Survival and life-expectancy in a young-onset dementia cohort with six years of follow-up: the NeedYD-study

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ABSTRACT

Objectives: The aim of this study was to investigate survival time and life-expectancy in people with young-onset dementia (YOD) and to examine the relationship with age, sex, dementia subtype and comorbidity.

Design, Setting and Participants: Survival was examined in 198 participants in the Needs in Young-onset Dementia study, including participants with Alzheimer’s dementia (AD), vascular dementia (VaD) and frontotemporal dementia (FTD).

Measures: The primary outcomes were survival time after symptom onset and after date of diagnosis. Cox proportional hazards models were used to explore the relationship between survival and age, sex, dementia subtype and comorbidity. Additionally, the impact on remaining life expectancy was explored.

Results: During the six-year follow-up, 77 of the participants died (38.9%), 78 participants survived (39.4%) and 43 were lost to follow-up (21.7%). The mean survival time after symptom onset and diagnosis was 209 months (95% CI 185-233) and 120 months (95% CI 110-130) respectively. Participants with AD had a statistically significant shorter survival compared with VaD participants, both regarding survival after symptom onset (p = 0.047) as well as regarding survival after diagnosis (p = 0.049). Younger age at symptom onset or at diagnosis was associated with longer survival times. The remaining life expectancy, after diagnosis, was reduced with 51% for males and 59% for females compared to the life expectancy of the general population in the same age groups.

Conclusion/Implications: It is important to consider the dementia subtype when persons with YOD and their families are informed about the prognosis of survival. Our study suggests longer survival times compared to other studies on YOD, and survival is prolonged compared to studies on LOD. Younger age at symptom onset or at diagnosis was positively related to survival but diagnosis at younger ages, nevertheless, still diminishes life expectancy dramatically.

Key words: Young Onset Dementia, Dementia, Long-Term Care

Introduction

Between 2% and 10% of the approximately 9.9 million persons who are annually diagnosed with dementia worldwide, experience their first symptoms before the age of 65 years; this is, so-called young-onset dementia (YOD) (Carter et al., 2018; Prince, et al., 2016; World-Health-Organization, 2012). Better insight into survival time and associated characteristics is necessary to improve our understanding of young-onset neurodegenerative diseases, and for planning specific services. Knowledge can be increased by gaining more insight into the differences in survival regarding the different...
was made between those with YOD and LOD expectancy, but in this comparison no distinction et al. survival in YOD can help in providing a prognosis, et al. (Armstrong, 2014; Barclay consistent negative relationship with survival in YOD more, male sex in YOD is not consistently associated been found to be negatively associated with survival in Alzheimer’s dementia (AD) and frontotemporal dementia (FTD) studies (Barclay et al., 1985a; Diehl-Schmid et al., 2007). However, despite the higher mortality risk in YOD found by Koedam et al. (2008), survival of YOD participants was longer compared with LOD (Koedam et al., 2008). Furthermore, male sex in YOD is not consistently associated with shorter survival, while comorbidity shows a more consistent negative relationship with survival in YOD (Armstrong, 2014; Barclay et al., 1985b; Brodaty et al., 2012; Kay et al., 2000). In the review of Brodaty et al. (2012), men and women showed the same life expectancy, but in this comparison no distinction was made between those with YOD and LOD (Brodaty et al., 2012).

Knowing the characteristics that are related to survival in YOD can help in providing a prognosis, and in reducing feelings of uncertainty after diagnosis (Stokes et al., 2015). The aim of this longitudinal cohort study was to investigate the survival time of people with YOD from both disease onset and date of diagnosis and the association of YOD with age at onset or diagnosis, gender, dementia subtype and comorbidity. Furthermore, we investigated the impact of the diagnosis of YOD on life expectancy.

Methods

Study design and selection of participants
Participants were selected from the Needs in Young-onset Dementia (NeedYD) study, which has been described previously (van Vliet et al., 2010). Participants were recruited from university medical centres, regional hospitals, mental health services and specialized Dutch day-care facilities. Only participants with AD, Vascular dementia (VaD)/mixed dementia and FTD were included in this study. Dementia subtypes were established according to regular criteria and the consensus on clinical dementia subtypes (Erkinjuntti, 1994; McKhann et al., 1984; Neary et al., 1998). The study protocol was approved by the Medical Ethics Committee of the University Medical Center, Maastricht. The local ethics committees of the participating institutions also gave consent. The research study was performed according to the principles of the Declaration of Helsinki (version January 2004; www.wma.net) and is in agreement with the law regarding medical-scientific research in humans (WMO). Data collection, after written informed consent was obtained, started in 2007 and 2008 (baseline). Information about the study was provided by the memory clinics or day-care facilities, and then again by the researcher. Participants who were not able to sign informed consent were asked to give oral consent and also their legal representative was asked to give written consent. This was followed by assessments at six-month intervals for two years and then at three, four and six years after inclusion.

Primary outcomes

Survival from symptom onset and survival from date of diagnosis were calculated in months. Using a semi-structured open-ended interview, the primary caregivers were asked for the date of the earliest signs or symptoms. Then, they were asked to elaborate on their answers and identify if there were any earlier signs or symptoms. The date of the earliest signs or symptoms, cognitive, behavioural or functional, was recorded as the date of symptom onset. Date of dementia was retrieved from the participants’ medical records. The date of symptom onset was set at January first in the year of onset if the exact date was not known by the primary caregiver. For both outcomes, survival time was calculated from date of symptom onset or date of diagnosis to date of death or date of censoring (date of the last contact with the participant or caregiver is used in the analysis, at that time participant is still alive) during the six-year follow up.

Determinants

Dementia subtype was established according to the criteria of McKhann, the NINDS-AIREN criteria, the consensus on clinical diagnostic criteria of FTD and the consensus on clinical dementia subtypes (Erkinjuntti, 1994; First et al., 2002; McKhann et al., 1984; Neary et al., 1998). Age at symptom onset and age at diagnosis were calculated in years from date of birth and date at symptom onset or date at diagnosis, respectively. Comorbidity was registered at baseline using the participants’ medical records and structured interviews with the primary caregiver. Comorbidity was classified by the first author (AG), using the International Classification of Diseases, 10th Revision (ICD-10) (World Health Organization). The ICD-10 classifies diseases in
categories, with sub-categories to describe specific diseases. For the current study, classification was performed at the sub-category level, or, if the information was not specific enough, at the category level.

Demographic characteristics

Sex, date of birth, and date of death were collected through structured interviews with primary caregivers. Dementia severity at baseline was assessed using the Global Deterioration Scale (GDS), which rates dementia severity from “no impairment” (GDS stage 1) to “very severe cognitive impairment” (GDS stage 7) (Reisberg et al., 1982).

Statistical analysis

The analyses were performed using the Statistical Package for Social Sciences (SPSS), version 22.2.0.01 (2013), (IBM SPSS Statistics, IBM Corporation, Chicago, IL). Proportions and means were calculated to describe characteristics of the participants. Group comparisons regarding dementia subtypes (AD, VaD, FTD) were analysed using analysis of variance (ANOVA) for continuous variables or chi-squared tests and log-rank tests for categorical variables. Survival analyses were performed with the Kaplan-Meier estimator (Kaplan and Meier, 1958). Cox proportional hazards (CPH) models were used to relate age at symptom onset or age at diagnosis, sex, dementia subtype and comorbidity with survival (Breslow, 1974; Crowley and Breslow, 1984). A sub-analysis on age at symptom onset or diagnosis was performed to see if there were differences between the diagnoses. Comorbidity was classified “yes” when one or more comorbid conditions were present; otherwise, classification was “no.” A t-test was used in a sensitivity analysis whether or not to consider left truncation. Left truncation means that a correction may be needed for potential participants who did not survive until the date of inclusion, and, thus, did not enter the study population, resulting in possible overestimation of survival (Addona et al., 2012; Vansteelandt et al., 2017). For this sensitivity analysis, the study population was divided into two groups, one with the participants who had the longest baseline survival time from symptom onset and one with the shortest. The two groups were compared considering the survival time during the six-year follow-up. A similar sensitivity analysis was performed for the groups with the longest and shortest baseline survival times from date of diagnosis. The relative loss of remaining life expectancy was calculated in percentages by dividing the years of life lost after diagnosis by the matched life expectancy in the Dutch general population aged 61 in 2007 (Statline, 2017a).

For all analyses, a P-value <0.05 was used as the threshold for statistical significance.

Results

A total of 198 participants were included, 122 with AD, 34 with VaD/mixed dementia, and 42 with FTD (van Vliet et al., 2010). The mean age at diagnosis was 58.6 (SD 5.5) years and median time from diagnosis until inclusion was 2.2 years (IQR 0.9–4.0). There were slightly more male than female participants (Table 1).

Table 1. Baseline findings

<table>
<thead>
<tr>
<th></th>
<th>ALL (N = 198)</th>
<th>AD (N = 122)</th>
<th>VaD (N = 34)</th>
<th>FTD (N = 42)</th>
<th>TEST*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male (%)</td>
<td>105 (53.0)</td>
<td>57 (46.7)</td>
<td>22 (64.7)</td>
<td>26 (61.9)</td>
<td></td>
</tr>
<tr>
<td>Mean age at inclusion (SD) [range]</td>
<td>61.4 (5.5) [43.4–74.7]</td>
<td>61.5 (4.9) [48.6–73.5]</td>
<td>61.2 (5.3) [46.4–69.6]</td>
<td>61.4 (7.3) [43.4–74.7]</td>
<td>F(2,198) = 0.38, p = 0.61</td>
</tr>
<tr>
<td>Mean age at diagnosis (SD) [N]</td>
<td>58.7 (5.5) [197]</td>
<td>58.9 (5.0) [122]</td>
<td>58.1 (5.2) [34]</td>
<td>58.5 (7.2) [41]</td>
<td>F(2,196) = 0.241, p = 0.79</td>
</tr>
<tr>
<td>Mean age at symptom onset (SD) [N]</td>
<td>54.3 (6.5) [197]</td>
<td>54.5 (5.5) [121]</td>
<td>53.2 (6.7) [34]</td>
<td>54.7 (8.6) [42]</td>
<td>F(2,196) = 0.594, p = 0.55</td>
</tr>
<tr>
<td>Time in months between symptom onset and diagnosis (SD) [N]</td>
<td>53 (44) [196]</td>
<td>52 (45) [121]</td>
<td>59 (46) [34]</td>
<td>49 (39) [41]</td>
<td>F(2,195) = 0.491, p = 0.61</td>
</tr>
<tr>
<td>Mean GDS (SD) [N]</td>
<td>4.4 (1.1) [188]</td>
<td>4.7 (1.0) [118]</td>
<td>3.9 (1.0) [31]</td>
<td>4.1 (1.3) [39]</td>
<td></td>
</tr>
<tr>
<td>Comorbidity N (%)</td>
<td>95 (48.0)</td>
<td>53 (43.4)</td>
<td>18 (52.9)</td>
<td>24 (57.1)</td>
<td>F(2,198) = 3.189, p = 0.001**</td>
</tr>
</tbody>
</table>

AD: Alzheimer’s dementia, VaD: vascular dementia including mixed AD/VaD, FTD: frontotemporal dementia.

*Comparison among diagnosis groups, χ² or F-test (ANOVA), **Significant difference among AD and VaD, FTD.
Table 2. Survival in months

<table>
<thead>
<tr>
<th></th>
<th>ALL (N = 198)</th>
<th>AD (N = 122)</th>
<th>VaD (N = 34)</th>
<th>FTD (N = 42)</th>
<th>TEST**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>After diagnosis</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>mean (SD)</td>
<td>120 (5.0)</td>
<td>111 (5.8)</td>
<td>142 (11.7)</td>
<td>120 (9.9)</td>
<td>χ² (df 2) = 8.064, p = 0.018</td>
</tr>
<tr>
<td>[95% CI]</td>
<td>[110–130]</td>
<td>[100–123]</td>
<td>[119–165]</td>
<td>[101–140]</td>
<td></td>
</tr>
<tr>
<td><strong>After symptom onset</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean (SD)</td>
<td>209 (12.1)</td>
<td>187 (13.2)</td>
<td>270 (29.5)</td>
<td>197 (12.6)</td>
<td>χ² (df 2) = 7.511, p = 0.023</td>
</tr>
<tr>
<td>[95% CI]</td>
<td>[185–233]</td>
<td>[161–213]</td>
<td>[212–327]</td>
<td>[172–221]</td>
<td></td>
</tr>
</tbody>
</table>

AD: Alzheimer’s dementia, VaD: vascular dementia including mixed dementia, FTD: frontotemporal dementia. * One missing value on FTD date of diagnosis, one missing value on AD date of symptom onset. **Comparison among diagnosis groups, ***Too many survivors to calculate 95% CI, ****Too many survivors to calculate median.

Table 3. Cox proportional hazard ratios

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE</th>
<th>WALD</th>
<th>DF</th>
<th>SIG.</th>
<th>EXP(B)</th>
<th>95.0% CI FOR EXP(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Survival after symptom onset</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LOWER</td>
</tr>
<tr>
<td>Dementia subtype</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alzheimer’s dementia</td>
<td>.771</td>
<td>.387</td>
<td>3.960</td>
<td>1</td>
<td>.047</td>
<td>2.162</td>
<td>1.012</td>
</tr>
<tr>
<td>Frontotemporal dementia</td>
<td>.141</td>
<td>.466</td>
<td>.092</td>
<td>1</td>
<td>.762</td>
<td>1.152</td>
<td>.462</td>
</tr>
<tr>
<td>Vascular dementia (ref)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>−.060</td>
<td>.241</td>
<td>.063</td>
<td>1</td>
<td>.80</td>
<td>.941</td>
<td>.587</td>
</tr>
<tr>
<td>Comorbidity (yes/no)</td>
<td>.281</td>
<td>.231</td>
<td>1.470</td>
<td>1</td>
<td>.23</td>
<td>1.324</td>
<td>.841</td>
</tr>
<tr>
<td>Age at symptom onset</td>
<td>.133</td>
<td>.023</td>
<td>32.641</td>
<td>1</td>
<td>&lt;.001</td>
<td>1.142</td>
<td>1.091</td>
</tr>
<tr>
<td>Alzheimer’s dementia</td>
<td>.137</td>
<td>.029</td>
<td>22.284</td>
<td>1</td>
<td>&lt;.001</td>
<td>1.147</td>
<td>1.084</td>
</tr>
<tr>
<td>Vascular dementia*</td>
<td>.164</td>
<td>.079</td>
<td>4.284</td>
<td>1</td>
<td>.04</td>
<td>1.178</td>
<td>1.009</td>
</tr>
<tr>
<td>Frontotemporal dementia</td>
<td>.149</td>
<td>.057</td>
<td>6.795</td>
<td>1</td>
<td>.009</td>
<td>1.161</td>
<td>1.038</td>
</tr>
</tbody>
</table>

*Vascular dementia including vascular/mixed Alzheimer’s dementia (~2 log likelihood 654.884), p < 0.001.

Survival

During the six-year follow-up, 77 of the participants died (38.9%), 78 participants survived (39.4%) and 43 were lost to follow-up (21.7%). Kaplan-Meier analysis showed a mean survival time from symptom onset of 209 months (95% CI 185–233) and a mean survival time after diagnosis of 120 months (95% CI 110–130) (Table 2). This corresponds with 17 years and 5 months and 10 years, respectively. In 2007, at the time of the first assessment in our study, general life expectancy in healthy adults at age 60 in the Netherlands was 21.4 years in males and 25.2 years in females (Stateline, 2017a). The expected loss of life years found in this study is approximately 11 years for male participants and approximately 15 years for female participants. The relative loss of remaining life expectancy after diagnosis was 52% in male participants and 61% in female participants, compared to the life expectancy of the general population in the same age groups.

Determinants of survival

A diagnosis of AD decreased the likelihood of survival by 2.16 times compared with a VaD diagnosis (Table 3, Figure 1). We also found a trend of a decreased survival for the participants with AD compared with FTD participants. The same association between dementia subtypes and survival from the date of diagnosis was found (Table 4, Figure 1). Age at symptom onset also showed an association with survival. The likelihood of a shorter survival increased 14% with each additional year of age at symptom onset (Table 3). This likelihood of a shorter survival was found in all three dementia subtypes (Table 3). In the CPH model of survival from date of diagnosis, a similar relationship between age at diagnosis and survival was found, with an almost 7% higher chance of a shorter survival with each extra year of age at the time of diagnosis (Table 4). In the sub analysis, however, statistical significance only was seen for AD and FTD subtypes.
No association was found between survival and sex, or having comorbid conditions in either CPH models.

The sensitivity analysis concerning left truncation revealed no significant difference in survival time during the six-year follow up. The mean difference was 0.4 months between the group with the longest versus shortest baseline survival time of diagnosis ($p = 0.884$). For symptom onset, the mean difference was 0.1 months in the six-year follow up ($p = 0.965$).

**Discussion**

The survival from date of diagnosis found in our study was substantially less than the general life expectancy in the Netherlands (Statline, 2017a). Furthermore, survival times after symptom onset and after diagnosis were associated with dementia subtypes but not with comorbidity or with sex.

The relative loss of more than 50% of remaining life expectancy that we found is lower than in a review by Brodaty et al. (2012) who calculated percentages of 60–94% in YOD populations (Brodaty et al., 2012). This lower loss of remaining life expectancy is in line with the longer survival times we found, but the outcome for these young persons with dementia is dramatic. Furthermore, in that review more dementia subtypes were included compared to our study, among which FTD with motor neuron disease, which also can contribute to the differences we found on the relative loss of remaining life expectancy.

The survival time after symptom onset found in our study was prolonged by about five years compared with findings in other studies (Brodaty et al., 2012; Todd et al., 2013). However, none of the study populations included in those reviews are comparable with our population. Todd et al. (2013) investigated survival after symptom onset in a review of

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**Table 4. Cox proportional hazard ratios**

<table>
<thead>
<tr>
<th>Dementia subtype</th>
<th>B</th>
<th>SE</th>
<th>WALD</th>
<th>DF</th>
<th>SIG.</th>
<th>EXP(B)</th>
<th>95.0% CI FOR EXP(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LOWER</td>
<td>UPPER</td>
</tr>
<tr>
<td>Alzheimer’s dementia</td>
<td>.761</td>
<td>.386</td>
<td>6.091</td>
<td>2</td>
<td>.048</td>
<td>2.140</td>
<td>1.004 – 4.559</td>
</tr>
<tr>
<td>Frontotemporal dementia</td>
<td>.161</td>
<td>.463</td>
<td>1.122</td>
<td>1</td>
<td>.727</td>
<td>1.175</td>
<td>.475 – 2.909</td>
</tr>
<tr>
<td>Vascular dementia*(ref)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>.020</td>
<td>.237</td>
<td>.007</td>
<td>1</td>
<td>.93</td>
<td>1.021</td>
<td>.642 – 1.623</td>
</tr>
<tr>
<td>Comorbidity (yes/no)</td>
<td>.126</td>
<td>.245</td>
<td>9.940</td>
<td>1</td>
<td>.002</td>
<td>1.069</td>
<td>1.026 – 1.115</td>
</tr>
<tr>
<td>Age at symptom onset</td>
<td>.067</td>
<td>.034</td>
<td>5.943</td>
<td>1</td>
<td>.015</td>
<td>1.085</td>
<td>1.016 – 1.154</td>
</tr>
<tr>
<td>Alzheimer’s dementia</td>
<td>.082</td>
<td>.034</td>
<td>9.240</td>
<td>1</td>
<td>.003</td>
<td>1.074</td>
<td>.915 – 1.261</td>
</tr>
<tr>
<td>Vascular dementia*</td>
<td>.071</td>
<td>.082</td>
<td>7.347</td>
<td>1</td>
<td>.007</td>
<td>1.169</td>
<td>1.044 – 1.308</td>
</tr>
<tr>
<td>Frontotemporal dementia</td>
<td>.156</td>
<td>.058</td>
<td>7.347</td>
<td>1</td>
<td>.007</td>
<td>1.169</td>
<td>1.044 – 1.308</td>
</tr>
</tbody>
</table>

*Vascular dementia including vascular/mixed Alzheimer’s dementia (-2 Log Likelihood 677.183), $p = 0.004$.

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**Figure 1. Survival.**
studies in dementia, in general, not specifically in YOD (Todd et al., 2013). In a review by Brodaty et al. (2012), ten studies reported on survival in YOD, of which five on YOD specifically, and two of them reported on survival after symptom onset (Jost and Grossberg, 1995; McGonigal et al., 1992). Median survival times from symptom onset reported in those two studies ranged from 5.8–10.8 years, while in our study this was 9.3 years. The study populations in those two studies are from before 1995; after this time, survival in the general population, and likely also in persons with YOD, has increased because of less mortality due to cardiovascular disease and cancer (Milieu, 2018). Furthermore, we thoroughly investigated the date of first symptoms.

Mean survival after diagnosis in our study is approximately two years longer than the longest survival time (7.9 years) reported in a review of Brodaty et al. (2012) (Brodaty et al., 2012). In two studies investigating survival after diagnosis, median survival times ranged from approximately 3.4 to 6 years in young participants. The study populations of those two studies differed from our population. One study included AD and VaD, while we also included FTD. The other study examined survival times regardless of dementia subtype (Kay et al., 2000; Koedam et al., 2008). We know that the time needed to establish a diagnosis of YOD, and accuracy has been improved during the 20 years between the start of the study of Kay et al. (2000) and the start of our study, due to improved structural behavioural and psychiatric assessments, neuroimaging and the examination of cerebrospinal fluid (Kay et al., 2000; Rossor et al., 2010). This likely resulted in an earlier diagnosis in our cohort and, consequentially, a longer survival after diagnosis.

We found an association of dementia subtypes with survival in which AD participants had lower survival rates compared to VaD participants. This seems in contrast with the results of other studies that found an equal or longer survival in AD subtypes compared with VaD (Kay et al., 2000; Koedam et al., 2008). However, again, these figures are from populations that show some important differences from our study population. Kay et al. (2000) only compared AD and VaD, and Koedam et al. (2008) made a comparison of all the study participants (young and elderly) with a control group of participants without dementia (Kay et al., 2000; Koedam et al., 2008).

Having a diagnosis or symptoms of dementia at a younger age resulted in this study in higher survival rates, which has also been found by others, who found longer survival times in younger YOD persons (Jost and Grossberg, 1995; Knopman et al., 2003). Within a young-onset Alzheimer’s dementia (YO-AD) study population, the opposite was found; younger AD participants showed higher mortality rates in comparison with those who were older at the time of diagnosis, and some studies found no association of age with survival (Kay et al., 2000; McGonigal et al., 1992; Ueki et al., 2001). We found no YOD studies investigating the association of age with survival, in which, survival analysis were performed correcting for dementia subtypes (Hodges et al., 2003; Knopman et al., 2003; Rait et al., 2010; Roberson et al., 2005). It is known that in LO-AD, younger age is related to shorter survival. We found the opposite for all dementia subtypes. We do know that comorbidity in YO-AD is less compared to LO-AD; however, we included comorbidity in the statistical model to correct for this factor. We found the opposite for all dementia subtypes. We do know that comorbidity in YO-AD is less compared to LO-AD, but we corrected for comorbidity when we found this outcome (Gerritsen et al., 2016; Hodges et al., 2003; Holland et al., 2012; Knopman et al., 2003; Perrault et al., 2002; Rait et al., 2010; Rasmussen et al., 1996; Roberson et al., 2005; Stanley and Walker, 2014). Therefore, the finding that the youngest participants showed the longest surviva, might be due to their better physical condition in comparison to the older YOD participants.

For age at symptom onset, all three dementia subtypes showed an association with longer survival when symptoms arose earlier, but for age at diagnosis, the subanalysis showed no statistical significance for the VaD participants (Tables 3 and 4).

No association has been found between survival and the presence (or lack) of comorbidity. We found only one study on YO-AD investigating this association between comorbidity and survival (Ueki et al., 2001). In that study, concurrent physical illness was found to negatively influence survival, but our analysis did not show this outcome. The findings of our study might suggest that persons with YOD have a disease trajectory that is less affected by comorbidity compared with LOD, as was also found in a study on YO-AD (Chang et al., 2017). Furthermore, it is likely that frailty, including the burden of comorbidity, might be a more important risk factor of mortality in LOD than comorbidity (Kane et al., 2012).

Sex showed no association with survival in our study, and it remains unclear why this finding differs from many LOD studies in which male sex has been found to be associated with shorter survival (Garcia-Ptacek et al., 2014; Ientile et al., 2013; Lee and Chodosh, 2009). However, in the review of Brodaty et al. (2012) men and women showed the same life expectancy taking no account for the categories YOD and LOD (Brodaty et al., 2012). The a priori chance of dying before 2016, when aged 61 in 2007, in the Netherlands was less than 2% in males and...
less than 1.5% in females. Therefore, dementia, and not sex, is more likely the main cause of the limited survival at this age (Statline, 2017b).

Limitations and strengths

There are some limitations in this study that have to be considered. First, by setting January first as the date of symptom onset when the exact date was not available, survival could be prolonged six months, on average. However, knowing that there were 77 survivors means that survival time will be longer when we would have been able to extend our follow-up period beyond six years. Of course, it is difficult for caregivers to give an exact date of symptom onset, because dementia often has an insidious onset. This can result in a possible under- or overestimation of survival time after symptom onset. However, this is inherent to the study design. Second, we were not able to include disease severity at diagnosis in the CPH models because this information was not available. There are some indications that disease severity at diagnosis shows a relationship with survival; however, not all studies found this relationship (Atkins et al., 2012; Ientile et al., 2013; Todd et al., 2013; Tschanz et al., 2004). Third, 21.7% of the participants were lost during our six-year follow-up and 39.4% survived. We think losing participants is inherent for long lasting cohort studies. The chosen statistical analysis, Kaplan-Meijer, can address this loss and surviving participants; however, outcomes remain estimates until all participants are deceased. Fourth, unfortunately, we had no access to the death certificates to examine the causes of death. This would be helpful as in a study on survival, information about causes of death is informative for both families and clinicians. However, our study did reveal survival times for the three most common subtypes of dementia in YOD and showed that comorbidity was not related to survival. Fifth, we did not have information on the severity of the comorbid conditions, which would have been interesting to take into account. Also, we had no information on intercurrent diseases such as pneumonia which could have influenced survival. However, studying the relationship of comorbidity and survival in YOD, is a reasonably unexplored topic.

The strength of our study is the sensitivity analysis we did on left truncation. Cohort studies are frequently influenced because some potential participants do not enter the study because they pass away before the date of inclusion, which is considered left truncation (Addona et al., 2012; Vansteelandt et al., 2017). However, we found that survival time after the date of diagnosis in our cohort was not influenced due to this effect, and this was confirmed with the sensitivity analysis.

Conclusion/Relevance

Our study outcomes add information to the knowledge about survival in YOD and provide support for longer survival in persons with YOD compared to LOD. This underlines the need for long lasting support systems that are focused on the needs of these patients.

An indication was found for a different survival in the three main subtypes of YOD, with AD participants having the shortest survival. Therefore, an accurate diagnosis is relevant to take into account concerning prognosis.

Distress and uncertainty perhaps can be diminished by using our study outcomes when informing individuals with YOD and their families. Nevertheless, lost life years, both absolute and relative, will have an impact on the future perspective of these persons and their families. This burden is added to the uncertainty about prognosis and life expectancy, after the struggle of getting a proper diagnosis (Baptista et al., 2016; van Vliet et al., 2011). Our findings are perhaps not as negative as often thought, but they address the reason for intensive care support as long as dementia is only treatable symptomatically.

A recommendation for future research might be to include disease severity at the time of diagnosis in studies on survival in patients with YOD. Death certificates or interviews with caregivers can help to better clarify our understanding of the relationship between an early death and the course of the dementia. Furthermore, given the different findings about survival in young persons with FTD, survival in this dementia subgroup also needs further investigation.

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Conflicts of interest

None.

Description of authors' roles

A. Gerritsen designed the study, collected parts of the data, performed the analyses and wrote the paper. C. Bakker designed the study, collected parts of the data and co-wrote the paper. J. Millenaar
collected parts of the data and critically reviewed the paper. R. Koopmans designed the study and critically reviewed the paper. F. Verhey, Y. Pijnenburg and M. de Vugt advised about the study design and critically reviewed the paper.

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