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Original Article

Top five Alzheimer Disease trial eligibility criteria favor men compared to women in a clinic-based cohort

Lieza G. Exalto [a,b,*], Siti S. Syaziyah [c], Xiaotian T Fang [a], Niels D. Prins [d], Sietske A.M. Sikkes [b], Wiesje M. van der Flier [e,f,g,h], Everard G.B. Vijverberg [b,1], Yvonne M.F. Lim [c,1]

[a] Julius Clinical, Zeist, Netherlands
[b] Alzheimer Center Amsterdam, Neurology, Vrije Universiteit Amsterdam, Amsterdam UMC location VUmc, Amsterdam, Netherlands
[c] Institute for Clinical Research, National Institutes of Health, Ministry of Health Malaysia, Shah Alam, n.a., Malaysia
[d] Brain Research Center, Amsterdam, Netherlands
[e] Alzheimer Nederland, Amersfoort, the Netherlands
[f] Epidemiology and Data Science, Vrije Universiteit Amsterdam, Amsterdam UMC location VUmc, Amsterdam, the Netherlands
[g] Amsterdam Neuroscience, Neurodegeneration, Amsterdam, the Netherlands
[h] Amsterdam Public Health, Amsterdam, the Netherlands

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ABSTRACT

Background: Less women participate in Alzheimer Disease (AD) trials compared to their estimated representation in the global dementia population.
Objectives: We aimed to apply five most commonly used eligibility criteria to a real-world memory clinic population to compare male and female eligibility according to these criteria.
Design: Observational.
Setting: Memory clinic setting.
Participants: Consecutive patients (2000–2024) from Amsterdam Dementia Cohort with a diagnosis of mild cognitive impairment (MCI) or AD (n = 3835).
Measurements: Free-text eligibility criteria of n = 608 phase II and III AD drug trials were downloaded from ClinicalTrials.gov (March 28, 2025). A machine-learning model was trained and validated to extract all eligibility criteria. Next the criteria were applied on observational real world data from on memory clinic diagnostic work-up.
Results: Top 5 most common AD clinical trial eligibility criteria were 1) no other central nervous system disorder related to cognitive impairment (84%), 2) participation of a caregiver (72%), 3) MMSE (66%, range 20–30), 4) no comorbidities, specifically vascular and mental health (62%), 5) no contra-indications for study procedures such as lumbar puncture, MRI and PET (59%). Applying the abovementioned criteria results in 33% of men and 23% of women remaining eligible ($p<.001$). Main reason for non-eligibility is caretaker absence (applicable for 20% of men and 38% of women) and low MMSE (32% of man and 54% of women).
Conclusion: Based on five commonly used eligibility criteria of AD clinical trials, women in our clinic-based cohort are less eligible for participation in AD drug trials than men. This discrepancy was mainly attributed to lack of caregiver presence and lower MMSE at presentation. These results provide clues for trial design to facilitate more equal inclusion of women.

1. Background

Fewer women participate in Alzheimer Disease (AD) trials than their representation in the general dementia population. A recent systematic review by Pinho-Gomes showed that in the last 10 years in AD trials 58% was women while their estimated representation in the global dementia

* Corresponding author.
E-mail address: l.g.exalto@amsterdamumc.com (L.G. Exalto).
[1] joined last authorship

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population is 64% [1]. The relative underrepresentation of women limits our ability to explore heterogeneity in treatment effects based on sex differences. A real omission, as sex-based pharmacokinetic differences have been found in 76 out of 86 commonly used drugs [2]. These are related to more adverse drug reactions in women compared to men [2]. Furthermore, some drugs seem to be more effective in one sex compared to the other [3–5]. Highlighting the necessity of a representative study population.

In recent years, differences have been demonstrated in the phenotype of AD between men and women [6]. For example, women are on average older at the time of their initial diagnosis. Men and women with AD exhibit different cognitive and psychiatric symptoms. There is emerging data that also biomarker levels differ by sex, suggesting a difference in biology [7]. Women might less often be eligible for AD trials due to these sex differences in AD phenotype. Clinical trial eligibility criteria specify the characteristics and health factors required for a person to participate in a study. To date, it has not yet been systematically investigated how different eligibility criteria affect eligibility of men and women for AD trials. If specific eligibility criteria affect males and females differently, amending these eligibility criteria could facilitate more inclusive trials.

We aimed to investigate the influence of common eligibility criteria of AD trials on the proportion of eligible men and women. Firstly, we established the top 5 most commonly used eligibility criteria in phase II and III AD interventional trials. Secondly, we applied these eligibility criteria separately to men and women presenting at a memory clinic and compared the proportion eligible.

2. Method

2.1. Identification of AD trials

Clinical study data (n = 1810) were downloaded from the Aggregated Analysis of ClinicalTrials.gov (March 28, 2025). From the condition or disease field, we queried 'Alzheimer's disease' or 'mild cognitive impairment' (n = 1371) and kept studies with intervention categories for 'drug', 'dietary supplement', or 'biological' (n = 1021). All phase II and III trials were included (n = 617). We excluded studies on mild cognitive impairment related to other forms of dementia and those specifically investigating diagnostics or biomarkers for AD. If a study was labelled as a combination of two trial phases, the latter phase is used for categorizing the study. Finally, one study was excluded due to missing trial phase and 8 for missing eligibility criteria, resulting in 608 studies remaining for analysis. Of which 398 (65%) phase II and 210 (35%) phase III studies. Flowchart of eligibility is presented in Fig. 1.

2.2. Extraction of eligibility criteria

The trial dataset contained structured information on study start year, anticipated sample size and intervention type. However, eligibility criteria for each trial were documented in continuous free text format. To extract specific eligibility criteria, we trained and validated a machine learning model for named entity recognition, details are described below.

Stratified by phases II and III, the eligibility criteria text for a random subset of 113 trials (19%) were manually annotated using LANN, a web-based annotation tool (https://ieeexplore.ieee.org/document/9874575). Three independent researchers (LGE, XTF and YMFL) annotated the inclusion and exclusion criteria through a series of standardizations, cross-checks and discussions. Relationships between interdependent entities such as a laboratory measurement and its value were also specified. We developed a first version of an annotation guide and subsequently compared annotations between annotators and revised the guidelines iteratively. A set of gold standard criteria were determined based on the final agreement between annotators. Overall inter-annotator agreement was >0.70 for Cohen's Kappa and the F1 measure ranged between 0.61 and 0.71. Comparable criteria were grouped, for instance informant and caregiver. Comorbidities were grouped by body systems. Only depression was kept separate because of its high frequency. A named entity recognition (NER) model was trained and validated in Python 3.9.20 using PyCharm Community Edition 2024 IDE. The validated model was then used to extract all eligibility criteria from the remaining 495 unannotated trials. Manual checks were performed. The eligibility criteria were grouped into 6 main categories; demographics, diagnostic cognitive assessment, concurrent treatment, medical history, AD specific treatment and safety/clinical stability. A

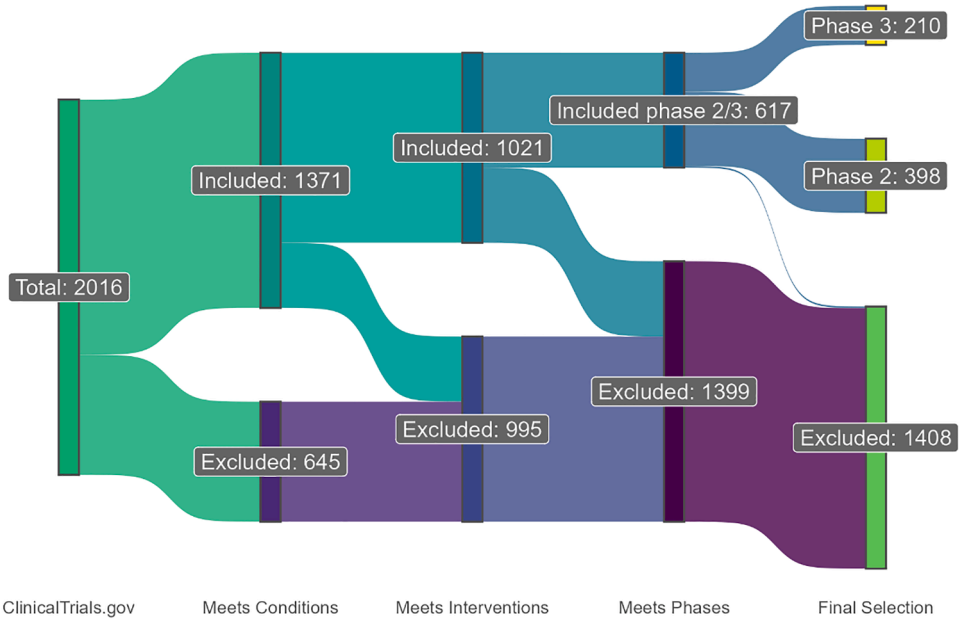

Fig. 1. flowchart of deriving unique interventional studies
Meets conditions: 'Alzheimer's disease' or 'mild cognitive impairment due to AD'Meets Interventions: 'drug', 'dietary supplement', or 'biological'.
Meets Phases: phase II and/or III trials were included (n = 617).

sensitivity analyses was performed to align with contemporary trial design. The data was restricted to industry phase III studies in the last 5 years and eligibility criteria were manually checked (n = 26). Further details can be found in Supporting Information, Methods S1. The structured dataset on trial inclusion and exclusion criteria is available upon request by contacting the study authors.

2.3. Memory clinic participants

We included all consecutive patients with a diagnosis of MCI or AD (n = 3835) who were seen for a first diagnostic visit between June 1999 and December 2024 from the Amsterdam Dementia Cohort. Patients underwent a standardized diagnostic work-up consisting of a visit to a neurologist including physical and neurological examination during which medical history and current medications were systematically recorded, standardized neuropsychological testing, brain Magnetic Resonance Imaging (MRI), laboratory investigations, and CSF biomarker testing as described elsewhere [8,9] The clinical diagnoses were made in a multidisciplinary consensus meeting based on applicable criteria for MCI [10] and dementia due to AD [11]. All participants provided informed consent for research use of their medical data. The non-consent rate <5%.

Variables that were used for this study included age, sex, living situation, marital status, clinical diagnosis, Mini Mental State Examination (MMSE) [12], Geriatric Depression Scale (GDS) [13], infarct on brain MRI, medical history and medication were assessed to create a variable on potential contra-indications for study procedures such as PET and/or lumbar punction. Other non-AD central nervous system (CNS) disorder related to cognitive impairment, was defined as potential temporal relation with cognitive symptoms and other CNS diagnosis mentioned at clinical diagnosis, such as seizures and substance abuse. Amyloid positivity was defined on local positive CSF ptau/AB-42 ratio or positive PET. Presence of study partner was defined as living situation independent with partner/family. A sensitivity analysis on this proxy was performed by using clinic visit accompanied by spouse or child. Depression was defined by a GDS score of ≥9. Variables were dichotomized into the presence or absence of a characteristic.

2.4. Data analysis

The top 5 eligibility criteria that were identified through text mining of clinicaltrials.gov were applied stratified by sex on the Amsterdam Dementia Cohort. For variables with varying ranges (for example MMSE), the most commonly used range was used for analysis. The proportion of eligible men and women was compared by the Chi-Square test. The analysis was repeated in a cohort with amyloid positive patients, a sensitivity analysis to reflect contemporary diagnostic insights in biomarker-confirmed AD.

3. Result

Fig. 2 displays the eligibility criteria that were present in phase II and III trials at a frequency of >10%. The five most common AD clinical trial eligibility criteria were 1) no other central nervous system (CNS) disorder related to cognitive impairment (84%), 2) participation of a caregiver (72%), 3) MMSE (66%; most common range 20–30, see *supplementary figure 1*), 4) no pre-specified comorbidities, in particular vascular and mental health conditions (62%), 5) no contra-indications for study procedures such as lumbar puncture, MRI and PET (59%). When restricting to phase III trials in the last 5 years, the same 5 criteria were the most common, with participation of caregiver in 77% and the other 4 share the first place with 96% each (see supplemental Figure S1). A steep increase of frequency in eligibility criteria was observed for CDR (65%), amyloid positivity (69%), no comorbidities (range 23–96%), memantine (65%) and contraindications for study procedures (96%).

From the total 3835 patients 48% was women. The average age was 66.3 years (SD 8) and the far majority had an independent living situation (91%). Median MMSE was 23 [inter quartile range 19–26]. For the informant history, the patients were most often accompanied by their spouse (men 78% and women 57%) or a child (men 8% and women 24%).

The eligibility funnel for men and women is presented in Fig. 3. After screening for no other CNS disorder 84% of men and 90% of women remained eligible. Additional screening on participation of caregiver reduces eligibility to 67% of men and 56% of women reflecting 17% versus 34%-point reduction in women. MMSE (20–30) further reduces eligibility to 52% of men and 36% of women reflecting 15% versus 20%-point reduction in women. Further increasing the gap. No vascular or mental health comorbidities reduces eligibility to 33% of men and 23% of women. Lastly, applying no contra-indications for study procedures excluded only a few patients, resulting in an overall eligibility of 33% of men and 23% of women (p<.001). Main reason for non-eligibility is caretaker absence (applicable for 20% of men and 38% of women) and low MMSE (32% of man and 54% of women). When we restrict

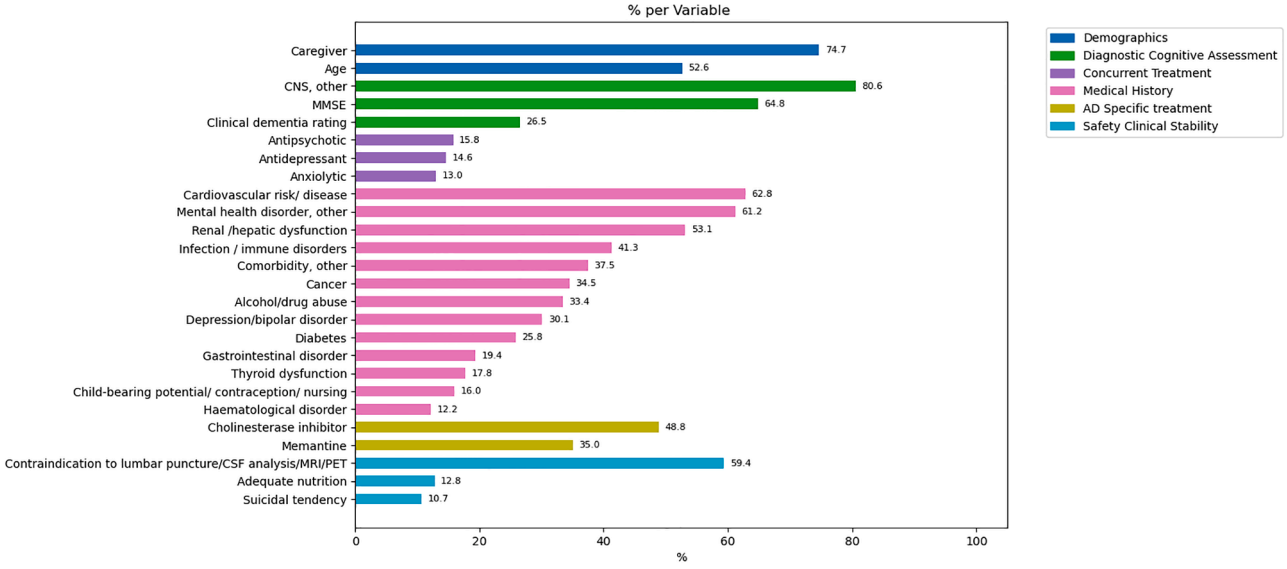

Fig. 2. Frequency of the eligibility criteria
Frequency of the eligibility criteria grouped by themes, only criteria that were mentioned >10% are depicted.

Men N=2011			Criterion	Women N=1824		
Unknown	Eligible	Eligibility funnel		Eligibility funnel	Eligible	Unknown
n.a.	1685 (84%)		No other CNS[a] diagnosis		1646 (90%)	n.a.
		84%		90%		
104 (6%)	1354 (80%)		Study partner[b]		1025 (62%)	115 (7%)
		67%		56%		
14 (1%)	1036 (77%)		MMSE 20-30[c]		659 (64%)	18 (2%)
		52%		36%		
308 (30%)	673 (65%)		Comorbidities[d]		426 (65%)	202 (31%)
		33%		23%		
n.a.	632 (94%)		Contra-indications[e]		420 (99%)	n.a.
		33%		**23%**		

Percentage of eligible participants are presented by the addition of each criterion for men and women separately. Missing data rates in cohort are presented in the Unknown column. The column percentage of remaining eligible patients is shown for men in blue and women in purple.

a) CNS diagnosis with potential temporal relation with cognitive symptoms, such as seizures and substance abuse.

b) Person with regular contact that joins study visits as informant, in the data set defined as living situation independent with partner/family

c) Defined as infarct on brain MRI and/or GDS ≥9.

d) Medical history and medication were assessed for potential contra-indications for study procedures such as PET and/or lumbar punction (MRI needed to be available for comorbidities).

n.a. = not applicable.

Fig. 3. Funnel of eligible percentage for men and women.
Percentage of eligible participants are presented by the addition of each criterion for men and women separately. Missing data rates in cohort are presented in the Unknown column. The column percentage of remaining eligible patients is shown for men in blue and women in purple.
a) CNS diagnosis with potential temporal relation with cognitive symptoms, such as seizures and substance abuse.
b) Person with regular contact that joins study visits as informant, in the data set defined as living situation independent with partner/family
c) Defined as infarct on brain MRI and/or GDS ≥9.
d) Medical history and medication were assessed for potential contra-indications for study procedures such as PET and/or lumbar punction (MRI needed to be available for comorbidities).
n.a. = not applicable.

informant to spouse, 31% of men and 22% of women remained eligible (p<.001), while if we add children as informant this would increase to 34% of men and 31% of women (p.064). A sensitivity analyses restricting the cohort to known amyloid positive patients, showed a comparable difference in eligibility between men (37%) and women (26%, p<.001; supplemental figure S3).

Table 1.

4. Discussion

When applying five commonly used eligibility criteria of AD clinical trials in a clinic-based cohort, only one in five women remained eligible for trial inclusion compared to one in three men. This discrepancy was mainly related to lack of caregiver presence and too advanced cognitive decline at presentation. These results provide clues for trial design to facilitate more equal inclusion of women.

The requirement for caregiver participation in AD trials mainly relates to informant-based outcome measures and consequently cannot simply be removed from the eligibility criteria. An informant needs to have regular and frequent contact with the participant to be able to provide the requested information. The clinical dementia rating scale (CDR) is an example of a commonly used assessment that needs informant input. Preferably, the same well-informed informant provides input during trial duration, as CDR scores are modified according to informant characteristics [14,15]. Women with AD are more often living alone/widowed [6,16], hence they are less likely to have a spouse that can accompany them to the trial site. This is also seen in our memory clinic data, where 79% of men and 57% of women visited the clinic with their spouse. While children accompany their parent in 8% in men and 24% in women. When we restrict informant to spouse and apply the five

Table 1
Demographic and clinical characteristics of participants.

	All n = 3835	Men n = 2011	Women n = 1824
Demographics			
Age, yr	66.3 (SD 8.0)	66.6 (SD 7.9)	66.1 (SD 8.1)
Sex, female	1824 (48%)		
Independent living	3480 (91%)	1844 (92%)	1636 (90%)
Alone	747 (20%)	243 (12%)	504 (27%)
With partner/family	2733 (71%)	1601 (80%)	1132 (63%)
Clinical diagnosis			
MCI	1184 (31%)	753 (37%)	431 (24%)
MMSE	23 [19–26]	24 [21–27]	22 [18–26]
MMSE 20–30	2398 (63%)	1398 (70%)	99 (56%)
Amyloid pos		1255	1315
Amyloid neg		279	105
Comorbidity			
Depression	192 (5%)	88 (4%)	104 (6%)
Stroke	106 (3%)	69 (3%)	37 (2%)
Contra-indication LP	212 (6%)	161 (8%)	51 (3%)
Social support			
Widow(er), n (%)	330 (9%)	61 (3%)	269 (15%)
Informant history by			
Spouse	2602 (68%)	1572 (78%)	1030 (57%)
Child	602 (16%)	167 (8%)	435 (24%)
Sibling	131 (3%)	49 (2%)	82 (5%)
Other	183 (5%)	64 (3%)	119 (6%)
None/missing	317 (8%)	159 (8%)	158 (9%)

Values are presented as mean (SD) or n(%), except for MMSE median and interquartile range.
MMSE = Mini Mental State Examination.
Depression is defined as GDS≥9 (missing n = 450, 12%), Stroke is defined as MRI evidence of brain infarct (missing 954, 25%).

criteria, 31% of men and 22% of women remained eligible, while if we add children this would increase to 34% of men and 31% of women. In addition to information, the study partner responsibilities include communicating with the study team, accompanying the participant to visits, and monitoring adherence [17]. Children of a patient without a partner, are more likely to need to perform supportive activities in addition to regular working hours. Regular trial site visits therefore might be too demanding. Facilitating participation of this group will likely increase participation of women with AD. This could be accomplished by being considerate of the caregiver burden in the trial design and execution. Examples could be remote/online assessments at a time that fits the informant, on-site support of participants that visit the site without a caregiver, accompanied transport to and from the site and home-visits.

The MMSE eligibility criterion is used to define the severity of the cognitive symptoms. In AD-drug development, the trend is to recruit participants in early stages of the disease. In general, the hypothesis is that for most disease modifying therapies, the benefit is early in the disease process. Women, however tend to be more severely affected at time of an AD diagnosis [6], which makes them less eligible for trial participation. Lowering the MMSE threshold will increase the proportion of eligible women. However data from previous trials of both successful and unsuccessful anti-Amyloid therapies suggested that there was little clinical effect of amyloid removal if patients progressed past the mild dementia phase [18]. The challenge at hand therefore seems to be how to get more women diagnosed at an earlier disease stage. General practitioners can help with timely referrals to memory clinics. Partners often initiate visiting a physician, but elderly women more often life alone, which could cause delay in help seeking. An Australian study has shown that men are more likely to delay help seeking on behalf of someone else that has early signs of dementia, while women are more likely to seek help for others [19]. It is imaginable that women present later at a memory clinic because of a delay by their male spouse. In addition, women seem to have a cognitive advantage in very early stages, especially in verbal memory, however they then progress more rapid compared to men [20]. This could complicate early recognition by the patient, family and/or professional caregivers. Overall, awareness in both the general public as well as medical experts of sex and gender differences in AD presentation could support earlier recognition of AD.

Underrepresentation of women in trials due to eligibility criteria, could result in less women being eligible for treatment once approved. Appropriate use criteria for newly approved drugs often reflect the trial eligibility criteria [21,22]. Furthermore, growing evidence has surfaced to challenge the assumption that the results from RCTs are generalizable to all patient populations. The underrepresented groups, like women, can have distinct disease presentations or health circumstances that affect how they will respond to an investigational drug or therapy. Hence, representative populations in clinical trials has become an important policy priority and several strategies have been employed. Leveraging technology for remote access and decentralized studies, partnering with community groups and patient advocacy organizations, addressing financial and logistical barriers for participants, and recruitment strategies accounting for gender-related factors [23].Our study shows that mindful design of the eligibility criteria, avoiding unnecessarily restrictive criteria, is another strategy to recruit a more representative population. Additionally, our findings here support the call for sex-stratified reporting of AD clinical trial results, which ensures conscious efforts to power future trials for adequate representation of both female and male participants [24].

Our study should be considered in the context of some limitations. This study does not evaluate actual trial screening outcomes but rather compares the proportion of men and women who would remain eligible after applying selected criteria in an observational memory clinic cohort. Not all trial eligibility criteria are collected with an identical definition during a memory clinic visit, so we needed to use a proxy. For instance, the informant during the memory clinic visit is not asked whether he/she is willing/able to be a study partner in a clinical trial. Furthermore, we don't know how much time the informant spends on average with the patient. We operationalized the criterion "study partner" as "living situation independent with partner/family", as this group most likely will be in the position to provide a well-informed informant. The criterion "comorbidities" in clinical trials is often specified as "clinically relevant in the opinion of the investigator", we therefore did not want to use medical history alone. We have operationalized it more objectively with a GDS score for mental health and MRI imaging for cerebrovascular disease. This strategy might underestimate the number of excluded subjects as some clinically relevant comorbidities might not be captured. Although clinical trial design and AD diagnostics have evolved over time, sensitivity analyses restricting to contemporary insights showed comparable results. The memory clinic data represents a tertiary center setting with relatively more young patients compared to general memory clinics. At a young age the incidence rates do not differ much by sex, the difference is mainly seen at older age [25]. This likely explains the higher number of men (n = 2011) compared to women (n = 1824) and potentially hampers generalizability of the percentages to the general AD population. The two main reasons for non-eligibility, namely that women present with more severe cognitive problems and without a partner can likely be extrapolated to older populations and other memory clinics/countries. The gender difference in life expectancy and the tendency of women to marry older men creates a worldwide situation where significantly more elderly men are married, while more elderly women are widowed and living alone [26]. Several studies have shown that women at time of diagnosis are more severely affected [27, 28]. In addition, in an US-based cohort a delay in diagnosis has been reported more likely with adult child carer compared to a spouse carer [29]. Our finding that less women are eligible is in our opinion likely to be relevant to other countries and memory clinics. As this does not concern specific biological disease aspects but rather relates to sociocultural aspects that are even more pronounced at older age.

Our results highlight that trial eligibility criteria should not be overlooked in the quest for representative trial populations in AD drug development. As they differently impact chances of men and women participating in a trial. Even if a criterion is essential and cannot be removed, the trial design and execution could be altered to facilitate participation.

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AI statement

We have not used any AI in the writing process.

Data statement

Data may be shared (anonymized) for purposes of replicating procedures and results within the boundaries imposed by the informed consent and data sharing legislation.

CRediT authorship contribution statement

Lieza G. Exalto: Writing – review & editing, Writing – original draft, Visualization, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Siti S. Syaziyah:** Writing – review & editing, Formal analysis, Data curation. **Xiaotian T Fang:** Writing – review & editing, Visualization, Data curation. **Niels D. Prins:** Writing – review & editing, Funding acquisition, Conceptualization. **Sietske A.M. Sikkes:** Writing – review & editing, Data curation. **Wiesje M. van der Flier:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Data curation. **Everard G.B. Vijverberg:** Writing – review & editing, Data

curation. **Yvonne M.F. Lim:** Writing – review & editing, Supervision, Formal analysis, Data curation.

Declaration of Competing Interest

LGE is part-time employed by Julius Clinical as scientific officer, a CRO that is involved in AD trials. As employee of Brain Research Center she was PI of studies by Treeway, EIP Pharma and GemVax, via her university affiliation she is PI of studies of Novarits. LGE reports financial support was provided by Amsterdam University Medical Centres. LGE reports a relationship with Julius Clinical BV that includes: employment. LGE is part of the editorial board of JPAD, but had no involvement in the peer review of this article and had no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to another journal editor. XTF is a fulltime employee of Julius Clinical. NP performed consultancy work for Aribio, Amylyx, Eli-Lilly and Janssen and received a speaker fee from Biogen. He is co-PI of of a current trial with Fuji Film Toyama Chemical. He is CEO and co-owner of Brain Research Center, the Netherlands. SAMS is part of the Scientific Advisory Board of REMIND, and was part of the scientific advisory board of Prothena and Cogstate. She and provided consultancy services for Nationale Nederlanden Ventures. She is the developer of the Amsterdam IADL Questionnaire and received license fees from Brain Research Center. She received funding from Health~Holland (LSHM19051; LSHM20084; LSHM22026-SGF), ZonMW (#10510032120003, (#7,330502051 and #73305095008), Alzheimer Nederland (WE. 32–2022–01), Ministry of Health, Welfare and Sports (#90001586), JPND (Remote-AD), AD-RIDDLE and YOD-Molecular. YMFL declares other research funding from Novartis, outside the submitted work. WF: As of 1–11–2025 she is executive director at Alzheimer Nederland, Amersfoort the Netherlands. Before 1–11–2025, research programs of Wiesje van der Flier have been funded by ZonMW, NWO, EU-JPND, EU-IHI, Alzheimer Nederland, Hersenstichting CardioVascular Onderzoek Nederland, Health~Holland, Topsector Life Sciences & Health, stichting Dioraphte, Noaber foundation, Pieter Houbolt Fonds, Gieskes-Strijbis fonds, stichting Equilibrio, Edwin Bouw fonds, Pasman stichting, Philips, Biogen MA Inc, Novartis-NL, Life-MI, AVID, Roche BV, Eli-Lilly-NL, Fujifilm, Eisai, Combinostics. WF is recipient of ABOARD, which is a public-private partnership receiving funding from ZonMW (#73305095007) and Health~Holland, Topsector Life Sciences & Health (PPP-allowance; #LSHM20106). Before 1–11–2025, WF has been an invited speaker at Biogen MA Inc, Danone, Eisai, WebMD Neurology (Medscape), NovoNordisk, Springer Healthcare, European Brain Council. WF has been consultant to Oxford Health Policy Forum CIC, Roche, Biogen MA Inc, Eisai, Eli-Lilly, Owkin France, Nationale Nederlanden Ventures. WF has participated in advisory boards of Biogen MA Inc, Roche, and Eli Lilly. All funding is paid to her institution. In 2024-2025, WF has been member of the steering committee of phase 3 EVOKE/EVOKE+ studies (NovoNordisk). In 2025, WF has been member of the steering committee op phase 3 Trontinemab study (Roche). All funding has been paid to Amsterdam UMC. WF was associate editor of Alzheimer, Research & Therapy in 2020/2021. WF was associate editor at Brain 2021-2025. WF is chair of the Scientific Leadership Group of InRAD. WF is member of Supervisory Board (Raad van Toezicht) Trimbos Instituut. All other authors declare no conflicts of interests.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.tjpad.2026.100580.

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