtraction or spelling, and recall of three words (Tombaugh and McIntyre 1992). For participants that were unable to perform the test, cognition was assessed by interviewing a proxy, if possible. For these interviews an abbreviated form of the IQCODE (Jorm 2004) was used: a 6-item scale ranging from 18 to 30 concerning the decline in the last 10 years on remembering conversations, addresses, phone numbers, handling domestic appliances, handling money for groceries, and handling finances. Higher scores indicated worse decline. For those participants who switched to the IQCODE at some point during the study, we imputed sMMSE data based on the IQCODE-scores. Despite

there being indications of the IQCODE and MMSE not entirely measuring the same construct (Mackinnon et al. 2003), we argue that keeping the participants that were assigned the IQCODE at some point during the study is better than excluding them. Since our study focusses on cognitive decline, and the IQCODE is more likely to be assessed when participants experience considerable decline, excluding these participants would have likely resulted in missing a considerable portion of the trajectories showing cognitive decline. Since the model aims to be descriptive and not explanatory, we decided that the occurrence of decline was more informative than the rate of decline. Even if the imputed data based on IQCODE-scores is an under- or overestimation of the "true" sMMSE-score, we expect the direction of cognitive decline to still be in accordance with the "true" direction.

There were no guidelines on how to harmonize the IQCODE with the sMMSE, so we tried various ways of harmonizing the two, based on studies that used both scales and reported which scores indicated similar levels of cognition (Chiriboga, McHugh, and Sweeney 2008; Comijs et al. 2004). Since these values differed across studies, as a sensitivity check, we estimated the trajectories using these various ways of harmonizing the two scales, to assess whether this affected the shapes of the estimated trajectories. This did not affect the estimated shapes considerably. Because the choice of the different cut-off points did not rigorously affect the trajectory shapes, we chose the cut-off points based on a previous LASA-study (Comijs et al. 2004), since this would likely reflect our sample best. The table with the values of the IQCODE and sMMSE are reported in table 2. Because an IQCODE-score of 18 indicated no change in the last years, this value either corresponded with the participants' previous MMSE-score, or if that score was not available, an sMMSE-score of 16. The eventual 'cognition-scale' was constructed by summing all the points scored on the 8 sMMSE items

(or by harmonizing the IQCODE to an sMMSEscore), resulting in a scale that ranged from 0 to 16, with 16 indicating the highest level of cognitive functioning.

Table 2 about here

Mortality

Mortality-data (date of decease) were obtained through the registration of municipalities (GBA), and were last updated in February 2020. It was included as a dichotomous variable, with ‘0’ indicating being alive and ‘1’ indicating being deceased, per wave.

Independent Variables

Age, gender, partner status (partner/ no partner), socioeconomic status, and chronic disease status were used to give a description of respondents in the identified trajectories. This selection of characteristics was chosen because they represent some of the main vectors of social and economic disadvantage in older populations and reflect vulnerable groups. They were all measured at baseline (2015/16). We measured socioeconomic status as education, with low (primary school) middle (secondary school or lower vocational training) and high level (higher vocational training or higher). For chronic disease we grouped ten diseases into five categories: heart- and lung disease (coronary-, pulmonary-, and vascular disease), rheumatic disease (arthritic and osteopathic), diabetes, cancer, and cerebrovascular accidents (CVA).

Sensitivity and Missing Data

Data were either missing at the item level (e.g. one of the six ADL-items missed), or at the wave level (e.g. not participating in one or two waves). Missing data

between waves were imputed with the respondents' mean of the two nearest waves, for a more in depth review on the rationale for this imputation method see: Halpin (2012). Data were imputed for 79 participants. Of the initial sample of 601 4.7% (N=27) dropped out for other reasons than decease, and were thus excluded from the analysis. We conducted sensitivity checks, by estimating the models stratified by gender, only for survivors, and for deceased. The models stratified for gender did not differ substantially in terms of shapes of the trajectories, while the models only for survivors and deceased participants were comparably different, as expected.

Method of Analysis

Group Based Trajectory Modelling

The analyses were conducted using the STATA package Proc Traj (Jones, Nagin, and Roeder 2001). Building on the work of Kok et al. (2015) we started with estimating an unconditional model, in which even chronological age was not included. This approach has the advantage for not allowing for one covariate to have a disproportionately big influence on the model. Subsequently, the independent variable in the model was the time of the measurement waves. We fitted two group-based trajectory models with mortality jointly estimated, for physical and cognitive functioning. Because the dependent variables were continuous scales, we used the Tobit model, thereby assuming a censored normal distribution (Jones and Nagin 2013). First, we determined the number of identified trajectories that fitted the data best, by using the Bayesian Information Criterion (BIC) and the posterior probabilities (Jones et al. 2001; Raftery 1995). We also assessed whether an extra trajectory group revealed a relevantly different trajectory. After having identified the optimal number of trajectories, cognitive or physical limitations were estimated in a trajectory model, with the

dropout-function accounting for dropout due to decease (Jones and Nagin 2007). Participants who had missing data due to other reasons than death and could not have their data imputed, were excluded from the analysis, using the obsmar-function.

Subsequently we calculated the average marginal effects (AME). The AME are a variation on a multinomial logistic regression, and show the association between a certain characteristic (i.e. age) and a trajectory for a one-unit change of that characteristic. The AME's main advantage over the estimates of multinomial logistic regression lies in the fact that their provided estimates are more intuitive in terms of interpretation since they don't require a reference group during interpretation (Jann 2013).

Descriptive Statistics

Table 3 about here

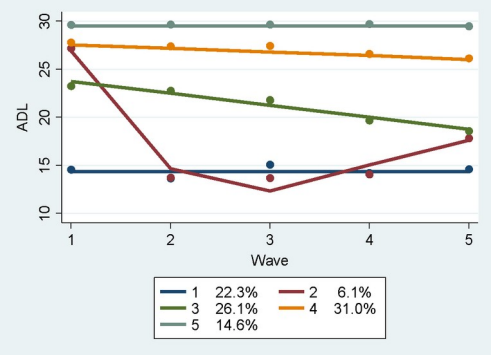
The baseline (wave 2015/16) characteristics of the 574 participants are shown in table 3. The average age was 82.18 years, with 61% being female, 50% currently having a partner, and respectively 48%, 30%, and 22% having had low, middle, and high education. Over the three years of follow-up 24% (N=139) deceased. For each wave, data were collected by proxy for 12.3 to 15.3% of the sample. Most participants suffered from rheumatoid diseases (63%) and heart- and lung disease (49%), whereas less people had diabetes (16%), CVA (10%), or cancer (23%).

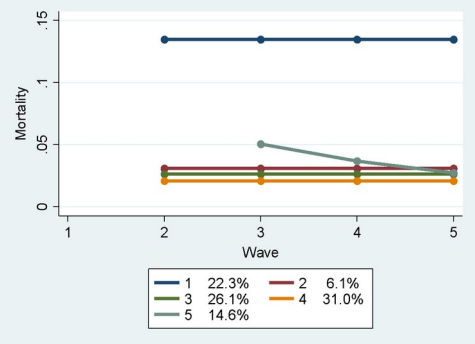
Results

Functional limitations

A model with five trajectories proved to be the best fit for the data. The descriptive statistics per trajectory and the multivariate estimates are shown in tables 3 and 4, and the trajectory plot and estimated mortality probability are shown in figure 1.

Figure 1. *Trajectories in functional limitations (left), a higher score indicates better cognitive functioning, and mortality probability (right) by age.*





The first group, containing 22.3% of the respondents, showed stable low levels of physical functioning: The trajectory started at a mean ADL-score of 15, and stayed at that level for the following waves. Such scores usually indicate that respondents were unable to perform 3 ADL-indicators, but were still able to perform 2 without help, although for some it meant that they had much difficulty performing all of the five ADL-indicators, and needed help with at least one of them. This group had the highest mortality probability per year, 14% at each wave. Older people (dy/dx=0.015) and people who lived in an institution (dy/dx=0.461) were more likely to follow this trajectory, as were people who suffered from diabetes (dy/dx=0.118), and CVA (dy/dx=0.143). People with a high education were 10.9% less likely compared to those with a low level of education to have a stable low ADL trajectory. Participants who had cancer were

less likely to follow this trajectory as well (dy/dx=-0.08).

The second group showed a decline in functioning, followed by a slight recovery in which some of the initial functioning was regained. The decline was steep: in the course of nine months the respondents' ADL-score declined from 26 to 15, which is indicative of gaining two severe limitations. At the end the average ADL-score was 17. Relatively few participants followed this trajectory (6.1%), and the mortality probability was stable at 3%. Having a CVA decreased the probability of following this trajectory with 4.5%, but none of the other features were significantly associated with this trajectory.

The third trajectory showed slight decline, and gradually decreased from an average ADL-score of 24 to 19. This trajectory contained 26.1% of the participants, and had a stable mortality probability of 3%. Older people were more likely to follow this trajectory, with 1.4% extra for each life year. Participants who suffered from cancer or rheumatoid disease were respectively 11.8% and 7.8% more likely to follow this trajectory.

The fourth trajectory was stable, with an average ADL-score of 27, which indicated being able to perform all ADL-indicators with no or a little help. The mortality probability was stable at 3%, and 31% of the participants followed this trajectory. Age decreased the probability of following this trajectory with 1.4% per year. Not living in an institution was statistically significant associated with this trajectory as well (dy/dx=-0.221).

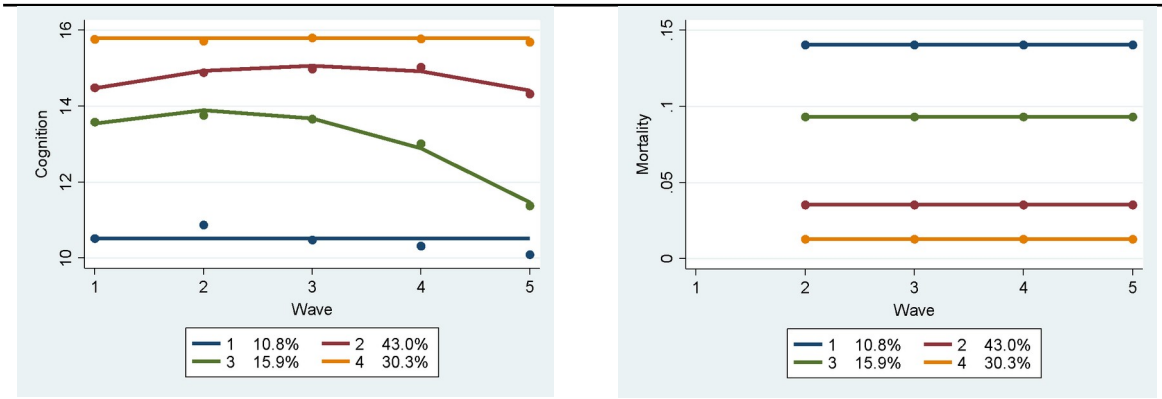
The fifth trajectory was stable as well, and the participants (14.6%) in this trajectory experienced no ADL-limitations at all. Older people were less likely to follow this trajectory (dy/dx=-0.018), as were people that did not suffer from heart- and lung disease (dy/dx=-0.058), diabetes (dy/dx=-0.071), or rheumatoid disease (dy/dx=-0.061). Living in an institution decreased the probability of this trajectory with 15.9%.

Sensitivity analyses were performed: not jointly modelling mortality resulted in different group sizes: 13.8% in the first, 6.6% in the second, 27.7% in the third, 35.4% in the fourth, and 16.5% in the fifth trajectory. This is an overestimation of 2%, 4%, 1.5%, and 0.5% of respectively the highest (G5), moderate (G4), gradual decline (G3), and rapid decline (G2) physical functioning trajectories, and an 8.5% underestimation of the low physical functioning trajectory (G1).

Cognitive limitations

For cognitive limitations a four-trajectory model, shown in figure 2, proved to be the best fit.

Figure 2. *Trajectories in cognitive limitations (left), a higher score indicates better cognitive functioning, and mortality probability (right) by age.*



The first group showed very low cognitive functioning across time, the trajectory started at the threshold for dementia (11) with a mean sMMSE of 11. The trajectory showed no further decline, but it could be argued that given the low baseline scores, there was little further decline possible for this group. Containing 10.8% of the sample, this group was the smallest of the four trajectories. The mortality probability was continuously high at 14%. Age was not significantly statistically associated with this trajectory. This might be explained by the low

power of this study, and looking at the directionality age does show a positive relation with the low cognitive functioning trajectory. Suffering from heart- and lung disease decreased the probability of this trajectory with 5.5%, while living in an institution increased the probability with 37.3%.

The second group, containing 43% of the participants, started at a mean sMMSE of 14, slightly increased to 15, and then decreased to 14. It had a stable mortality probability of 4%. People with a high education, or people that lived in an institution were respectively 13.7% and 22.8% significantly less likely to follow this trajectory.

The third trajectory (16%) showed decline, decreasing from probable mild cognitive impairment (sMMSE= 13) to probable dementia (sMMSE= 11). The mortality probability was quite high: 9%. Being older increased the probability of this trajectory (dy/dx=0.009), as did having diabetes (dy/dx=0.124). Having had a middle or high education decreased the probability of this trajectory with 7.7% and 11.3%, as did having rheumatoid disease (dy/dx=-0.064).

The last trajectory showed continuous high cognitive functioning combined with a low mortality probability (2%), and contained 30.3% of the participants. Older age decreased the probability of this trajectory (dy/dx=-0.009), as did having diabetes (dy/dx= -0.098), CVA (dy/dx=-0.192), or living in an institution (dy/dx=-0.205). People with a middle or high education respectively had a 16.4% and 27.2% higher probability of following this trajectory, and people with rheumatoid disease were 7.6% more likely to experience continuous high cognitive functioning.

Not jointly modelling mortality resulted in the following group sizes: 5.7% in the first, 47.5% in the second, 8.9% in the third, and 37.9% in the fourth trajectory. The high (G4) and moderate (G2) cognitive functioning trajectories

would have been overestimated with 7.2% and 4.5%, while the declining (G3) and low (G1) trajectories would have been underestimated with 7% and 5%.

Overlap between the trajectories

Figures 3 and 4 show which trajectories of the other form of functioning are followed within each trajectory. A certain coherence is visible: people in the adverse physical functioning trajectories experience low cognitive functioning more often, and high physical functioning is often associated with high cognitive functioning. This is however not a one-on-one relation, since 22% of people with high cognitive function experience a trajectory with severe ADL-limitations. The picture for the declining physical trajectory shows little correlation with cognition: the percentages of the cognitive trajectories are distributed almost evenly over this group.

Discussion

This study identified trajectories in both physical and cognitive functioning among Dutch older adults aged 75 and older. Using the innovative methodology of Group Based Modelling, which estimated mortality jointly, we were able to estimate more precise group sizes. We identified five trajectories in functional limitations and four trajectories in cognitive decline. A considerable proportion of the Dutch older adults experienced high levels of functioning over the course of three years. For physical functioning 15% of the sample experienced continuous high levels of physical functioning, and 31% of the sample experienced high moderate physical functioning. As for cognitive functioning, 30% of the sample experienced high cognitive functioning and 43% experienced moderately high cognitive functioning. But, adverse trajectories were present as well. For the physical functioning trajectories 26% of the participants experienced moderate decline and 6% experienced steep decline followed by slight recovery. For

cognitive functioning 16% experienced rapid cognitive decline. The most adverse trajectories showed continuous low physical functioning with at least 2 severe ADL-limitations (22%), and continuous low cognitive functioning (11%) with probable dementia. These trajectories had high mortality levels (~14%). The declining and low functioning trajectories are the trajectories where the requirement for care is probably highest.

Older participants, and incorporating mortality risk, the trajectories seem to reflect similar patterns identified in previous studies, despite our study using shorter time intervals. For functional limitations a stable high, stable low, and declining trajectories are generally reported (Gill et al. 2013; Kingston et al. 2015; Kok et al. 2015; Martin et al. 2017), and for cognitive functioning stable high, moderately high, and declining trajectories are reported (Comijs et al. 2004; Kok et al. 2015). Our relatively old study sample resulted in a low trajectory for cognition, that is not identified among younger study samples (Comijs et al. 2004; Kok et al. 2015), but is also identified among older study samples (Han, Lee, and Kim 2014; Hu et al. 2019b). It can be concluded that our study corroborates that there is considerable diversity in health trajectories among the 75-plus.

Taking mortality into account resulted in bigger group sizes for the more adverse trajectories, while it led to overestimations of the more favourable trajectories, which is in line with what we expected based on the studies conducted by Haviland et al. (2011) and Zimmer et al. (2012), who also used the same methodology. The relation between decline and mortality is not that apparent for functional limitations, since modelling mortality resulted in a very slight underestimation of the declining functional limitation trajectories. This finding may be attributable to the differential rates between sexes in mortality, which is higher among men, and decline, which is higher among women (van

Houwelingen et al. 2014).

The second aim of our study was to explore how the trajectories vary for several background variables (gender, age, level of education and partner status) and types of diseases. Results are somewhat mixed and not that easy to interpret. What is clear is that the persons following the three best trajectories (with either high or high moderate levels of physical functioning, or high levels of cognitive functioning) had rather favourable characteristics. They were younger, middle or high educated, lived independently, and did not have diabetes or heart- and lung disease.

Yet, there was no common denominator between the people following the three declining trajectories. Older age, having cancer, or rheumatoid disease increased the probability of the steady declining physical functioning trajectory, which is understandable as these chronic diseases are more limiting mobility in more advanced stages. Older age also increased the chance of cognitive decline, as did having a low education, or diabetes. The link with diabetes can be explained by the adverse effects of hyperglycaemia, inflammatory cytokines, and neuropathic process (Chiu, Wray, and Ofstedal 2011). Having suffered a stroke reduced the chance of steep decline in physical functioning, but increased the chance of continuous functional limitations. This shows the severe debilitating effects of CVA, since it drastically reduces the level of functioning in such a severe way that the chance of following a trajectory that starts with high functioning (Taylor and Lynch 2011). The fact that CVA is only (negatively) associated with high cognitive functioning is in line with previous findings that CVA does not necessarily lead to dementia, but reduces cognitive functioning, thereby resulting in mild cognitive impairment for most (Levine et al. 2015; Tham et al. 2002). People experiencing mild cognitive impairment are likely to be found

in all other three cognition trajectories (Comijs et al. 2009), which probably leads to the absence of other associations.

While rheumatoid diseases increased the chance of gradually declining physical functioning, a finding also reported by for example Botes et al. (2018), they also increased the probability of high levels of cognitive functioning. This association might be explained by the protective effect some drugs for treating arthritis might have on cognition (de Craen et al. 2005; Landi et al. 2003).

As expected based on previous studies, living in an institution, having diabetes and/or CVA were significantly associated with the two trajectories of poor functioning: with severe functional limitations, and with severe cognitive problems (Botes et al. 2018; Comijs et al. 2009; Marengoni et al. 2011). Also, being older or low educated increased the probability of stable low functional limitations, but not of low cognitive functioning. In addition, people who suffered from heart- and lung disease were more likely to have continuous cognitive dysfunction. These trajectories seem to contain persons that experienced the deleterious effects of chronic diseases, and about half of them had to be taken into residential care due to the resulting limitations.

Although we expected men to be more likely to follow the favourable trajectories, associations for sex were not present. Most previous studies report sex differences (Gill et al. 2013), or stratify by sex a priori (Kok et al. 2015; Zimmer et al. 2012). Due to our small sample size stratifying by sex would have reduced our statistical power substantially, and analysis stratified by sex showed comparable trajectories for men and women. The absence of sex differences might be explained by the finding that these differences are most pronounced in the level of functional impairment, while rates of change are similar for men and women (Liang et al. 2008). It could be possible that due to our shorter measurement intervals the rate of change has had a bigger impact in defining

the trajectories. On the other hand, the absence of sex differences is not entirely anomalous; for functional limitations Bolano et al. (2019), and Holstein et al. (2007) do not report any statistically significant sex differences, and Comijs et al. (2004) do not always identify sex differences for trajectories in cognition. Moreover, our analyses included mortality, various diseases, age and level of education, which are all factors that differ by sex, which may have decreased the effect of sex itself to non-significance.

If we consider education to be an indicator of socioeconomic status (SES) than our results lend support for a cumulative disadvantage hypotheses where inequality is a strong predictor of adverse health outcomes. That low education tends to be associated with low levels of physical functioning is a finding also reported by Boyd et al. (2009) and Kingston et al. (2015). The finding that education is negatively associated with moderate or declining levels of cognitive functioning, and positively associated with high cognitive functioning, corroborates the link between education and cognition. Furthermore, it is partly in line with the MMSE being less sensitive for cognitive decline among higher educated people (Aevarsson and Skoog 2000), but also in line with education having a protective effect on cognitive decline (Anstey and Christensen 2000), and people having more cognitive capacities having pursued more education.

Although we expected having a partner to be associated with good levels of functioning, associations were absent. This might have been due to the decision not to stratify by gender, since there are indications that the effect of partner status differs for men and women (Avlund et al. 2002).

Strengths and Limitations

The main strength of this study was the use of the 75PLUS LASA-data, containing a representative sample of the Dutch oldest old: the study has a high response and cooperation rate, and enabled for studying both community dwelling and

institutionalized people by allowing for conducting interviews by phone or by proxy. Accounting for attrition by jointly modelling mortality is also a strength, enabling us to estimate the group sizes correctly. Third, defining ADL as a scale forms a strength in opposition to previous studies that compressed the range of the severity of ADL-limitations by dichotomizing ADL. Because the overall degree of limitations decides the need for care, it is precisely this degree that is of vital importance for policymakers, and by measuring ADL as a scale we were better at capturing the existence and the range of need for care that follow from functional limitations.

The first limitation of the study was not being able to study the interconnectedness between cognitive decline and ADL-limitations that is implied by previous studies (Braungart Fauth et al. 2007; Mansbach and Mace 2019), by conducting a multi-trajectory model. Since jointly modelling mortality in a multi-trajectory model was not possible, and accounting for decease is necessary in a very old population, we decided to report the estimates of the trajectories separately. Second, although the use of proxy data allowed us to also include severely cognitively impaired respondents, this resulted in two different measurements for cognition (the MMSE and the IQCODE) (Mackinnon et al. 2003). Although different ways of harmonizing did not affect the trajectories much, the absence of guidelines on how to harmonize the MMSE and IQCODE leaves some uncertainty on whether the eventual scores are an accurate reflection of cognitive functioning among our participants. Although we did not have a considerable amount of missing items for ADL or MMSE, we are mindful of the slight overestimation of both cognitive and ADL-levels in which the imputation of these items might have resulted. On the flip side, not including these participants in the analysis would have likely resulted in an overestimation of favourable trajectories as well.

Implications

This study has implications for policymakers in long term care. The trajectories with the highest requirements of care are the two stable low trajectories (11-22%), and part of those group are already living in residential care. This simultaneously shows how half of these people apparently have a high requirement of care, but do still live in independent housing, probably with a large demand on care from informal and formal caregivers. The declining trajectories (6%, 16%, 26%) are of most interest due to the increasing care need over time. This increase makes this group vital for policies aimed at future care planning, since they require more adjustments in care provision than the stable trajectories do. Our study does not provide one indicator to target all these groups, but shows old age, low education, diabetes, and CVA as the best indicators for targeting risk groups.

Conclusion

Our study underscores the diversity in health trajectories among the older old. Most Dutch 75-plus had high levels of functioning. Yet, about a quarter of the respondents experienced moderate functional decline, while 6% and 16% experienced rapid functional and cognitive decline. A small part experiences very low levels of functioning: 22% and 11% experienced severe functional limitations or cognitive limitations with probable dementia and high mortality probabilities. The findings show that chronic diseases impact physical and cognitive functioning differently, with diabetes mostly contributing to decline. Older age, low education, diabetes and CVA should be the predictors policymakers use for future care planning and identifying people at risk for adverse functioning. A small part of the Dutch oldest old lives independently while having a high care requirement, and a considerable number of people has an increasing care need.

It is important to identify whether the groups with currently high and an increasing care requirement get the care they need.

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