Dementia Is Not Inevitable: A Population-Based Study of Danish Centenarians

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The authors evaluated the prevalence of dementia in centenarians. In this population-based survey, persons living in Denmark who turned 100 during the period April 1, 1995-May 31, 1996 (N = 276) were interviewed and examined at their residences. Additional health information was retrieved from medical files, including the National Discharge Registry. A participation rate was 75%, and no differences were found between participants and nonparticipants regarding sex and type of housing. The prevalence of mild to severe dementia in centenarians was 51%; 37% had no signs of dementia. Among the 105 demented centenarians, 13 (12%) had diseases (vitamin B12 and folic acid deficiencies, hypothyroidism, Parkinson’s disease) that could contribute to a dementia diagnosis. Of the remaining 92 demented participants, 46 (50%) had one or more cerebro- or cardiovascular diseases known to be risk factors in the development of dementia. The prevalence of these risk factors was the same in demented and nondemented participants, whereas hypertension was significantly more frequent in nondemented than demented participants. Dementia is common but not inevitable in centenarians. Cerebro- and cardiovascular diseases are equally common in demented and nondemented persons.

It is widely recognized that the prevalence of dementia increases with advancing age and that this increase shows an exponential pattern, with a doubling of the prevalence every 5 years to a level higher than 20% at the age of 85 (Hofman et al., 1991; Jorm, Korten, & Henderson, 1987). Extrapolation into very old ages has been used to predict the burden of dementia in the population of oldest persons, that is, those aged 85 years and older. Jorm and colleagues (1987) predicted a prevalence of 62% at the age of 95; others have predicted that the prevalence of dementia levels off at 45% at the same age (Ritchie & Kildea, 1995; Ritchie, Kildea, & Robine, 1992; Wernicke & Reischies, 1994). The latter could be caused by a differential mortality in demented and demented persons, as suggested by Johansson and Zarit (1995). They also reported a lower annual incidence rate from age 86 to 94 as compared with the incidence in a comparable but slightly younger cohort observed from age 84 to 92. In contrast, in a recent meta-analysis Jorm and Jolley (1998) showed that the incidence of dementia rises exponentially at least to the age of 90 years.

Recently, reliable demographic data from the past 30 years in developed countries have shown a leveling off of mortality rates of persons aged 80 and older (Vaupel et al., 1998). This phenomenon may also be seen in connection with the prevalence of dementia, as proposed by Ritchie and Kildea (1995). They found a modified logistic pattern for the prevalence of late life dementia rather than an exponential pattern, which would predict that nearly all extremely old people, such as centenarians, would be demented. Because the proportion of oldest old persons has increased dramatically within the last 30 years, and probably will continue to increase in the future (Vaupel et al., 1998), there is a need to estimate both the incidence and the prevalence of dementia in extremely old individuals.

To our knowledge, there are no incidence studies on centenarians. However, in several recent prevalence studies (Asada et al., 1996; Eby, Parhad, Hogan, & Fung, 1994; Iván, 1990; Olsen, Jeune, & Andersen-Ranberg, 1996; Powell, 1994; Samuelsson et al., 1997; Sobel et al., 1995)—all using diagnostic criteria from the revised third edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-III-R; American Psychiatric Association, 1987)—prevalence rates show a huge variation, ranging from about 27% to 85%. This diversity may be explained by differences in sample sizes and methods. Also, the high mortality among centenarians makes it difficult to estimate a point prevalence in a representative sample. It is also difficult to evaluate cognitive function in these very old individuals, because physical impairment, including poor vision and hearing, is associated with relative isolation and apathy, which can mimic a cognitive decline, and makes cognitive tests difficult to administer. Only few centenarian studies discuss these problems in detail (Iván, 1990; Powell, 1994; Samuelsson et al., 1997). However, despite the variations between the different studies, it seems that a certain proportion of centenarians are cognitively intact, although the exact magnitude of this proportion and the proportion of moderately to severely demented are not known.

Knowledge regarding the subtypes and causes of dementia in advanced age is also inconclusive. Most studies have reported Alzheimer’s disease (AD) to be the predominant dementia subtype. In studies of 85-year-olds, Eby and colleagues (1994) found that AD accounted for 75%, and a vascular etiology alone for 13%, of all dementia cases. Recent studies have indicated a larger cerebrovascular involvement in the development of dementia, especially the presence of hypertension earlier in life (Hofman et al., 1997; Skoog et al., 1996; Skoog, Nilsson, Palmertz, Andreasson, &
In brain autopsy material, Snowdon and colleagues (1997) showed that persons with both brain infarcts and neuropathologic lesions compatible with AD had poorer cognitive function and higher prevalence of dementia compared with persons with neuropathologic lesions alone.

The proportion of centenarians reported to have AD ranges from very low (Iván, 1990; Powell, 1994) to very high (Asada et al., 1996; Sobel et al., 1995). However, none of these studies based their diagnosis of AD on the strict criteria of National Institute of Neurological and Communicative Disorders and Stroke-Alzheimer’s Disease and Related Disorders Association (NINCDS-ADRDA; McKhann et al., 1984); at best, only a modified version of these criteria has been used (Asada et al., 1996; Sobel et al., 1995). Two centenarian studies (Asada et al., 1996; Sobel et al., 1995) based on different criteria (the National Institute of Neurological and Communicative Disorders and Stroke-Association Internationale pour la Recherche et l’Enseignement en Neurosciences [NINCDS-AIREN; Roman et al., 1993] and the International Classification of Diseases [ICD-10; World Health Organization, 1992]) both reported a prevalence of vascular dementia (VaD) of around 3%. A prevalence of mixed type of dementia (MIX), that is, possible AD with a vascular component, at 6% has been reported in a single centenarian study (Asada et al., 1996). Both the divergence in AD prevalence and the lacking prevalence of VaD and MIX in some studies illustrate the difficulties in assessing dementia subtypes in extremely old people with concomitant high comorbidity, which would highly interfere with the current criteria for AD and VaD.

We launched the Longitudinal Study of Danish Centenarians to elucidate the health and morbidity of people at the extreme end of a human life span. In this article we address the issue of mental health by assessing the prevalence of dementia and its relation to other diseases. Additionally, we discuss the difficulties in assessing cognitive function in extremely old people, such as centenarians.

METHODS

Participants

The Longitudinal Study of Danish Centenarians is a nationwide clinical epidemiological survey of all individuals living in Denmark who celebrated their 100th birthday during the period April 1, 1995–May 31, 1996, a total of 276 persons. All participants were identified in the Civil Registration System and were admitted to the study as they turned 100, a so-called dynamic cohort. The group of nonparticipants consisted of 56 persons who refused to take part in the study and 13 who died within a few weeks after their 100th birthday and before contact was made. Thus, a total of 207 centenarians (162 women and 45 men) participated in the survey, which corresponds to a participation rate of 75%. There were no significant differences between participants and nonparticipants regarding sex and the proportion living at home or in a nursing home (Table 1).

In all, 177 of the 207 participants could actively take part in the interview. For the remaining 30 participants, a proxy respondent was interviewed instead; 25 participants were almost totally unable to communicate, and 5 only accepted to participate through a proxy.

Table 1. Participants and Nonparticipants According to Sex and Type of Housing

<table>
<thead>
<tr>
<th></th>
<th>Eligible</th>
<th>Participants</th>
<th>Non-Participants</th>
<th>Deceased</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>54 20</td>
<td>45 22</td>
<td>6 11</td>
<td>3 23</td>
</tr>
<tr>
<td>Women</td>
<td>222 80</td>
<td>162 78</td>
<td>50 89</td>
<td>10 77</td>
</tr>
<tr>
<td>Housing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At home</td>
<td>104 38</td>
<td>70 24</td>
<td>27 48</td>
<td>7 54</td>
</tr>
<tr>
<td>Sheltered housing</td>
<td>29 10</td>
<td>23 11</td>
<td>6 11</td>
<td>0</td>
</tr>
<tr>
<td>Nursing home</td>
<td>143 52</td>
<td>114 55</td>
<td>23 41</td>
<td>6 46</td>
</tr>
<tr>
<td>All</td>
<td>276 100</td>
<td>207 100</td>
<td>56 100</td>
<td>13 100</td>
</tr>
</tbody>
</table>

Procedure and Measures

With the exception of the 5 participants who refused to have a personal visit, all the centenarians were interviewed and examined by the same geriatrician (K.A.-R.) and geriatric nurse (L.V.) at their place of residence, including institutions. The interviews were conducted within 3 months of the participants' 100th birthday with the exception of 3 centenarians who were interviewed within 101, 113, and 146 days, respectively. The sociodemographic interview included items on family background, education, occupation, and lifestyle. The assessment of activities of daily living (ADLs) was based on an instrument previously used and validated in Denmark (Avlund, Kreiner, & Schultz-Larsen, 1996), including the items of Katz’s ADL index (Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963) and the items on instrumental activities of daily living (IADL) of Lawton and Brody (1969). This information was collected from both participants and caregivers on all 207 subjects and represents the minimum amount of available data for the entire sample. We screened cognitive function using the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975). A proxy to each of the 207 participants was interviewed regarding their short- and long-term memory and ability to recognize other people, find their way home, recall the time of the year, understand messages, and make decisions.

Health was assessed by a thorough interview with the centenarians (when possible) and/or proxies. The interview included specific questions regarding diseases associated with dementia, for example, neurological disease, cerebrovascular and cardiovascular disease, vitamin B12 and folic acid deficiencies, and thyroid disease. At the end of the interview the centenarians had a physical examination including a neurological examination, blood pressure measurements (average of three measurements), and electrocardiography. Hypertension was defined as blood pressure higher than 160/100 mm Hg. The diagnoses of vitamin B12 and/or folic acid deficiency were based on medical records and actual medication, and the diagnoses of hypothyroidism and diabetes were based on both blood examination and medical history. A neurologist confirmed the diagnosis of Parkinson’s disease according to international criteria (Calne, Snow,
The diagnosis of dementia was made according to WHO's (1992) criteria of ICD–10, which include the pattern of daily activities. The severity was rated according to the criteria in the Clinical Dementia Rating (CDR; Hughes, Berg, Danziger, Coben, & Martin, 1982).

We assessed every participant in detail regarding the following items, which were used to operationalize the ICD–10 criteria:

G1 (1). Decline in memory: Proxy information regarding changes in participants’ short- and long-term memory and ability to recognize other people, find their way home, and recall the time of the year; MMSE questions regarding orientation and recalling; ability to answer questions in the sociodemographic interview.

G1 (2). A decline in other cognitive abilities: Proxy information regarding participants’ judgment, orientation, and ability to understand messages and make decisions; MMSE questions regarding attention, learning, serial subtractions or reverse spelling, and constructional capacities; use of language; and ability in performing ADLs, both physical and instrumental. In the assessment of functional capacity we excluded purely physical handicaps as a reason for impaired independence in ADLs.


G3. Decline in emotional control/motivation or change in social behavior: Proxy information and clinical judgment.

G4. Presence for at least 6 months: Proxy information. Further support: apraxia, agnosia, aphasias: Ability to recognize other people; MMSE questions regarding language, naming of objects; and IADLs.

The specific domains of memory, orientation, and judgment + problem solving in the CDR were rated by the same markers used for the ICD–10 criteria. The more complex domain of community affairs was assessed with information on participants’ ability to make decisions on shopping and financial affairs, and the domain of home and hobbies was assessed through information on the centenarians’ interest in reading or hearing the newspaper or books read aloud, housework, gardening, or hobbies. When rating according to the CDR, we excluded the evaluation of job functioning. As in the diagnosis of dementia, a distinct evaluation was made in each case of whether physical handicaps were interfering with the IADL items (e.g., shopping, managing financial affairs, cooking, doing the laundry, looking up a phone number, socializing, reading books, or playing solitaire).

In our dementia rating we found it appropriate to add an additional category, probably no dementia, to the existing five levels of the CDR (healthy, questionable, mild, moderate, and severe dementia). This category consisted of all centenarians whose sensory deficits and/or unwillingness to perform all the items in the MMSE made it difficult to rate them as nondemented according to the strict criteria. However, all other information indicated normal cognitive function (e.g., recalling during the interview). Centenarians on whom we did not have enough information to make a solid evaluation of cognitive function were placed in a separate category, termed not classified.

Because the criteria of NINCDS–ADRDA (McKhann et al., 1984) for AD and NINCDS–AIREN (Roman et al., 1993) for VaD could not be applied to our data, we tried another approach to identify possible etiologies of dementia. First, on the basis of the physical examination together with information from medical records, all individuals who were suffering from diseases defined in ICD–10 to have a potential influence on cognitive function (e.g., hypothyroidism, vitamin B12 or folic acid deficiency, and Parkinson’s disease) were identified. Demented participants with these diagnoses were classified as having possible other dementia (pOD).

Second, we tried to identify those centenarians in whom a cerebro- or cardiovascular disease could be identified on the basis of the information in the medical records and the findings in the physical and neurological examinations. No brain imaging was done.

For the 56 centenarians who refused to participate in the study, a brief evaluation of cognitive status (possible nondementia or suspected dementia) was possible at the time of the initial contact with the centenarian or the proxy. We used either the impression they made at the time of contact or information from proxies, that is, family members or caregivers, to rate the cognitive status of the centenarians.

The Scientific-Ethical Committee of the Counties of Funen and Vejle approved the Longitudinal Study of Danish Centenarians. We used chi-square to test for differences between groups. A significance level of .05 was chosen.

RESULTS

In this study of 100-year-old Danes, we found the prevalence of dementia (mild, moderate, and severe) to be 51% (n = 105; Table 2). However, 25% (n = 52) were diagnosed as having no signs of dementia. Additionally, when we included the 24 centenarians classified as having probably no dementia, this proportion increased to 37%, leaving a proportion of questionable dementia of 7%. Only 5% (n = 11) of participants, all women, could not be categorized, owing to insufficient information.

When dichotomizing the clinical dementia evaluation into demented (including mild, moderate, and severe dementia) and nondemented (including no dementia, probably no dementia, and questionable dementia), we diagnosed more...
women than men as being demented, but this difference was not significant. We also did not observe any significant difference when we reanalyzed the dichotomous groups after switching participants with questionable dementia from the group of nondemented into the group of demented.

Seventy-five percent ($n = 156$) of the centenarians were tested by means of the MMSE (Table 2). About one fifth (22%) had a score of 24 or more, and a slightly higher proportion (29%) had scores below 17. More than 90% of the 45 centenarians who scored 24 points or more in the MMSE were clinically assessed as having no dementia or probably no dementia. The remaining 4 were diagnosed as having either questionable dementia or mild dementia. A wider variation in the CDR was seen among those scoring 23–18 points and 17–10 points; among those scoring 9–0 points, more than 75% were clinically evaluated as having moderate to severe dementia.

The difficulties in applying the MMSE are shown in Table 3. Of the 156 participants who were examined, less than half (46%) went through a complete examination. In the remaining 54% the major reason for incomplete examination was visual impairment. Six participants were totally deaf and could not participate in the MMSE. The special hearing aid Hear-It improved communication for 27 participants.

Of the 51 participants who were not tested with the MMSE, the clinical evaluation rated the majority (71%) to be mildly to severely demented and only 4 (8%) to be not demented or probably not demented. The reason for the missing MMSE in these last two groups was unwillingness to complete the test. We were not able to make a valid clinical evaluation of the mental status of the remaining 11 (21%) participants because of insufficient information ($n = 8$), terminal illness ($n = 2$), or frailty as a result of premature discharge from the hospital ($n = 1$).

In all, 13 (12%) of 105 demented centenarians could be identified as belonging to the group of pOD (Table 4), although they could have had a cerebro- or cardiovascular disease, too. One centenarian had both hypothyroidism and vitamin B12 deficiency, and 1 had Parkinson’s disease (mildly demented).

Of the remaining 92 demented participants (Table 5), 18 (20%) had a history of cerebrovascular disease in the form of stroke, including transitory cerebral ischemia (TCI), alone or in combination with other cardiovascular diseases. Another 16 (17%) currently had hypertension, either alone or in combination with atrial fibrillation, myocardial infarction, or diabetes. Twelve (13%) had one or more of the following diagnoses: atrial fibrillation, myocardial infarction, or diabetes without previous stroke/TCI or hypertension. A total of 46 (50%) of the 92 demented participants had a cerebrovascular and/or a cardiovascular disease at the time of the study. In the remaining 46 (50%) demented centenarians, neither clinical signs nor medical information of any cerebro- or cardiovascular disease could be identified, with the exception of 14 participants who had previously been but were not currently hypertensive.

There were no significant differences in the prevalence of stroke/TCI, atrial fibrillation, myocardial infarction, and diabetes between nondemented and demented participants, with the exception of actual hypertension, which was signific-

Table 2. MMSE Score in Relation to Clinical Dementia Rating in 207 Centenarians

<table>
<thead>
<tr>
<th>MMSE Score</th>
<th>No Dementia</th>
<th>Probable Dementia</th>
<th>Questionable Dementia</th>
<th>Mild Dementia</th>
<th>Moderate Dementia</th>
<th>Severe Dementia</th>
<th>Not Classified</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-24</td>
<td>41</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>45 (22%)</td>
</tr>
<tr>
<td>23-18</td>
<td>8</td>
<td>19</td>
<td>11</td>
<td>13</td>
<td>1</td>
<td>1</td>
<td>52 (25%)</td>
<td></td>
</tr>
<tr>
<td>17-10</td>
<td>2</td>
<td>3</td>
<td>15</td>
<td>16</td>
<td>1</td>
<td>2</td>
<td>37 (18%)</td>
<td></td>
</tr>
<tr>
<td>9-0</td>
<td>1</td>
<td></td>
<td>4</td>
<td>15</td>
<td></td>
<td>2</td>
<td>22 (10%)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>3</td>
<td></td>
<td>1</td>
<td>1</td>
<td>25</td>
<td>11</td>
<td>51 (25%)</td>
<td></td>
</tr>
<tr>
<td>Clinical evaluation</td>
<td>52 (25%)</td>
<td>23 (12%)</td>
<td>16 (7%)</td>
<td>35 (17%)</td>
<td>42 (20%)</td>
<td>28 (14%)</td>
<td>11 (5%)</td>
<td>207 (100%)</td>
</tr>
</tbody>
</table>

Note: MMSE = Mini-Mental State Examination.

Table 3. Number of Participants Who Could Perform a Complete or Incomplete MMSE, or No MMSE at All, According to Different Items

<table>
<thead>
<tr>
<th>MMSE Score</th>
<th>Complete Examination ($n = 72$)</th>
<th>Visual Impairment</th>
<th>Hearing Impairment</th>
<th>Reluctance or Refusal</th>
<th>Other Reasons</th>
<th>All ($N = 207$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-24</td>
<td>32</td>
<td>11</td>
<td>0</td>
<td>2</td>
<td>1^</td>
<td>13</td>
</tr>
<tr>
<td>23-18</td>
<td>25</td>
<td>16</td>
<td>10</td>
<td>9</td>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td>17-10</td>
<td>12</td>
<td>15</td>
<td>8</td>
<td>7</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>9-0</td>
<td>3</td>
<td>10</td>
<td>0</td>
<td>11</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>Not tested</td>
<td>6</td>
<td>12</td>
<td>10</td>
<td>36^</td>
<td></td>
<td>51</td>
</tr>
</tbody>
</table>

Note: MMSE = Mini-Mental State Examination.

*a* Some participants had more than one reason for not completing the examination.

*b* Refused writing a sentence, probably because of illiteracy.

*c* Severe neuropathy in both hands, interfering with writing a sentence.

*d* Mainly due to severe dementia, proxy denial in demented participants, or acute or terminal illness.
because such proportions would imply a continued increase
ated by the study methods used in many of these previous
mentia in very old people, a finding that would be accentu-
we therefore would expect to find lower prevalences of de-
mortality probably does exist, disfavoring demented persons,
participants with cognitive decline or mild dementia.
found in most centenarian studies (Asada et al., 1996; Ebly et
is comparable to the Finnish study, which showed 23% of
of questionable dementia together with mild dementia (24%)
criteria. Also, our proportion
mented according to
DSM-III-R
tings (34%), whereas 79 (44%) could be classified as unclassifiable/unknown.
Among the 13 deceased the level of cognitive function prior
to death was unknown. If all the unclassifiable persons
among participants and nonparticipants and the deceased
were demented (i.e., worst case scenario), the prevalence of
dementia in the total population would be 58.7%, which
was not significantly different from the estimated preva-
ence among the participants.

Discussion
This population-based study of unselected 100-year-old
Danes suggests that about 50% can be described as mildly
to severely demented. It supports the suggestion that the
prevalence of dementia does not increase exponentially
with advanced age. Additionally, because at least 25% were
found to be not demented—a figure that rose to 37% when
we included the group of probably no dementia—our data
also indicate that it is possible to reach an extremely ad-
vanced age and still remain nondemented.

Our findings are compatible with the representative study
of Sobel and colleagues (1995), who found that among 179
Finns aged 100 years or more the proportion of moderately
to severely demented centenarians was 33%, similar to our find-
ings (34%), whereas 79 (44%) could be classified as nonde-
mented according to DSM-III-R criteria. Also, our proportion
of questionable dementia together with mild dementia (24%)
is comparable to the Finnish study, which showed 23% of
participants with cognitive decline or mild dementia.

The higher proportions (58–85%) of demented participants
found in most centenarian studies (Asada et al., 1996; Ebly et
al., 1994; Iván, 1990; Powell, 1994) are difficult to explain,
because such proportions would imply a continued increase
in incidence and no differential mortality between demented
and nondemented persons. However, because differential
mortality probably does exist, disfavoring demented persons,
we therefore would expect to find lower prevalences of de-
mentia in very old people, a finding that would be accentu-
ated by the study methods used in many of these previous

Table 4. Relation Between Dementia and Diseases With a Known Possible Influence on Dementia Development

<table>
<thead>
<tr>
<th></th>
<th>Actual Hypertension</th>
<th>Stroke/Transitory Cerebral Ischemia</th>
<th>Atrial Fibrillation</th>
<th>Myocardial Infarction</th>
<th>Diabetes</th>
<th>Vitamin B12 or Folic Acid Deficiency</th>
<th>Hypothyroidism</th>
<th>Parkinson's Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>n (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nondemented</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n = 91)</td>
<td>39</td>
<td>43</td>
<td>22</td>
<td>24</td>
<td>12</td>
<td>13</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Demented</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n = 105)</td>
<td>25</td>
<td>24</td>
<td>22</td>
<td>21</td>
<td>12</td>
<td>11</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Missing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n = 11)</td>
<td>1</td>
<td>9</td>
<td>2</td>
<td>18</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>All</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N = 207)</td>
<td>65</td>
<td>31</td>
<td>46</td>
<td>22</td>
<td>25</td>
<td>12</td>
<td>9</td>
<td>4</td>
</tr>
</tbody>
</table>

Notes: Percentages are row percentages. A person can be registered in more than one column, depending on the number of diagnoses.

significantly more prevalent among nondemented than demented centenarians (p < .05).

The crude evaluation of suspected dementia/possible no
dementia in the nonparticipants showed that 23 (41%) could
be evaluated as possible no dementia, 17 (30%) as sus-
pected dementia, and 16 (29%) as unclassifiable/unknown.
Among the 13 deceased the level of cognitive function prior
to death was unknown. If all the unclassifiable persons
among participants and nonparticipants and the deceased
were demented (i.e., worst case scenario), the prevalence of
dementia in the total population would be 58.7%, which
was not significantly different from the estimated preva-
ence among the participants.

Table 5. Number of Centenarians With Cerebro- and Cardiovascular Diseases, Alone or in Combination, Among 92 Demented Centenarians Without Possible Other Dementia

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke alone</td>
<td>8</td>
</tr>
<tr>
<td>Stroke + hypertension</td>
<td>5</td>
</tr>
<tr>
<td>Stroke + myocardial infarction</td>
<td>1</td>
</tr>
<tr>
<td>Stroke + diabetes</td>
<td>1</td>
</tr>
<tr>
<td>Stroke + atrial fibrillation</td>
<td>1</td>
</tr>
<tr>
<td>Stroke + hypertension + diabetes</td>
<td>1</td>
</tr>
<tr>
<td>Hypertension alone</td>
<td>10</td>
</tr>
<tr>
<td>Hypertension + atrial fibrillation</td>
<td>4</td>
</tr>
<tr>
<td>Hypertension + diabetes</td>
<td>2</td>
</tr>
<tr>
<td>Atrial fibrillation alone</td>
<td>4</td>
</tr>
<tr>
<td>Atrial fibrillation + diabetes</td>
<td>1</td>
</tr>
<tr>
<td>Diabetes alone</td>
<td>4</td>
</tr>
<tr>
<td>Myocardial infarction alone</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>46</td>
</tr>
</tbody>
</table>
Dementia in extremely old persons are illustrated by the fact that the whole neuropsychological assessment battery could be performed on only approximately half of the Swedish centenarians (Samuelsson et al., 1997). Furthermore, in cases of severe problems with hearing and vision, dementia diagnosis could not be based on the DSM-III-R criteria. These difficulties were also seen in our study, where only one third of the participants could complete the whole MMSE adequately, and the rest were only examined partly due to different deficits or could not or would not go through the examination.

The MMSE is not an adequate test in centenarians, as illustrated in this study. Others have shown how deficits in vision affect MMSE scores among community-dwelling centenarians (Holtsberg, Poon, Noble, & Martin, 1995). In our study impaired vision interfered with the tasks of drawing two pentagons (n = 52) and writing a sentence (n = 34) in the 84 centenarians who did not complete the MMSE. The task of reading an order (“Close your eyes!”) could be overcome, in most cases, by showing the command in big letters, with the exception of 30 participants, for whom we had to omit the task.

Hearing disability can partly be overcome by the use of hearing aids, which most of the Danish centenarians have. Although hearing aids improved communication, poor hearing could still be a problem. For example, if the centenarian did not hear the three words the first time in the learning and recalling test of the MMSE we repeated them, but this might have created a learning effect, which could have biased the result. This may have also been a problem in the item concerning reiterating a sentence. In some cases the hearing disability was so severe that we had to give up further questioning.

Impaired physical capability, which is common among extremely aged persons such as centenarians (Andersen-Ranberg et al., 1999), makes it difficult to evaluate the ability and degree of maintaining an independent life. Caregiving necessitated by physical disability may obscure a higher level of cognitive function, especially in the groups of probably no dementia and questionable dementia. But we achieved full information regarding ADLs (Avlund et al., 1996; Katz et al., 1963) and IADLs (Lawton & Brody, 1969) as well as proxy information regarding intellectual abilities, which enabled us to distinguish between disability due to cognitive or physical impairment. In this study only the MMSE and a complete physical examination could not be performed on all participants. However, for most of the participants with missing MMSE data, other variables could provide us with information to assess cognitive functions.

The large differences in the reported prevalence of dementia are probably due to the use of different methods both in sampling and in assessment, as well as the diagnostic criteria. The use of a dynamic population-based cohort is essential in minimizing selection bias in studies of dementia in extremely aged people. Cognitive function tests and neuropsychological assessment that can evaluate participants with sensory impairment at the extreme end of life must be developed for future studies regarding cognition. In our opinion the optimal way to conduct such studies is to use a two-phase strategy, keeping the number of investigators visiting the participant to a minimum. A clinician (e.g., a geriatrician) and a neuropsychologist should make the first visit together; the same neuropsychologist could conduct the second interview. It is important that the participants and proxies have to meet more than two investigators, even if the study is longitudinal. A two-phase strategy would also minimize fatigue in the participants, which can otherwise become a major problem and interfere negatively with the results in an extensive and clinical examination. Unfortunately, in a population study like ours, we did not have the capacity required to carry through such a two-phase strategy.

We characterized the type of dementia by applying the ICD-10 criteria of dementia and using medical history and previous diagnoses, as well as results from the clinical examination. It would have been preferable to have brain imaging done in order to make a proper evaluation of cerebrovascular disease. However, this was not feasible mainly because of the centenarians’ or their relatives’ negative attitude to transportation to the hospital. On the other hand, our collection of registered diagnoses from hospitals and general practitioners’ files, together with the objective clinical examination and results from a blood test, allowed us to carefully identify and assess a possible vascular component or other somatic disease relevant to the pathogenesis of dementia.

In 13 centenarians we found a history of systemic disorders or Parkinson’s disease resulting in a 12% prevalence of pOD. This is nearly the same as in the Finnish study (9%; Sobel et al., 1995). The use of the group of pOD is mainly due to exclusion criteria from NINCDS-ADRDA and NINDS-AIREN. They could very well have had AD or VaD.

It is even more complicated for us to differentiate between AD and VaD. The NINCDS-ADRDA criteria for diagnosing AD were not applicable to our data because the criteria require onset of disease between the ages of 40 and 90, and such information was not sufficiently valid in our material. We could not apply the NINDS-AIREN criteria for diagnosing VaD because we lacked brain imaging data. Instead, we evaluated the prevalence of different cardiovascular and cerebrovascular diseases known as risk factors in the development of VaD. In half of the demented population we found a cerebro- or cardiovascular disease, which might indicate at least a coexisting vascular component. The diseases were mainly stroke/TCD, atrial fibrillation, and hypertension.

The findings of Snowdon and colleagues (1997) suggest that both neuropathologic lesions of AD and cerebrovascular lesions are necessary in the development of poorer cognitive function and dementia among oldest old persons. This might explain why in our material, with the exception of hypertension, we could not show any differences in the prevalences of the different cardiovascular and cerebrovascular diseases between nondemented and demented persons. Maybe the demented centenarians had neuropathologic lesions of AD in addition to cerebrovascular lesions, whereas the nondemented had only cerebrovascular lesions. Only postmortem studies of centenarian brains can give us the answer. The neuropathologic criteria for AD used in younger elderly persons might not be applicable in centenarians, as suggested by others (Giannakopoulos, Hof, Giannakopou-
Hypertension surprisingly turned out to be more common in nondemented than in demented centenarians. In this cross-sectional study we can suggest two explanations for this finding: Either hypertension protects against dementia, or blood pressure falls in the course of dementia. The first explanation is somewhat contradictory to the hypothesis of cerebrovascular disease’s being a risk factor in the development of dementia. In contrast, the latter explanation is supported by the findings of Skoog and colleagues (1996) in their 15-year follow-up survey of 70-year-old people, in which they found a decline in blood pressure in the years before onset of dementia.

Although the causes of dementia are still unknown, the findings of Skoog and colleagues (1993, 1996), Hofman and colleagues (1997), and Snowdon and colleagues (1997) indicate that treatment of risk factors in the development of cerebrovascular disease could play an important role in lowering the risk of becoming demented, whatever the subtype. In the last decade the beneficial effects of treating hypertension even in highly aged persons have been recognized, and more people are being treated. If the abovementioned findings are true, this may influence the prevalence of dementia in old people, so that we will not find the same high prevalence of dementia in the growing proportion of very old people in the future.

In conclusion, our data show that dementia is a common, but not inevitable, phenomenon in extremely aged people such as centenarians, thus implying that the prevalence of this disease does not reach 100% at the extreme end of the human life span.

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