

## Featured Article

## Subjective cognitive decline and rates of incident Alzheimer's disease and non-Alzheimer's disease dementia

Rosalinde E. R. Slot<sup>a</sup>, Sietske A. M. Sikkes<sup>a,b</sup>, Johannes Berkhof<sup>b</sup>, Henry Brodaty<sup>c</sup>, Rachel Buckley<sup>d,e,f</sup>, Enrica Cavado<sup>g,h,i,j</sup>, Efthimios Dardiotis<sup>k</sup>, Francoise Guillo-Benarous<sup>l</sup>, Harald Hampel<sup>g,h,i,j</sup>, Nicole A. Kochan<sup>c,m</sup>, Simone Lista<sup>g,h,i,j</sup>, Tobias Luck<sup>n,o</sup>, Paul Maruff<sup>e,p</sup>, José Luis Molinuevo<sup>q</sup>, Johannes Kornhuber<sup>r</sup>, Barry Reisberg<sup>l</sup>, Steffi G. Riedel-Heller<sup>n</sup>, Shannon L. Risacher<sup>s,t</sup>, Susanne Roehr<sup>n,u</sup>, Perminder S. Sachdev<sup>c,m</sup>, Nikolaos Scarmeas<sup>v,w</sup>, Philip Scheltens<sup>a</sup>, Melanie B. Shulman<sup>l</sup>, Andrew J. Saykin<sup>s,t</sup>, Sander C. J. Verfaillie<sup>a</sup>, Pieter Jelle Visser<sup>a,x</sup>, Stephanie J. B. Vos<sup>x</sup>, Michael Wagner<sup>y,z</sup>, Steffen Wolfsgruber<sup>y,z</sup>, Frank Jessen<sup>y,aa</sup>, the Alzheimer's Disease Neuroimaging Initiative, the DESCRIPA working group, the INSIGHT-preAD study group, on behalf of the SCD-I working group, Wiesje M. van der Flier<sup>a,b,\*</sup>

<sup>a</sup>Alzheimer Center Amsterdam, Department of Neurology, Amsterdam Neuroscience, Vrije Universiteit Amsterdam, Amsterdam UMC, Amsterdam, the Netherlands

<sup>b</sup>Department of Epidemiology and Biostatistics, Vrije Universiteit Amsterdam, Amsterdam UMC, Amsterdam, the Netherlands

<sup>c</sup>Center for Healthy Brain Ageing and Dementia Centre for Research Collaboration, University of New South Wales, Sydney, Australia

<sup>d</sup>University of Melbourne, Melbourne, Australia

<sup>e</sup>The Florey Institutes of Neurosciences and Mental Health, Melbourne, Australia

<sup>f</sup>Harvard Medical School, Massachusetts General Hospital, Boston, MA, USA

<sup>g</sup>AXA Research Fund & Sorbonne University Chair, Paris, France

<sup>h</sup>Sorbonne University, GRC n° 21, Alzheimer Precision Medicine (APM), AP-HP, Pitié-Salpêtrière Hospital, Paris, France

<sup>i</sup>Brain & Spine Institute (ICM), INSERM U 1127, CNRS UMR 7225, Paris, France

<sup>j</sup>Institute of Memory and Alzheimer's Disease (IM2A), Department of Neurology, Pitié-Salpêtrière Hospital, AP-HP, Paris, France

<sup>k</sup>Department of Neurology, Faculty of Medicine, University of Thessaly, Larissa, Greece

<sup>l</sup>New York University Alzheimer's Disease Center, NYU Langone Medical Center, New York, NY, USA

<sup>m</sup>Neuropsychiatric Institute, Prince of Wales Hospital, Randwick, Australia

**Disclosures:** R.E.R.S., J.B., R.B., E.C., E.D., F.G.-B., N.A.K., T.L., P.M., J.L.M., J.K., B.R., S.G.R.-H., S.L.R., S.R., P.S.S., N.S., M.B.S., S.C.J.V., S.J.B.V., M.W., S.W., and F.J. report no conflicts of interest. All authors report no conflict of interest with the content of the present manuscript. In the last 3 years, H.B. has worked on a drug trial for patients with MCI and Alzheimer's disease sponsored by Tau Therapeutics and has been a consultant or advisory board member for Eli Lilly and Nutricia. H.H. serves as Senior Associate Editor for the Journal Alzheimer's & Dementia; he received lecture fees from Biogen and Roche, research grants from Pfizer, Avid, and MSD Avenir (paid to the institution), travel funding from Functional Neuromodulation, Axovant, Eli Lilly and company, Takeda and Zinfandel, GE Healthcare and Oryzon Genomics, consultancy fees from Jung Diagnostics, Cytos Ltd., Axovant, Anavex, Takeda and Zinfandel, GE Healthcare and Oryzon Genomics, and Functional Neuromodulation, and participated in scientific advisory boards of Functional Neuromodulation, Axovant, Eli Lilly and company, Cytos Ltd., GE Healthcare, Takeda and Zinfandel, Oryzon Genomics and Roche Diagnostics; he is coinventor of patent applications and has received no royalties. S.L. received lecture honoraria from

Roche. P.S. has received grant support for the institution Alzheimer Center, VU University Medical Center from GE Healthcare and MERCK; he has received speaker's fees paid to the institution Alzheimer Center, VU University Medical Center, from Lilly, GE Healthcare and Roche. S.A.M.S. provided consultancy services in the past 2 years for Nutricia and Takeda. All fees were paid to her institution. W.M.v.d.F. has received research funding and speaker honorarium from Boehringer Ingelheim and Biogen Inc. Research programs of W.M.v.d.F. have been funded by ZonMW, NWO, EU-FP7, Alzheimer Nederland, CardioVasculair Onderzoek Nederland, Stichting Dioraphte, Gieskes-Strijbis Fonds, Pasman Stichting, Boehringer Ingelheim, Piramal Neuroimaging, Roche BV, Janssen Stellar, Biogen, Combinostics. All funding is paid to her institution. A.J.S. received research support from a collaborative grant from Eli Lilly during the time this project was completed, co-led an NIA SBIR grant with Arkley Biotek, and received PET tracer precursor assistance from Avid Radiopharmaceuticals.

\*Corresponding author. Tel.: +31204440816; Fax: +31204448529.

E-mail address: [wm.vdflier@vumc.nl](mailto:wm.vdflier@vumc.nl)

<sup>a</sup>Institute of Social Medicine, Occupational Health and Public Health (ISAP), Faculty of Medicine, University of Leipzig, Leipzig, Germany

<sup>o</sup>Social Psychiatry, Department of Economic and Social Sciences, University of Applied Sciences Nordhausen, Nordhausen, Germany

<sup>p</sup>Cogstate Ltd., Melbourne, Australia

<sup>q</sup>Neurology Department, Hospital Clínic i Universitari-IDIBAPS and BarcelonaBeta Brain Research Center, Pasqual Maragall Foundation, Barcelona, Spain

<sup>r</sup>Friedrich Alexander University Erlangen-Nürnberg, Erlangen, Germany

<sup>s</sup>Center for Neuroimaging, Department of Radiology and Imaging Sciences, Indiana University School of Medicine Indianapolis, IN, USA

<sup>t</sup>Indiana Alzheimer Disease Center, Indiana University School of Medicine Indianapolis, IN, USA

<sup>u</sup>LIFE – Leipzig Research Center for Civilization Diseases, University of Leipzig, Leipzig, Germany

<sup>v</sup>National and Kapodistrian University of Athens, Athens, Greece

<sup>w</sup>Department of Neurology, Columbia University Medical Center, New York, NY, USA

<sup>x</sup>Department of Psychiatry and Neuropsychology, Alzheimer Center Limburg, Maastricht University, Maastricht, the Netherlands

<sup>y</sup>DZNE, German Center for Neurodegenerative Diseases, Germany

<sup>z</sup>Department of Psychiatry and Psychotherapy, University of Bonn, Bonn, Germany

<sup>aa</sup>Psychiatry Department, University of Cologne, Cologne, Germany

## Abstract

**Introduction:** In this multicenter study on subjective cognitive decline (SCD) in community-based and memory clinic settings, we assessed the (1) incidence of Alzheimer's disease (AD) and non-AD dementia and (2) determinants of progression to dementia.

**Methods:** Eleven cohorts provided 2978 participants with SCD and 1391 controls. We estimated dementia incidence and identified risk factors using Cox proportional hazards models.

**Results:** In SCD, incidence of dementia was 17.7 (95% Poisson confidence interval 15.2–20.3)/1000 person-years (AD: 11.5 [9.6–13.7], non-AD: 6.1 [4.7–7.7]), compared with 14.2 (11.3–17.6) in controls (AD: 10.1 [7.7–13.0], non-AD: 4.1 [2.6–6.0]). The risk of dementia was strongly increased in SCD in a memory clinic setting but less so in a community-based setting. In addition, higher age (hazard ratio 1.1 [95% confidence interval 1.1–1.1]), lower Mini-Mental State Examination (0.7 [0.66–0.8]), and apolipoprotein E  $\epsilon$ 4 (1.8 [1.3–2.5]) increased the risk of dementia.

**Discussion:** SCD can precede both AD and non-AD dementia. Despite their younger age, individuals with SCD in a memory clinic setting have a higher risk of dementia than those in community-based cohorts.

© 2018 The Authors. Published by Elsevier Inc. on behalf of the Alzheimer's Association. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## Keywords:

Subjective cognitive decline; Dementia incidence; Preclinical Alzheimer's disease; Alzheimer's disease; Vascular dementia; Frontotemporal dementia; Dementia Lewy bodies

## 1. Introduction

Neurodegenerative changes, eventually leading to dementia due to Alzheimer's disease (AD), begin to accumulate approximately 20 years before clinical symptoms appear [1]. With the lack of curative treatment for dementia due to AD, research is moving toward the prodromal and preclinical stages of AD [2]. Subjective cognitive decline (SCD) refers to the subjective experience of cognitive decline, without objective impairment on cognitive assessment [3]. Compared to individuals without SCD, cognitively normal elderly subjects experiencing complaints have an increased risk of subsequent objective cognitive decline, that is, progression to mild cognitive impairment (MCI) and dementia [4–9]. Therefore, SCD has been suggested to be a possible first symptomatic expression of preclinical AD [2,3].

The conceptual framework on SCD published by the international Working Group (SCD-I) has a focus on SCD as an early harbinger of AD, proposing the SCD-plus criteria as potential risk factors for preclinical AD [3]. However, SCD may also precede other dementia subtypes with a

gradual onset, such as vascular dementia (VaD), dementia with Lewy Bodies (DLBs), or frontotemporal dementia (FTD). Although individuals with SCD have an increased risk of dementia [4–9], the incidence rate of progression from SCD to AD dementia, and especially to non-AD dementia, has not been estimated before.

For cognitively normal individuals, risk factors of dementia include higher age, lower education, and apolipoprotein E (APOE)  $\epsilon$ 4 status [10,11]. Whether these risk factors influence the risk of progression to AD and non-AD types of dementia in patients with SCD in a similar way remains to be further investigated. The aim of our multicenter study including both memory clinic and community-based cohorts of SCD was to estimate incidence rates of dementia, both for AD and non-AD.

## 2. Methods

This collaborative project was initiated during a public meeting of the Subjective Cognitive Decline Professional Interest Area during the Alzheimer's Association International Conference in 2015, which was facilitated by the

Table 1  
Overview of participating centers and their characteristics

Center	Setting	Definition of SCD	Follow-up information	N, total	N, SCD	N, controls
Alzheimer Disease Neuroimaging Initiative (ADNI) and Indiana Alzheimer Disease Center [41,42]	USA	Memory clinic; multicenter with standardized methods	Normal cognition + MC visit because of complaints (assessed by CCI)	Annual FU	372	126 246
Australian Imaging, Biomarkers and Lifestyle Study (AIBL) [43]	Australia	Community; multicenter with standardized methods	Normal cognition + cognitive complaints question (Mac-Q): Yes	FU interval 18 months	1636	491 161
Amsterdam Dementia Cohort [44–46]	The Netherlands	Memory clinic; single-center	Normal cognition + MC visit because of complaints	Annual FU	463	463 0
Barcelona Hospital Clinic i Universitari	Spain	Memory clinic; single-center	Normal cognition + MC visit because of complaints	Annual FU	75	52 23
German Dementia Competence Network (DCN) [47]	Germany	Memory clinic; multiple single-center studies	Normal cognition + MC visit because of complaints Participant did not meet Jak-Bondi criteria [48]	Annual FU	256	256 0
Development of Screening Guidelines and Clinical Criteria for Pre-dementia AD study (DESCRIPA) [49]	Europe*	Memory clinic; multiple single-center studies	Normal cognition + MC visit because of complaints	Annual FU	245	224 0
Hellenic Longitudinal Investigation of Aging and Diet (HELIAD) [50]	Greece	Community; single-center	Normal cognition + cognitive complaints questionnaire: Yes	Annual FU	531	154 309
INSIGHT pre-AD study, Paris [51,52]	France	Community; single-center	Normal cognition + cognitive complaints questionnaire: Yes	FU after 3 years	318	318 0
Leipzig Longitudinal Study of the Aged (LEILA75+) [53]	Germany	Community; single-center	Normal cognition + cognitive complaints questionnaire: Yes	FU interval 18 months	670	169 501
Sydney Memory and Ageing Study (MAS) [54]	Australia	Community; single-center	Normal cognition + cognitive complaints question: Yes	FU interval 24 months	467	316 151
New York University Langone Medical Center (NYU)	USA	Memory clinic; single-center	Normal cognition + MC visit because of complaints	Annual FU	488	409 0

Abbreviations: CCI, Cognitive Change Index; FU, follow-up; MC, memory clinic; SCD, subjective cognitive decline.

NOTE: Of the participating cohorts, there were eight single-center studies, two multicenter studies with standardized methods (ADNI and AIBL), and two cohorts composed of data from multiple single-center studies (DCN Germany and DESCRIPA). ADNI and the single site Indiana ADC cohort were combined as both were assessed and included based on the CCI.

\*To prevent possible overlap of participants, all cases from the VU Medical Center included in the DESCRIPA data set were not included in analyses ( $n = 22$ ). See [Supplementary Table](#) for more information.

## International Society to Advance Alzheimer's Research and Treatment.

### 2.1. Setting and recruitment

Eleven cohorts provided data, see [Table 1](#) for an overview of participating cohorts and the number of subjects included. Across studies, there are differences in operationalization of SCD. We deliberately took the case definition of each study as the starting point; [Table 1](#) provides information on center-specific operationalization of SCD. Cohorts were defined as memory clinic setting when patients were referred to the memory clinic by a physician, or actively approached the respective center for evaluation. Cohorts were labeled as community setting when the study was population based, for example, if recruitment was organized via standardized evaluation of eligible participants in a predefined district or when participants were recruited by active (media) appeal.

### 2.2. Participants

We included SCD participants in the analysis if (1) the participant reported subjective experience of cognitive decline on one or more cognitive domains; (2) the participant had normal baseline cognition, defined by results of cognitive assessment within normal ranges (center-specific), and criteria for MCI or any dementia were not met [12–15], and (3) had at least one follow-up assessment (>8 months from baseline) with repeated evaluation of diagnosis. Controls were provided by the same cohorts but did not endorse inclusion criterion (1). Exclusion criteria were MCI, dementia, alcohol or substance abuse, or any psychiatric or neurological disease possibly causing memory complaints (i.e. epilepsy, Parkinson's disease). In sum, 11 cohorts provided 5521 participants; 2978 cases with SCD and 1391 controls without SCD, see [Fig. 1](#) for an overview of participant selection.

### 2.3. Outcome measure

The main outcome measure was progression to dementia. Definitions and criteria of specific dementia used in each cohort are provided in the supplement or study design reports. Besides dementia due to AD [13,16], we evaluated the following non-AD dementia: VaD [17], FTD [14], and DLBs [15]. Other less frequent neurodegenerative causes of dementia, such as corticobasal syndrome or progressive supranuclear palsy, were classified as “dementia other.”

### 2.4. Demographic features of the study population

Sociodemographic features and cognition were assessed in each cohort. Here, we report on age, sex, education, global cognition, and *APOE*  $\epsilon 4$  carrier status. Information on years of education was available for 2142 (71.9%) participants. Cognitive function was screened with the Mini-Mental State Examination (MMSE) [18] and available for 2928 (98.3%) participants. *APOE* genotyping was performed according to local procedures and available for 2417 (81.2%) participants. We dichotomized *APOE*  $\epsilon 4$  status (0  $\epsilon 4$  alleles vs. 1 or 2  $\epsilon 4$  alleles).

### 2.5. Statistical analyses

Data were analyzed using SPSS (version 22; IBM, Armonk, NY, USA) and Stata 15 (Stata Statistical Software: Release 15, StataCorp LP). We evaluated baseline characteristics and assessed differences between memory clinics and community cohorts using linear mixed models (continuous variables) or generalized estimating equations (dichotomous variables), taking into account random center effects.

We calculated incidence rates of dementia per 1000 person-years with accompanying 95% Poisson confidence intervals and incidence rates of AD and non-AD dementia separately.

We studied the effect of age, sex, MMSE, number of education years, *APOE*  $\epsilon 4$  carrier status, and recruitment setting (memory clinic vs. community cohort) on the risk of dementia by using shared-frailty Cox proportional hazards models, taking into account within-group center effects. We conducted simple and multiple Cox regression models and accounted for residual variation in progression risk among studies by including a center-specific random effect. To evaluate whether effects of MMSE and education were generalizable between centers, we added mean MMSE and mean number of education years per center as variables. Finally, we added interaction effects of recruitment setting and variables age, sex, MMSE, and number of education years. We repeated the analyses stratified for AD and non-AD dementia.

For visualization, we constructed Kaplan-Meier curves of progression to dementia in general and for dementia due to AD and to non-AD per decade of age. When calculating the risk of AD, cases progressing to non-AD dementia were censored and vice versa.  $P < .05$  was considered to be significant.

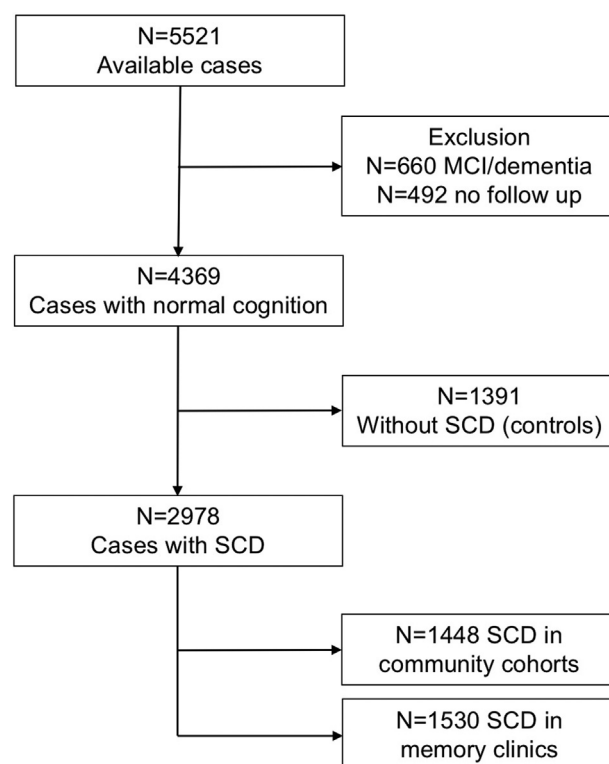


Fig. 1. Flowchart of participant selection. Overview of inclusion of participants. Abbreviations: MCI, mild cognitive impairment; SCD, subjective cognitive decline.

## 3. Results

### 3.1. Demographics

Table 2 shows the baseline demographic features of the study population. Individuals with SCD in memory clinic cohorts were on average 10 years younger, and they were less often females, had more years of education, and were more often *APOE*  $\epsilon 4$  positive than individuals with SCD in community-based cohorts and controls. Adjusted for random center effects, MMSE scores were lower in controls than in individuals with SCD. For all variables, individuals with SCD from the community were intermediate between SCD from a memory clinic and controls. Center characteristics are provided in [Supplementary Table](#).

### 3.2. Progression to AD and non-AD dementia

During follow-up,  $3.9 \pm 2.2$  years (range 0.9–12.8 years), 84 (6% of 1391) controls without SCD progressed to dementia, of which 61 (66% of demented) to AD and 23 (33% of demented) and non-AD. Among individuals with SCD, 194 (7% of 2978) progressed to dementia, attributed to AD for 127 (65% of demented) or another type of dementia for 67 (35%). Within the non-AD dementia cohort, 30 (16% of all dementia cases) individuals with SCD progressed to VaD, 8 (4%) progressed to frontotemporal



Table 2  
Baseline demographic features of study participants (N = 4369)

Characteristics	All N = 4369	Controls N = 1391	Community N = 1448	Memory clinic N = 1530	P value
Number of cohorts		6	5	6	
Age, year	73 ± 9	77 ± 7	76 ± 6	67 ± 9	.000
Female gender	2611 (60%)	889 (64%)	901 (62%)	821 (54%)	.000
MMSE	28.3 ± 1.7	27.9 ± 1.9	28.4 ± 1.4	28.4 ± 1.6	.000*
Education, year <sup>†</sup>	12 ± 4	11 ± 5	10 ± 4	14 ± 4	.000
APOE ε4 carrier <sup>‡</sup>	888 (28%)	184 (26%)	261 (22%)	443 (36%)	.000
Follow-up, year	3.9 ± 2.2	4.3 ± 2.0	3.9 ± 2.0	3.5 ± 2.3	.000

NOTE: Values are displayed as unadjusted mean ± standard deviation (SD) or N (%). Differences between memory clinic and community cohorts were assessed using linear mixed models (continuous variables) or generalized estimating equations (dichotomous variables) taking into account center random effects.

\*When taking into account center random effects, MMSE is lower in controls versus community cohorts versus memory clinic cohorts ( $P < .001$ ), whereas unadjusted means are shown in the table.

<sup>†</sup>Data available for 77% (memory clinic 98%, community 44%, controls 88%).

<sup>‡</sup>Data available for 72% (availability memory clinic 82%, community 81%, controls 51%).

lobar degeneration (FTLD), 9 (5%) to DLB, and 20 (10%) to another type of non-AD dementia. Fig. 2 shows the percentages of dementia diagnoses in community cohorts and memory clinics. In a multilevel model, we compared percentages of dementia diagnoses in community and memory clinic cohorts and found that individuals with SCD in community-based cohorts more often received a diagnosis of VaD (23% community vs. 9% memory clinic [ $P = .01$ ]). By contrast, diagnoses of DLB and FTLD were more frequently made in a memory clinic setting (DLB 8% memory clinic vs. 1% community ( $P = .070$ ); FTLD: 8% memory clinic versus 0% community, model did not converge). The percentage of a diagnosis of AD did not differ between recruitment settings (67% vs. 63%,  $P = .55$ ), nor did the number of cases with “dementia other” (memory clinic 8% vs. community cohort 13% [ $P = .34$ ]).

### 3.3. Incidence rate of dementia

Among individuals with SCD, the incidence rate of dementia was 17.7 (95% Poisson confidence interval

15.2-20.3) per 1000 person-years. The incidence rate per 1000 person-years for dementia due to AD was 11.5 (9.6-13.7) and for non-AD dementia 6.1 (4.7-7.7). In controls without SCD, the incidence rate of dementia was 14.2 (11.3-17.6); 10.1 (7.7-13.0) for AD and 4.1 (2.6-6.0) for non-AD. Table 3 shows the incidence rates of dementia in memory clinics (20.0 [16.4-24.1]) and community cohorts (15.4 [12.3-19.0]) per decade and for AD and non-AD dementia separately. Incidence rates increased with age, as visualized in Figs. 3 and 4. Multivariate Cox proportional hazards models showed that compared to controls without SCD, individuals with SCD in memory clinic cohorts are at a clearly increased risk of dementia (Table 4). The increased risk of dementia in community-based cohorts did not reach significance. In addition, higher age, lower MMSE, and APOE ε4 carrier status were independent predictors of incident dementia. We evaluated center random effects for MMSE and education in the Cox proportional hazards models, which did not specifically alter results, concluding that findings were generalizable for MMSE and education.

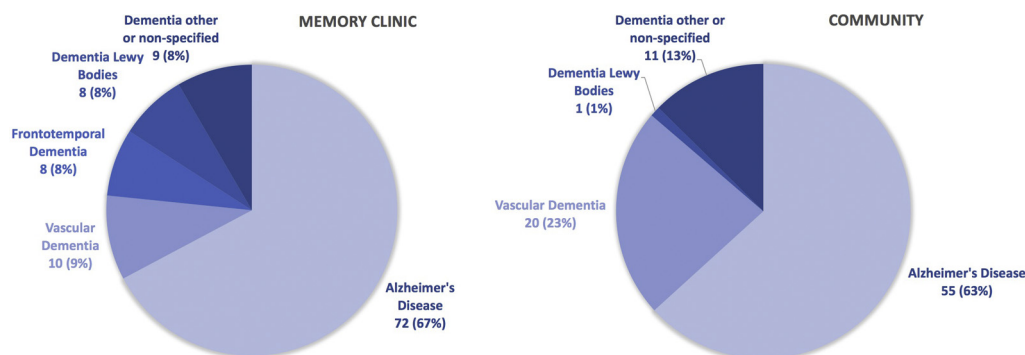


Fig. 2. Type of dementia diagnosis in memory clinic and community settings. Dementia diagnoses per type of recruitment setting. Total number of dementia diagnoses: memory clinic n = 107, community n = 87. Results are represented as N (%).

Table 3  
Incidence rates of dementia in general, and dementia due to AD and non-AD

		Incidence rate/1000 person-years (95% Poisson confidence intervals)		
Groups with age-bins	Number of person years	Dementia	AD	Non-AD
Controls (n = 1391)				
All		14.2 (11.3-17.6)	10.1 (7.7-13.0)	4.1 (2.6-6.0)
Age category				
<60	55	0	0	0
60-70	859	2 (0-8)	2 (0-8)	0
70-80	3379	7 (5-11)	4 (2-7)	3 (2-6)
80-90	1547	33 (25-43)	25 (18-34)	8 (4-14)
>90	81	74 (27-161)	62 (20-144)	12 (0-69)
Community (n = 1448)				
All	5647	15.4 (12.3-19.0)	9.7 (7.3-12.7)	5.7 (3.9-8.0)
Age category				
<60	12	0	0	0
60-70	904	2 (0-8)	2 (0-8)	0
70-80	3222	11 (8-15)	6 (4-9)	5 (3-8)
80-90	1509	32 (24-42)	23 (16-32)	9 (5-16)
>90	47	60 (12-175)	20 (1-111)	40 (5-145)
Memory clinic (n = 1530)				
All	5355	20.1 (16.4-24.1)	13.4 (10.5-16.9)	6.5 (4.6-9.1)
Age category				
<60	1271	6 (2-11)	2 (0-6)	4 (1-9)
60-70	1952	17 (12-24)	11 (7-16)	6 (3-11)
70-80	1571	32 (24-42)	22 (15-30)	10 (6-16)
80-90	447	26 (20-58)	31 (17-52)	4 (1-15)
>90	12	0	0	0

Abbreviation: AD, Alzheimer's disease.

NOTE: Results are displayed as incidence rates (95% Poisson confidence interval) per 1000 person-years. Analyses stratified for AD and non-AD types of dementia, age category, and recruitment setting.

Stratified for AD or non-AD outcomes, the increased risk of dementia in individuals with SCD was particularly attributable to incident non-AD dementia. Lower MMSE increased the risk of both AD and non-AD dementia (Table 4), while higher age was associated with an increased risk of non-AD dementia. There was no significant effect of sex, education, or APOE in the stratified analyses.

#### 4. Discussion

In this multicenter study including both memory clinic and community-based cohorts of SCD, we evaluated incidence rates of dementia, both for AD and non-AD. We found an overall dementia incidence rate in individuals with SCD of 17.7 per 1000 person-years, compared to 14.2 in controls without SCD. Particularly, in memory clinic patients with SCD, the risk of non-AD dementia is strongly increased. In line with incidence studies of dementia subtypes [19,20], roughly one of 3 incident dementia in individuals with SCD cases was due to non-AD. Of note, non-AD dementia in memory clinics often comprised FTD or DLB, while in community-based cohorts, VaD was relatively more common. Other determinants of incident dementia included higher age, lower baseline cognition, and APOE ε4 carriership.

Our data clearly showed that recruitment setting modifies the risk of progression from SCD to dementia. It is well known that recruitment setting (i.e. memory clinic vs. community) affects studies in SCD [3,21,22]. However, the number of studies directly comparing recruitment setting is small [9,23–25]. A previous meta-analysis suggested that the annual conversion rate from SCD to dementia did not differ between memory clinics and community cohorts [9], and likewise at first sight, our memory clinic cohorts also had only slightly higher incidence rates (20.1/1000 person-years) compared with community cohorts (15.4/1000 person-years). However, heterogeneity between studies has repeatedly been mentioned in SCD studies [9,21], and a recent study showed that progression to MCI is more common in individuals with SCD recruited at a memory clinic than in a community-based setting [26]. We also observed great heterogeneity between cohorts in study design, center, and patient characteristics, and to allow meaningful pooling of data, we used a multilevel statistical approach, carefully taking into account center differences. Particularly, memory clinic cohorts were on average a decade younger, explaining their overall lower incidence. When we stratified by age, our data revealed that in every age bin, incidence of dementia is higher in the memory clinic than in the community-based

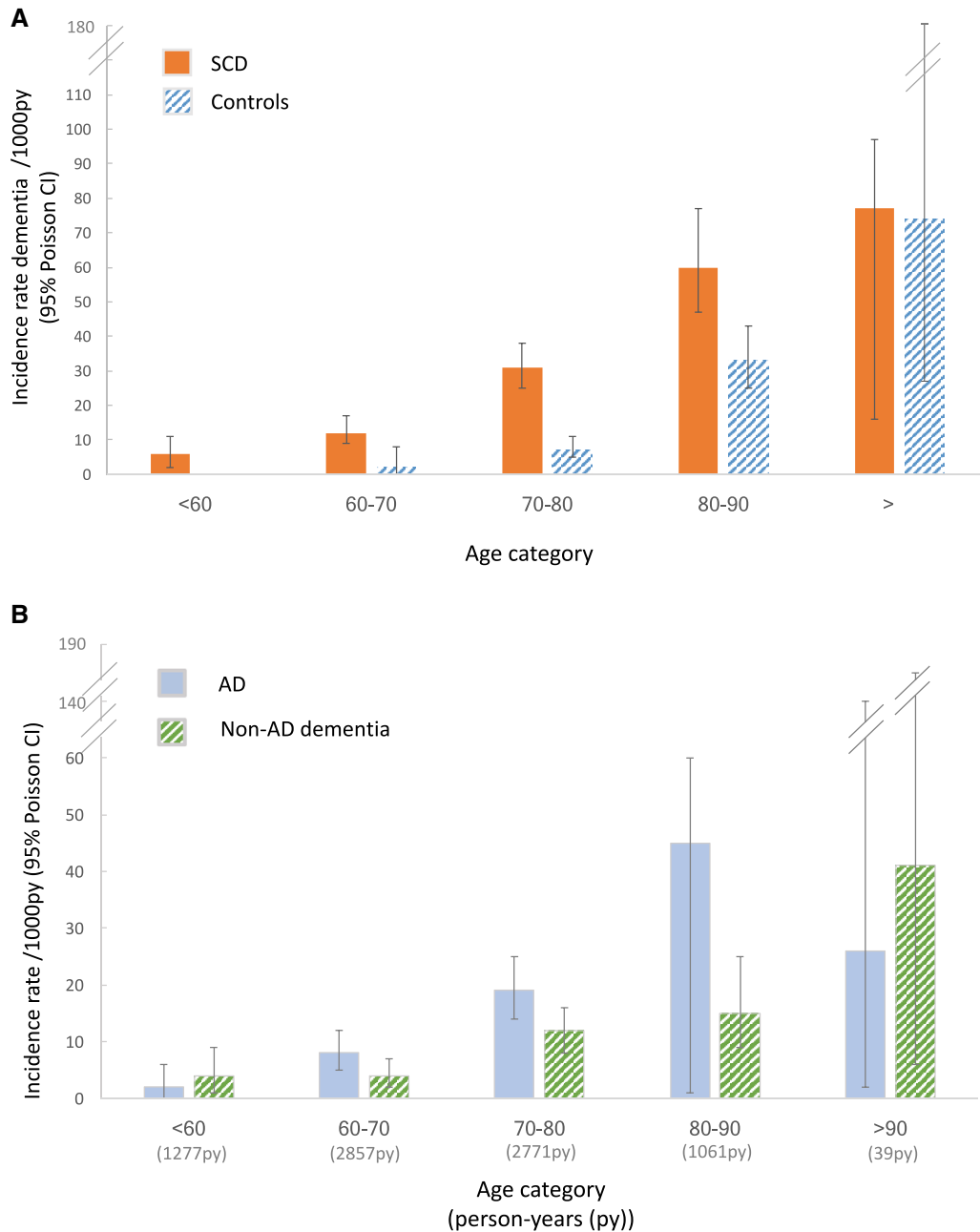


Fig. 3. Incidence rates of dementia and AD and non-AD dementia. (A) Incidence rates of dementia per decade in individuals with SCD and controls. (B) Incidence rates of AD and non-AD dementia per decade. Results are presented as incidence rates per 1000 person-years (95% Poisson confidence intervals) per decade. Abbreviations: AD, Alzheimer's disease; CI, confidence interval; SCD, subjective cognitive decline.

cohorts of individuals with SCD. The only exception was the oldest age bin >90 years, where data in memory clinics were simply lacking, and the incidence of dementia in community-based cohorts was high. Our data illustrate that memory clinic patients who actively seek help for their perceived cognitive problems, indeed, are more likely to experience the first (preclinical) signs of a neurodegenerative disease [23,24].

Our findings provide evidence that SCD is not only a potential harbinger of AD but also of other dementia. Two-third of incident dementia in individuals with SCD was attributable to AD dementia, whereas approximately one-third was attributable to another type of dementia. The relative frequencies of individuals with SCD progressing to FTLD, DLB, and VaD seemed comparable with previous dementia incidence studies [19,20,27–29]. In memory clinic

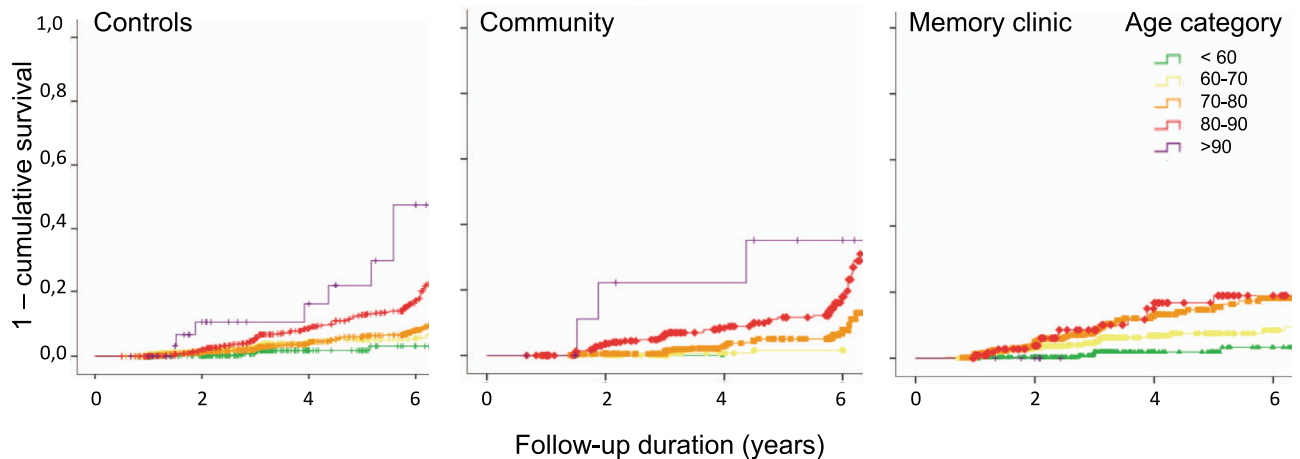


Fig. 4. Kaplan-Meier curves of cumulative risk of dementia in controls and individuals with subjective cognitive decline in memory clinic and community cohorts. Kaplan-Meier curves of the cumulative risk of progression to dementia per decade, stratified for recruitment setting.

cohorts, DLB and FTLTD were more frequently diagnosed than in community cohorts. By contrast, VaD was more often diagnosed in the older community cohort individuals with SCD. This difference could be a reflection of differing operationalization of diagnostic criteria for dementia, which may be handled differently between settings [30], for example, VaD in memory clinic settings often requires neuroimaging criteria, whereas in community-based settings such a diagnosis may be based on clinical presentation only. Diagnosis of DLB or FTLTD requires careful neurological examination by an expert neurologist, available mostly in specialized clinics rather than in community settings. Also, individuals with early VaD or DLB might be referred for evaluation to general neurology, instead of a memory clinic, as patients complain rather of neurological symptoms, such as parkinsonism or gait change, than memory decline. Furthermore, individuals

with FTLTD may be less likely to participate in voluntary studies because of disease characteristics [31].

The large majority of individuals with SCD in both memory clinic and community-based cohorts did not progress to any type of dementia, but rather remained cognitively normal. Despite the growing interest in SCD as a putative first syndrome stage of AD, the group of individuals seeking help where a neurodegenerative disorder can be excluded as cause of their problems also merits our attention. From studies in the field of MCI and early studies in SCD, it is clear that, for example, cerebrospinal fluid biomarkers have particularly good negative predictive value, illustrating that their optimal clinical use is for reassurance of individuals with normal biomarkers [32,33]. Alternative causes of SCD could be subclinical psychiatric disorders, personality traits, or surmenage. Individuals with SCD who are unlikely to progress to AD or non-AD

Table 4

Associations between determinants and the risk of dementia in general and dementia due to AD and non-AD in a combined SCD sample (n = 4369)

Determinant	Dementia		AD		Non-AD	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Controls	ref	ref	ref	ref	ref	ref
SCD—community	2.1 (0.6 – 7.7)	1.5 (0.4 – 5.8)	1.8 (0.8 – 4.1)	0.7 (0.3 – 1.9)	4.6 (1.1–19.0)	2.2 (0.5–9.7)
SCD—memory clinic	10.0 (2.9 – 34.0)	10.4 (3.4 – 32.0)	1.7 (0.8 – 3.6)	2.0 (1.0 – 4.1)	12.7 (3.1–51.4)	7.1 (1.8–27.3)
Age, years	1.1 (1.1 – 1.1)	1.1 (1.1 – 1.1)	1.0 (1.0 – 1.0)	1.0 (1.0 – 1.0)	1.09 (1.05 – 1.12)	1.07 (1.02 – 1.11)
Female gender	1.1 (0.9 – 1.4)	1.0 (0.7 – 1.5)	1.0 (0.9 – 1.04)	1.0 (0.9 – 1.1)	0.8 (0.5 – 1.3)	0.6 (0.3 – 1.0)
MMSE <sup>b</sup>		0.7 (0.65 – 0.8)		0.95 (0.92 – 0.98)		0.8 (0.7 – 0.9)
Education, years <sup>*</sup>		1.0 (0.97 – 1.1)		1.0 (0.98 – 1.01)		1.0 (0.9 – 1.1)
APOE ε4 status <sup>†</sup>		1.8 (1.3 – 2.5)		1.0 (0.9 – 1.1)		1.1 (0.6 – 2.1)

Abbreviations: AD, Alzheimer's disease; SCD, subjective cognitive decline.

NOTE: Results are presented as hazard ratios (95% confidence interval) and reflect the risk of progression from SCD to dementia in general and dementia due to AD and non-AD. Model 1: age and gender adjusted. Model 2; additionally adjusted for MMSE, education in years, and APOE ε4 status (due to missing data in MMSE, education, and APOE, model 2 has less observations). HRs were calculated per determinant in univariate models and combined in multivariate models.

<sup>b</sup>Higher scores reflect better performance.

<sup>\*</sup>Data available for 77%.

<sup>†</sup>Data available for 72%.



dementia could be reassured and might benefit from counseling and/or lifestyle interventions, aiming to promote a healthy brain.

We evaluated which determinants contributed to an increased risk of progression from SCD to dementia and found that higher age, lower baseline MMSE, *APOE*  $\epsilon 4$  status, and recruitment setting resulted in an increased risk of dementia, which is consistent with the literature [9,34,35]. We found that higher age contributed relatively more to the risk of AD than non-AD dementia in individuals with SCD. A possible explanation could lie in the fact that some non-AD dementia, such as FTLT, are relatively more often diagnosed at a younger age, thus reflecting less contribution of a higher chronologic age in the risk of non-AD dementia in comparison with AD dementia [31]. The effect of MMSE on the risk of clinical progression also seemed stronger for AD than for non-AD. The MMSE is mainly designed as a global cognitive screening tool and most sensitive for disturbances in memory and orientation [18]. Because the memory domain is relatively less affected in non-AD dementia, it is conceivable that MMSE is less sensitive for non-AD dementia [36]. *APOE*  $\epsilon 4$  status was associated with an increased risk of dementia, which appeared to be attributable to the risk of AD but not to non-AD, which is in agreement with the literature [37,38].

The limitations of the study include the substantial heterogeneity in cohort characteristics. The heterogeneity includes differences in demographics of participants among centers and substantial inherent center characteristics such as the definition of SCD, the administered SCD questionnaires, the use of (magnetic resonance imaging, positron emission tomography, or cerebrospinal fluid) biomarkers in the diagnostic process, and the outcome measures (differences in dementia criteria used). Furthermore, recruitment setting has been shown to be a moderator of SCD results, as discussed previously. Nonetheless, we were able to combine these cohorts by using a multilevel statistical approach, using shared-frailty Cox models and taking into account random center effects. Our results underline the importance of the harmonized research criteria for SCD, which have been put forward by the SCD-I working group [3,39]. In this study, we had no information available on different domains of cognitive complaints, such as memory domains versus nonmemory domains. As one-third of dementia diagnoses were non-AD, evaluation of SCD in nonmemory domains using questionnaires and also qualitative assessment is of interest to better understand the underlying pathology of SCD [40]. Also, we had no comprehensive cognitive test battery or biomarker data available for a large part of our cohort, and we cannot exclude the possibility of misdiagnosis in a number of cases. Future studies should include a wider range of cognitive tests and biomarkers to further evaluate the process of differentiating between AD and non-AD types of dementia. We did not take into account all available SCD cohorts, but this collaborative study did originate from the International

Society to Advance Alzheimer's Research and Treatment's SCD Professional Interest Area, including all centers that wanted to contribute data. The strengths of the study, therefore, include the large sample of SCD patients, with participating centers from around the world. Furthermore, this is the first time that the incidence of non-AD dementia is evaluated in the context of SCD.

Members of the international SCD Working Group (SCD-I) have published a conceptual framework on SCD research to facilitate harmonization of SCD research [3,39]. The framework, however, is focused on the detection of preclinical AD and not so much on the preclinical stages of other dementia. The risk of preclinical AD has been suggested to be specifically modified by self-reported memory decline [7], and a large overview of SCD measures indicated that most instruments indeed evaluate memory-specific decline [3,21]. However, as approximately one-third of progressing patients in our SCD sample progressed to another type of dementia than AD, the importance of nonmemory characteristics needs to be considered when evaluating SCD.

## Acknowledgments

This work was supported by the Alzheimer's Association and the International Society to Advance Alzheimer's Research and Treatment (ISTAART) Subjective Cognitive Decline Professional Interest Area (PIA). The authors are grateful to Keith Fargo and April Ross (ISTAART) for facilitating SCD PIA meetings.

R. Slot and S. Verfaillie are supported by a research grant from Gieske-Strijbis Fonds. W.M. van der Flier holds the Pasma chair. F. Jessen and S. Sikkes is recipient of JPND - EURO-SCD (grant no: JPND\_PS\_FP-689-019). The Alzheimer Center Amsterdam is supported by Alzheimer Nederland and Stichting VUmc fonds. The authors thank the collaborators from the DESCRIPA study for their work in the collection of the data. The DESCRIPA study group members include the following individuals: Mercè Boada, Fundació ACE, Barcelona, Spain; Peter Paul de Deyn, Institute Born Bunge, ZNA Middelheim, University of Antwerp, Antwerp, Belgium; Roy Jones, The Research Institute for the Care of Older People, Bath, UK; Giovanni Frisoni, IRCCS San Giovanni di Dio Fatebenefratelli, Brescia, Italy, and University Hospital and University of Geneva, Geneva, Switzerland; Luiza Spîru, 'Carol Davila' University of Medicine and Pharmacy, Bucharest, Romania; Flavio Nobili, Clinical Neurophysiology Service, Department of Neurosciences, Ophthalmology and Genetics, University of Genova, Genova, Italy; Yvonne Freund-Levi, Department of Neurobiology, Caring Sciences and Society (NVS), Division of Clinical Geriatrics, Karolinska Institutet, and Department of Geriatric Medicine, Karolinska University Hospital Huddinge, Stockholm, Sweden; Hilka Soininen, Institute of Clinical Medicine, Neurology, University of Eastern Finland and Neurocenter,

Neurology, Kuopio University; Frans Verhey, Department of Psychiatry and Neuropsychology, Maastricht University, School for Mental Health and Neuroscience, Alzheimer Centre Limburg, Maastricht, The Netherlands; Åsa K. Wallin, Lund University, Clinical Sciences Malmö, Clinical Memory Research Unit, Lund, Sweden; Jacques Touchon, Institute National de la Santé et de la Recherche Medicinale INSERM U 888, Montpellier, France; Marcel Olde Rikkert, Department of Geriatrics, Radboud University Medical Centre, Nijmegen, The Netherlands; Anne-Sophie Rigaud, Department of Geriatrics, Hopital Broca, Paris, France; Roger Bullock, Kingshill Research Centre, Swindon, UK; Magda Tsolaki, Aristotle University of Thessaloniki, Memory and Dementia Center, 3rd Department of Neurology, “G Papanicolaou” General Hospital, Thessaloniki, Greece; Bruno Vellas, Department of Internal Medicine and Clinical Gerontology, Toulouse University Hospital, Toulouse, France; Gordon Wilcock, Department of Care of Elderly, University of Bristol, Frenchay Hospital, Bristol, UK; Harald Hampel, Université Pierre et Marie Curie-Paris 6, AP-HP, Hopital de la Salpêtrière, Paris, France; Lutz Froelich, Department of Geriatric Psychiatry, Zentralinstitut für Seelische Gesundheit, University of Heidelberg, Mannheim, Germany.

The authors acknowledge the sharing of data by the INSIGHT-preAD study and thank the INSIGHT-preAD collaborators for their work. The INSIGHT-preAD study group includes Hovagim Bakardjian, Habib Benali, Hugo Bertin, Joel Bonheur, Laurie Boukadida, Nadia Boukerrou, Enrica Cavedo, Patrizia Chiesa, Olivier Colliot, Bruno Dubois, Marion Dubois, Stéphane Epelbaum, Geoffroy Gagliardi, Remy Genthon, Marie-Odile Habert, Harald Hampel, Marion Houot, Aurélie Kas, Foudil Lamari, Marcel Levy, Simone Lista, Christiane Metzinger, Fanny Mochel, Francis Nyasse, Catherine Poisson, Marie-Claude Potier, Marie Revillon, Antonio Santos, Katia Santos Andrade, Marine Sole, Mohamed Surtee, Michel Thiebaud de Schotten, Andrea Vergallo, Nadjia Younsi. INSIGHT-preAD Scientific Committee Members: Dubois B, Hampel H, Bakardjian H, Benali H, Colliot O, Habert Marie-O, Lamari F, Mochel F, Potier MC, Thiebaud de Schotten M. S. Vos receives research support from ZonMw. The DESCRIPA study was supported by the European Commission within the 5th Framework Program, contract number QLK-6-CT-2002-02455. The German DCN study has been supported by a grant from the German Federal Ministry of Education and Research (BMBF): Kompetenznetz Demenzen (01GI0420).

The HELIAD study has been supported by the following grants: IIRG-09-133014 from the Alzheimer's Association; 189 10276/8/9/2011 from the ESPA-EU program Excellence Grant (ARISTEIA), which is cofunded by the European Social Fund and Greek National resources, DY2b/oij.51657/14.4.2009 from the Ministry for Health and Social Solidarity (Greece).

N.A. Kochan and the Sydney Memory and Ageing Study were supported by grants from the National Health and Medical Research Center, Australia (350833, 1053804).

The INSIGHT-preAD study was promoted by INSERM in collaboration with ICM, IHU-A-ICM and Pfizer and has received support within the “Investissement d'Avenir” (ANR-10-AIHU-06) program. The study was promoted in collaboration with the “CHU de Bordeaux” (coordination CIC EC7), the promoter of Memento cohort, funded by the Foundation Plan-Alzheimer. The study was further supported by AVID/Lilly. H. Hampel is supported by the AXA Research Fund, the “Fondation partenariale Sorbonne Université” and the “Fondation pour la Recherche sur Alzheimer”, Paris, France. Ce travail a bénéficié d'une aide de l'Etat “Investissements d'avenir” ANR-10-AIHU-06. The research leading to these results has received funding from the program “Investissements d'avenir” ANR-10-AIHU-06 (Agence Nationale de la Recherche-10-IA Agence Institut Hospitalo-Universitaire-6). This Manuscript benefited from the support of the Program “PHOENIX” led by the Sorbonne University Foundation and sponsored by la Fondation pour la Recherche sur Alzheimer. Dr. Barry Reisberg's work on the project was supported in part by United States Department of Health and Human Services (DHHS) grants AG08051 and AG03051 for the National Institute on Aging, of the US National Institutes of Health, and by the Hagedorn Fund, the Stringer Foundation, the Louis J. Kay and June E. Kay Foundation, donations from Mrs. Miriam Glanbach and Dr. Felix Glanbach, and by a Clinical Research Development Fund of the New York University School of Medicine. A. Saykin and the Indiana Memory and Aging Study (IMAS) were supported by grants from the National Institute on Aging (P30 AG010133, R01 AG019771); S. Risacher was additionally supported by NIA K01 AG049050. ADNI data and sharing were funded by the Alzheimer's Disease Neuroimaging Initiative (National Institutes of Health Grant U01 AG024904) and DOD ADNI (Department of Defense award number W81XWH-12-2-0012). ADNI is funded by the National Institute on Aging, the National Institute of Biomedical Imaging and Bioengineering, and through contributions from Alzheimer's Association, Alzheimer's Drug Discovery Foundation, Araclon Biotech, BioClinica, Inc., Biogen Idec Inc., Bristol-Myers Squibb Company, Eisai Inc., Elan Pharmaceuticals, Inc., Eli Lilly and Company, EuroImmun, F. Hoffmann-La Roche Ltd and its affiliated company Genentech, Inc., Fujirebio, GE Healthcare, IXICO Ltd., Janssen Alzheimer Immunotherapy Research & Development, LLC, Johnson & Johnson Pharmaceutical Research & Development LLC, Medpace, Inc., Merck & Co., Inc., Meso Scale Diagnostics, LLC, NeuroRx Research, Neurotrack Technologies, Novartis Pharmaceuticals Corporation, Pfizer Inc., Piramal Imaging, Servier, Synarc Inc., and Takeda Pharmaceutical Company.

## Supplementary Data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.jalz.2018.10.003>.

## RESEARCH IN CONTEXT

1. Systematic review: We evaluated literature on incidence numbers of subjective cognitive decline (SCD) and risk factors of progression from SCD to dementia, with a particular focus on both AD and non-AD types of dementia.
2. Interpretation: This large collaborative study including 2978 participants with SCD, indicated that SCD is a prodrome of both AD and non-AD dementia. Risk factors for progression from SCD to dementia included higher age, lower MMSE, apolipoprotein E, and recruitment setting, specifically memory clinic setting.
3. Future directions: As we evaluated risk factors for progression from SCD to dementia, we concluded that these risk factors, in particular recruitment setting, should be taken into account while interpreting and comparing future study results. Future studies may include biomarker data while assessing risk factors of progression from SCD to dementia.

## References

- [1] Jack CR, Knopman DS, Jagust WJ, Petersen RC, Weiner MW, Aisen PS, et al. Tracking pathophysiological processes in Alzheimer's disease: an updated hypothetical model of dynamic biomarkers. *Lancet Neurol* 2013;12:207–16.
- [2] Sperling RA, Aisen PS, Beckett LA, Bennett D, Craft S, Fagan AM, et al. Toward defining the preclinical stages of Alzheimer's disease: Recommendations from the National Institute on Aging and the Alzheimer's Association workgroup. *Alzheimer's Dement* 2011;7:280–92.
- [3] Jessen F, Amariglio RE, van Boxtel M, Breteler M, Ceccaldi M, Chételat G, et al. A conceptual framework for research on subjective cognitive decline in preclinical Alzheimer's disease. *Alzheimer's Dement* 2014;10:844–52.
- [4] Schmand B, Jonker G, Hooijer C, Lindeboom J. Subjective memory complaints may announce dementia. *Neurology* 1996;46:121–5.
- [5] Geerlings MI, Jonker C, Bouter LM, Adèr HJ, Schmand B. Association between memory complaints and incident Alzheimer's disease in elderly people with normal baseline cognition. *Am J Psychiatry* 1999;156:531–7.
- [6] Reisberg B, Shulman MB, Torossian C, Leng L, Zhu W. Outcome over seven years of healthy adults with and without subjective cognitive impairment. *Alzheimer's Dement* 2010;6:11–24.
- [7] Jessen F, Wiese B, Bachmann C, Eifflaender-Gorfer S, Haller F, Kolsch H, et al. Prediction of dementia by subjective memory impairment: effects of severity and temporal association with cognitive impairment. *Arch Gen Psychiatry* 2010;67:414–22.
- [8] Donovan NJ, Amariglio RE, Zoller AS, Rudel RK, Gomez-Isla T, Blacker D, et al. Subjective cognitive concerns and neuropsychiatric predictors of progression to the early clinical stages of Alzheimer's disease. *Am J Geriatr Psychiatry* 2014;22:1642–51.
- [9] Mitchell AJ, Beaumont H, Ferguson D, Yadegarfar M, Stubbs B. Risk of dementia and mild cognitive impairment in older people with subjective memory complaints: meta-analysis. *Acta Psychiatr Scand* 2014;130:439–51.
- [10] Scheltens P, Blennow K, Breteler MMB, de Strooper B, Frisoni GB, Salloway S, et al. Alzheimer's disease. *Lancet* 2016;388:505–17.
- [11] Prince M, Ali G, Guerchet M, Prina AM, Albanese E, Wu Y. Recent global trends in the prevalence and incidence of dementia, and survival with dementia. *Alzheimer's Res Ther* 2016;8:23.
- [12] Albert MS, DeKosky ST, Dickson D, Dubois B, Feldman HH, Fox NC, et al. The diagnosis of mild cognitive impairment due to Alzheimer's disease: recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimer's Dement* 2011;7:270–9.
- [13] McKhann GM, Knopman DS, Chertkow H, Hyman BT, Jack CR JR, Kawas CH, et al. The diagnosis of dementia due to Alzheimer's disease: recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimer's Dement* 2011;7:263–9.
- [14] Rascofsky K, Hodges JR, Knopman D, Mendez MF, Kramer JH, Neuhaus J, et al. Sensitivity of revised diagnostic criteria for the behavioural variant of frontotemporal dementia. *Brain* 2011;134:2456–77.
- [15] McKeith IG, Dickson DW, Lowe J, Emre M, O'Brien JT, Feldman HH, et al. Diagnosis and management of dementia with Lewy bodies: third report of the DLB Consortium. *Neurology* 2005;65:1863–72.
- [16] McKhann GM, Drachman D, Folstein M, Katzman R, Price D, Stadlan EM. Clinical diagnosis of Alzheimer's disease: report of the NINCDS-ADRDA Work Group under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. *Neurology* 1984;34:939–44.
- [17] O'Brien JT, Thomas A. Vascular dementia. *Lancet* 2015;386:1698–706.
- [18] Folstein M. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 1975;12:189–98.
- [19] Fratiglioni L, Launer LJ, Andersen K, Breteler MM, Copeland JR, Dartigues JF, et al. Incidence of dementia and major subtypes in Europe: A collaborative study of population-based cohorts. Neurologic Diseases in the Elderly Research Group. *Neurology* 2000;54:S10–5.
- [20] Garre-Olmo J, Genis Batlle D, del Mar Fernandez M, Marquez Daniel F, de Eugenio Huelamo R, Casadevall T, et al. Incidence and subtypes of early-onset dementia in a geographically defined general population. *Neurology* 2010;75:1249–55.
- [21] Rabin LA, Smart CM, Crane PK, Amariglio RE, Berman LM, Boada M, et al. Subjective cognitive decline in older adults: an overview of self-report measures used across 19 International Research Studies. *J Alzheimer's Dis* 2015;48:S63–86.
- [22] Rodriguez-Gomez O, Abdelnour C, Jessen F, Valero S, Boada M. Influence of sampling and recruitment methods in studies of subjective cognitive decline. *J Alzheimer's Dis* 2015;48:S99–107.
- [23] Perrotin A, La Joie R, de La Sayette V, Barr L, Ezenge FM, Mutlu J, et al. Subjective cognitive decline in cognitively normal elders from the community or from a memory clinic: differential affective and imaging correlates. *Alzheimer's Dement* 2016;13:550–60.
- [24] Abdelnour C, Rodriguez-Gomez O, Alegret M, Valero S, Moreno-Grau S, Sanabria A, et al. Impact of recruitment methods in subjective cognitive decline. *J Alzheimer's Dis* 2017;57:625–32.
- [25] Archer HA, Newson MA, Coulthard EJ. Subjective memory complaints: symptoms and outcome in different research settings. *J Alzheimer's Dis* 2015;48:S109–14.
- [26] Snitz BE, Wang T, Cloonan YK, Jacobsen E, Chang C-CH, Hughes TF, et al. Risk of progression from subjective cognitive decline to mild cognitive impairment: The role of study setting. *Alzheimer's Dement* 2018;14:734–42.

- [27] Lobo A, Launer LJ, Fratiglioni L, Andersen K, Di Carlo A, Breteler MM, et al. Prevalence of dementia and major subtypes in Europe: a collaborative study of population-based cohorts. Neurologic diseases in the Elderly Research Group. *Neurology* 2000;54:S4–9.
- [28] Stevens TIM, Livingston G, Kitchen GTE, Manela M, Walker Z, Katona C. Islington study of dementia subtypes in the community. *Br J Psychiatry* 2002;180:270–7.
- [29] Prince M, Knapp M, Guerchet M, McCrone P, Prina M, Comas-Herrera A, et al (2014) *Dementia UK: Second edition - Overview*.
- [30] Rubinsztein JS, van Rensburg MJ, Al-salihi Z, Girling D, Lafortune L, Radhakrishnan M, et al. A memory clinic v. traditional community mental health team service: comparison of costs and quality. *BJPsych Bull* 2015;39:6–11.
- [31] Bang J, Spina S, Miller BL. Frontotemporal dementia. *Lancet* 2015;386:1672–82.
- [32] Van Harten AC, Visser PJ, Pijnenburg YaL, Teunissen CE, Blankenstein Ma, Scheltens P, et al. Cerebrospinal fluid Abeta 42 is the best predictor of clinical progression in patients with subjective complaints. *Alzheimers Dement* 2013;9:481–7.
- [33] van Maurik IS, Zwan MD, Tijms BM, Bouwman FH, Teunissen CE, Scheltens P, et al. For the Alzheimer's Disease Neuroimaging Initiative. Interpreting biomarker results in individual patients with mild cognitive impairment in the alzheimer's biomarkers in daily practice (abide) project. *JAMA Neurol* 2017;74:1481–91.
- [34] Prince M, Wimo A, Guerchet M, Ali G, Wu Y, Prina M (2015) *World Alzheimer report 2015: the global impact of dementia, an analysis of prevalence, incidence, costs and trends*, London.
- [35] Koppa A, Wagner M, Lange C, Ernst A, Wiese B, König H-H, et al. Cognitive performance before and after the onset of subjective cognitive decline in old age. *Alzheimers Dement (Amst)* 2015;1:194–205.
- [36] Tan KS, Libon DJ, Rascovsky K, Grossman M, Xie SX. Differential longitudinal decline on the Mini-Mental State Examination in frontotemporal lobar degeneration and Alzheimer disease. *Alzheimer Dis Assoc Disord* 2013;27:310–5.
- [37] Corder EH, Saunders AM, Strittmatter WJ, Schmechel DE, Gaskell PC, Small GW, et al. Gene dose of apolipoprotein E type 4 allele and the risk of Alzheimer's disease in late onset families. *Science* 1993;261:921–3.
- [38] Liu C-C, Kanekiyo T, Xu H, Bu G. Apolipoprotein E and Alzheimer disease: risk, mechanisms, and therapy. *Nat Rev Neurol* 2013;9:106–18.
- [39] Molinuevo JL, Rabin LA, Amariglio R, Buckley R, Dubois B, Ellis KA, et al. Implementation of subjective cognitive decline criteria in research studies. *Alzheimers Dement* 2016;13:296–311.
- [40] Buckley RF, Saling MM, Frommann I, Wolfsgruber S, Wagner M. Subjective cognitive decline from a phenomenological perspective: a review of the qualitative literature. *J Alzheimers Dis* 2015;48:S125–40.
- [41] Risacher SL, Kim S, Nho K, Foroud T, Shen L, Petersen RC, et al. APOE effect on Alzheimer's disease biomarkers in older adults with significant memory concern. *Alzheimers Dement* 2015;11:1417–29.
- [42] Rattanabannakit C, Risacher SL, Gao S, Lane KA, Brown SA, McDonald BC, et al. The cognitive change index as a measure of self and informant perception of cognitive decline: relation to neuropsychological tests. *J Alzheimers Dis* 2016;51:1145–55.
- [43] Ellis KA, Bush AI, Darby D, De Fazio D, Foster J, Hudson P, et al. The Australian Imaging, Biomarkers and Lifestyle (AIBL) study of aging: methodology and baseline characteristics of 1112 individuals recruited for a longitudinal study of Alzheimer's disease. *Int Psychogeriatr* 2009;21:672–87.
- [44] Van Der Flier WM, Pijnenburg YA, Prins N, Lemstra AW, Bouwman FH, Teunissen CE, et al. Optimizing patient care and research: the Amsterdam dementia cohort. *J Alzheimer's Dis* 2014;41:313–27.
- [45] Van Der Flier WM, Scheltens P. Amsterdam dementia cohort: performing research to optimize care. *J Alzheimer's Dis* 2018;62:1091–111.
- [46] Slot RER, Verfaillie SCJ, Overbeek JM, Timmers T, Wesselman LMP, Teunissen CE, et al. Subjective Cognitive Impairment Cohort (SCIENCE): study design and first results. *Alzheimers Res Ther* 2018;10:76.
- [47] Kornhuber J, Schmidtke K, Frölich L, Perneczky R, Wolf S, Hampel H, et al. Early and differential diagnosis of dementia and mild cognitive impairment: design and cohort baseline characteristics of the German dementia competence network. *Dement Geriatr Cogn Disord* 2009;27:404–17.
- [48] Jak AJ, Bondi MW, Delano-Wood L, Wierenga C, Corey-bloom J, Salmon DP, et al. Quantification of Five neuropsychological approaches to defining mild cognitive impairment. *Am J Geriatr Psychiatry* 2009;17:368–75.
- [49] Visser PJ, Verhey FRJ, Boada M, Bullock R, De Deyn PP, Frisoni GB, et al. Development of screening guidelines and clinical criteria for predementia Alzheimer's disease. The DESCRIPA Study. *Neuroepidemiology* 2008;30:254–65.
- [50] Dardiotis E, Kosmidis MH, Yannakoulia M, Hadjigeorgiou GM, Scarmeas N. The Hellenic Longitudinal Investigation of Aging and Diet (HELIAD): rationale, study design, and cohort description. *Neuroepidemiology* 2014;43:9–14.
- [51] Teipel SJ, Cavado E, Lista S, Habert M-O, Potier M-C, Grothe MJ, et al. Effect of Alzheimer's disease risk and protective factors on cognitive trajectories in subjective memory complainers: An INSIGHT-preAD study. *Alzheimers Dement* 2018;14:1126–36.
- [52] Dubois B, Epelbaum S, Nyasse F, Bakardjian H, Gagliardi G, Uspenskaya O, et al. Cognitive and neuroimaging features and brain beta-amyloidosis in individuals at risk of Alzheimer's disease (INSIGHT-preAD): a longitudinal observational study. *Lancet Neurol* 2018;17:335–46.
- [53] Riedel-Heller SG, Busse A, Aurich C, Matschinger H, Angermeyer MC. Prevalence of dementia according to DSM—III—R and ICD—10. *Br J Psychiatry* 2001;179:250–4.
- [54] Sachdev PS, Brodaty H, Reppermund S, Kochan NA, Trollor JN, Draper B, et al. The Sydney Memory and Ageing Study (MAS): methodology and baseline medical and neuropsychiatric characteristics of an elderly epidemiological non-demented cohort of Australians aged 70–90 years. *Int Psychogeriatrics* 2010;22:1248–64.