Prevalence of attention-deficit/hyperactivity disorder in older adults: a systematic review and meta-analysis

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**Abstract**

There is a significant knowledge gap in research on Attention-Deficit/Hyperactivity Disorder (ADHD) in older adults. Via a systematic review and meta-analysis, we aimed to investigate the prevalence of ADHD in older adults, considering different assessment methods. We searched five electronic databases up to June 26, 2020. We identified 20 relevant studies with 32 datasets providing a total sample size of 20,999,871 individuals (41,420 individuals with ADHD). The pooled prevalence estimates differed significantly across assessment methods: 2.18% (95% CI = 1.51, 3.16) based on research diagnosis via validated scales, 0.23% (0.12, 0.43) relying on clinical ADHD diagnosis, and 0.09% (0.06, 0.15) based on ADHD treatment rates. Heterogeneity was significant across studies for all assessment methods. There is a considerable number of older adults with elevated levels of ADHD symptoms as determined via validated scales, and the prevalence of treated ADHD is less than half of the prevalence of clinically diagnosed ADHD. This highlights the need for increased awareness of ADHD clinical diagnosis and treatment in older adults.

**Keywords:** *attention-deficit/hyperactivity disorder; prevalence; older adults; systematic review; meta-analysis*

1. **Introduction**

Attention-Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder associated with multiple psychiatric and physical disorders that can persist into adulthood.1-3 Based on pooled estimates from meta-analyses, ADHD affects 5.3% (95% CI = 5.0, 5.6)4 to 7.2% (95% CI = 6.7, 7.8)5 of children and adolescents, and 2.5% (95% CI = 2.1, 3.1) of adults across the world.6 Findings on the prevalence of ADHD in older adults have not been properly synthesized, although available data suggest a growing number of people aged 50 years and older in need for health-care related to ADHD.1-3 A rigorous understanding of prevalence estimates of ADHD in older adults can provide relevant information to clinicians in order to adjust clinical assessment procedures and treatment to this population.

To our knowledge, only one systematic review focusing on the ADHD prevalence in adults older than 50 has been conducted thus far.3 In that systematic review, published in 2016, Torgersen and colleagues3 identified only four studies assessing the prevalence of ADHD in older adults. Across the included studies, the prevalence estimates ranged from 1.0% to 6.2%. This seminal study can be extended in three important ways. First, by conducting a meta-analytic synthesis, which was beyond the scope of the study. Second, as the authors of that review did not restrict the age-range to older adults alone, it is of interest to estimate the pooled prevalence in this specific age group only. Third, the review by Torgersen et al3 only included studies based on research diagnosis in community samples assessing ADHD symptoms/syndrome using validated scales. Hence, there is a need to synthesize data from prevalence studies using clinical diagnoses and prescribed treatment to identify ADHD cases. Of note, previous systematic reviews and meta-analyses of ADHD prevalence in children, adolescents and young adults4-8 have shown that prevalence estimates are highly heterogeneous mostly due to methodological differences of included studies. None of these systematic reviews explored potential differences in the prevalence estimates between studies based on treatment seeking individuals and studies based on research diagnosis using validated scales in community samples.

We aimed to fill these gaps by conducting a meta-analysis of prevalence estimates from pertinent studies in what we define “older adults” (i.e., 50 years old and above) based on a systematic search in a broad range of databases. Additionally, the current study aimed to complement, with data in older adults, the evidence from previous systematic reviews3 and meta-analyses in children, adolescents or younger adults4-8 with ADHD, by exploring potential differences between ADHD prevalence estimates based on different assessment methods. Separate prevalence estimates of ADHD research diagnosis, clinical diagnosis and treatment may provide valuable information on potential over- or under-diagnosing and/or over- or under-treatment of ADHD in older adults.

1. **Methods**

We followed the guidance of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement.9 The protocol for this systematic review was registered in PROSPERO (CRD42019135062).

* 1. *Search Strategy*

The search strategy was developed with the support of librarians at the Medical Library, Örebro University, Sweden. The systematic literature search was conducted in the following electronic databases: Pubmed/MEDLINE, PsycINFO, Web of Science and EMBASE, using search terms (with adequate adjustments for each database) in relation to “Attention-Deficit/Hyperactivity Disorder”, and “Aging”, from inception until June 6, 2019. An updated search was conducted between June 22 and 26, 2020. Detailed search syntax and strategies are available in Appendix 1.There were no restrictions with regard to language/year of publication/type of document; full-text published articles or conference proceedings. We also hand-searched reference lists of relevant full-text articles and textbooks (Appendix 2), and contacted experts in the field (Appendix 8) to identify potentially additional relevant articles.

* 1. *Selection criteria*

We included observational cohort and cross-sectional studies, focusing on participants aged 50 and older with ADHD with any of the following:a) research diagnosis of ADHD, i.e., meeting the threshold/cut-off levels on an ADHD validated scales based on the DSM (III, IV, IV-TR or 5) criteria; b) clinical diagnosis according to ICD (9 or 10) or DSM (III, IV, IV-TR or 5) as reported in registers/medical files or self-reported medical history; c) presence of pharmacological (medications recommended in pharmacological treatment of ADHD)10, and/or non-pharmacological treatment (e.g. psychoeducation or psychotherapy) for ADHD, as reported in registers/medical files or self-reported prescription.

The age cut-off ≥50 was chosen as previous studies have shown that there is a growing number of people aged 50 or older who are being diagnosed with ADHD for the first time.1,3 If a study did not report on the separate prevalence in this age group, we contacted the authors in order to gather relevant data.

We excluded studies conducted in samples non-representative of the general population and studies that assessed childhood symptoms only, without addressing the presence of adult ADHD symptoms.

* 1. *Data extraction (selection and coding)*

References to studies identified in both electronic and manual search were managed in EndNote X9. After deletion of duplicates, titles/abstracts were screened by one author (MD), and full-texts articles were independently screened by two authors (MD and CS). A senior author (HL) was consulted in order to reach a consensus, when needed.

Two authors (MD and CS) independently extracted data. In case of disagreement, a third author checked the data (HL). The following data were extracted: first author and year of publication; year of data collection; country; age range; number of individuals with ADHD; sample size; and assessment method (research diagnosis/clinical diagnosis/treatment). We contacted authors to gather relevant unreported data (Appendix 5). Prevalence estimates from the same study based on different countries were considered as separate data sets. In case of overlapping study samples, the study that was published earlier and/or the study that was the most pertinent to our criteria, was included. If the prevalence estimate was not reported or could not be calculated based on data from the paper or could not be gathered from the authors, a study was excluded from the meta-analysis. We also contacted authors of studies with reported adjusted/weighted prevalence estimates in order to get crude prevalence estimates.

* 1. *Study quality appraisal*

Two reviewers (MD and CS) independently assessed the risk of bias/study quality of each included study with the adjusted Joanna Briggs Institute Critical Appraisal Checklist for Studies Reporting Prevalence Data13. In case of disagreement, a third reviewer (HL) arbitrated. We assigned a numerical score (0−9) to each study based on a number of fulfilled criteria, and considered a score over five as satisfactory. Studies with a potential high risk of bias and/or low quality were not excluded from the meta-analysis, but potential limitations in this regard were further addressed in the discussion section of the report.

Publication bias was not addressed since the results of studies reporting prevalence estimates should not affect the decision whether a study would be published.

*2.5. Statistical analysis*

The meta-analysis of included studies was conducted using the software Comprehensive Meta Analysis V3 (https://www.meta-analysis.com). We applied the random-effects model for meta-analyses, in order to allow the true population prevalence to vary between studies due to expected heterogeneity across studies. The pooled prevalence estimates were obtained using the inverse variance method (i.e., the variance in the random model includes both within- and between-study variance).11 We used the Cochran Q test, I² index and confidence intervals to assess heterogeneity of results.12 Values of the I² index higher than 75% were considered high.12

 We conducted subgroup analysis to test for statistically significant differences between the three assessment methods, with the mixed model method, which applies the random-effects model to combine studies within subgroups, and the fixed-effects model to combine subgroups.

We performed four sensitivity analyses to investigate the robustness of our findings:

1) Excluding studies that reported on the prevalence of ADHD research diagnosis based on assessing only the current ADHD symptoms. The underlying rationale was that such studies might be biased by misclassification of ADHD with other mental health problems;14-15

2) Excluding studies with self-reported medical history of ADHD diagnosis or pharmacological ADHD treatment, to retain only studies with the most rigorous diagnostic process;

3) Limited to studies conducted in regions other than North America within all three assessment methods, as previous studies indicate that the administrative prevalence estimates of ADHD might be higher in North America compared to other regions, probably due to different clinical practices;16-17

4) Limited to studies that included younger participants (i.e. 45­−49 years old) within all three assessment methods.

1. **Results**
	1. *Description of included articles*

A total of 9,784 references were screened, 132 full-text papers assessed for eligibility, and 20 studies with 32 data sets were included in the meta-analysis (figure 1). Table 1 presents the descriptive data for all studies included in the meta-analysis. The studies were published between 2005 and 2019, and the data were collected in the period between 1997 and 2015. Total sample size across studies included 20,999,871 participants, with 41,420 individuals presenting with ADHD research diagnosis, clinical diagnosis or treatment. A list of references not included in the meta-analysis after the full-text review, with reasons for exclusion, is presented in the Appendix 3. We did not identify any relevant unpublished studies or studies published in languages other than English. We excluded studies that did not provide crude prevalence estimates in the published report or upon e-mail request to the corresponding author.

-----------------------------------------Insert Figure 1------------------------------------------------------

-----------------------------------------Insert Table1------------------------------------------------------

We identified nine studies based on a research diagnosis of ADHD (45% of the included studies), reporting individual 14 data sets with 32,766 participants and 701 individuals presenting with a research diagnosis of ADHD. Five studies assessed both the presence of current ADHD symptoms and the persistence of childhood symptoms. Four studies assessed only the presence of current symptoms, without confirming the childhood symptoms. Five studies used the Adult ADHD self-report scale screener version 1.1 (ASRS)38 for assessment of current ADHD symptoms, but the applied cut-off score was not consistent across studies. Three studies applied a cut-off of 14 using a continuous scale with a possible range of 0−24.19,22,25 Two studies applied a cut-off of minimum four out of six symptoms present (a more strict cut-off).24,26 Park and colleagues, 24 in addition to the ASRS, confirmed the presence of at least one childhood symptom.

Additionally, seven studies (35% of the included studies), with nine data sets, based on clinical diagnosis of ADHD, were included in the analysis with 11,706,296 participants and 21,121 individuals with clinical diagnosis of ADHD. These studies were based on registry data (e.g. health insurance databases and population-based patient registries), and in two cases,27,29 on self-reported medical history of ADHD.

Finally, we identified four studies (20% of the included studies), which reported the prevalence of ADHD treatment drawn from different population-based registries with 9 260,809 participants and 19,598 individuals who received ADHD treatment. These studies contributed with nine data sets. One study in this group included different types of treatment35, including psychological and pharmacological treatment, while other studies investigated the prevalence of pharmacological ADHD treatment only.

Although diverse geographical regions were represented in the analysis, the majority of studies, 10 out of 20 (50%), were conducted in Europe, seven (35%) from North America, two (10%) from Asia, and one (5%) from other regions (Australia) (table 1).

Some of the studies provided data sets with a slightly lower age cut-off. For research diagnosis, three data-sets imposed a lower age cut-off at 4819,26 and two data-sets at 45 years;18,20 for clinical diagnosis, two data-sets imposed an age cut-off at 45 years;30,33 and for ADHD treatment, seven data-sets imposed the lower age cut-off at 45.34,36-37

All selected studies showed satisfactory levels of study quality with summary scores over five (table 1). The item-by-item assessment is provided in the Appendix 7.

* 1. *Main meta-analyses and sub-group analyses*

 We conducted three main meta-analyses that provided pooled prevalence estimates for each assessment method (table 2). Using the random-effects model, the estimated pooled prevalence was 2.18% (95% CI = 1.51, 3.16), for ADHD research diagnosis based on validated scales. The corresponding estimated pooled prevalence was 0.23% for clinical diagnosis (0.12, 0.43), and 0.09 for ADHD treatment (0.06, 0.15). Across all levels of the analysis, heterogeneity (Cochran Q test) was significant with the I² values higher than 75%15 (table 2).

-----------------------------------------Insert Table 2------------------------------------------------------

Subgroup analysis showed a significant difference in pooled prevalence estimates between the studies based on research diagnosis, clinical diagnosis and treatment, with Q (2) = 108.74, P < 0.0001. Direct comparisons of the prevalence between the different ADHD outcome measures revealed statistically significant differences between the prevalence provided in studies using research diagnosis of ADHD versus studies using either clinical diagnosis or treatment, with Q (1) = 35.52, P < 0.0001, and Q (1) = 99.40, P < 0.0001, respectively. The subgroup analysis also revealed a statistically significant difference in the prevalence estimated in studies using clinically diagnosed ADHD versus treated ADHD, with Q (1) = 4.80, P < 0.0001.

As shown in table 2, the pooled prevalence estimates varied across the sensitivity analyses for all assessment methods, but with overlapping confidence interval before and after exclusions. The I² values decreased slightly after conducting sensitivity analyses, although heterogeneity remained significant.

1. **Discussion**

To our knowledge, the present study is the first to assess the prevalence of ADHD in older adults via a comprehensive systematic review and meta-analysis. Additionally, this is the first systematic review and meta-analysis of the prevalence of ADHD that took into consideration potential differences between studies investigating ADHD prevalence according to the method to establish the diagnosis. Our systematic search of the literature identified 20 studies, reporting 32 data-sets for the meta-analysis. Our findings indicate a notable prevalence gap with significantly higher estimates for ADHD research diagnosis compared to the prevalence of individuals with clinical diagnosis or based on the rates of treatment prescriptions.

Our pooled prevalence estimates of ADHD research diagnosis from the main analysis and sensitivity analyses ranged from 1.49% to 2.18%. These estimates are lower than previously identified pooled prevalence estimates based on validated scales: 2.5% (95% CI = 2.1, 3.1) in adults with the mean age of 34,6 and 5.0% (95% CI = 4.1, 6.2) in young adults.8 This is consistent with the well-established effect of age on the prevalence of ADHD.39-40

Our findings suggest that a considerable number of older adults reported elevated levels of ADHD symptoms. However, methodological aspects need to be considered when interpreting the gap between the pooled prevalence estimates based on different assessment methods. The estimates from studies based on research diagnosis may overestimate the prevalence of ADHD in older adults. Previous research in children and adolescents has identified higher prevalence estimates based on research diagnosis via DSM-validated scales, compared to the prevalence based on the ICD-9 or ICD-10 diagnostic criteria,4,7 commonly used in register-based studies. Additionally, five out of nine studies based on research diagnosis included in the present review were based on ADHD screeners, which cover ADHD symptoms present in the last six months and may misdiagnose the condition with other mental health problems or neurological conditions with a similar clinical presentation.14 Indeed, after excluding these studies, the magnitude of the prevalence estimates from studies assessing both childhood and current symptoms decreased, although with overlapping confidence intervals. As problems with attention, anterograde memory and executive functions are common in ADHD and age related cognitive impairment, such as Mild cognitive impairment (MCI) or prodromal dementia1,41 a careful differential diagnosis of ADHD should consider the childhood onset of current symptoms and their life long persistence.1,41 Included studies with prevalence estimates based on clinical diagnosis, treatment and research diagnosis with a confirmed childhood history of ADHD likely ruled out dementia or other mental health disorder as potential causes of current cognitive symptoms. Among studies that used ADHD screeners without confirming history of childhood symptoms, only one study19 controlled for probable dementia by excluding individuals with the Mini Mental State Examination (MMSE) score 23 or less. Thus, screening assessment tools for ADHD should only be used as a first step of a more comprehensive clinical ADHD assessment. Future research conducted in community samples should address whether individuals with elevated levels of ADHD symptoms severity meet established diagnostic criteria by applying more comprehensive assessment tools, including the assessment of childhood symptoms. Moreover, future studies should investigate potential reasons behind elevated levels of ADHD symptoms reported via validated scales, such as misclassification with another mental-health or neurological condition,14 or age-inappropriate clinical assessment procedures.42,43

Our results also suggest that clinicians, to some extent, might fail to recognize and properly treat ADHD symptoms in older adults. Clinical presentation of ADHD may change with age, with inattentive symptoms becoming more prevalent than hyperactivity and impulsivity.42,43 Additionally, some older adults who do not meet official clinical criteria for an ADHD diagnosis may experience distressing symptoms and may be in need for care.1 Thus, mental health care providers should be aware that symptoms of ADHD persist across the life span in a substantial number of individuals with ADHD.

With the exception of one study that included both pharmacological and non-pharmacological treatment35, studies included in the present review only considered pharmacological treatment. We found that the prevalence of ADHD treatment in older adults is less than half of the prevalence of clinically diagnosed ADHD. It is difficult to interpret whether these differences reflect under- or over-treatment, because precise estimates of the proportion of individuals receiving ADHD treatment is lacking. Previous research is mixed and the percentage of diagnosed individuals who receive pharmacological treatment varies substantially for studies of adults (25−80%)18,32 as well as older adults (28−88%).32,41 Older adults have been reported to have similar benefits from pharmacological treatment as younger adults,42,44 however, clinicians may lack awareness on the benefits and proper drug dosage in this age group.1,42 Additionally, older patients and/or their medical care providers may have concerns regarding potential ADHD medication side effects due to older age, comorbid psychiatric and somatic disorders (in particular cardiovascular conditions), and interactions with other medications.1,42,43,45 Thus, adequate pharmacological and psychological treatment in this population should be carefully considered.

We included only studies that provided crude prevalence estimates in the published report or upon request. Prevalence estimates weighted to represent general population were not included in the present meta-analysis but they offer important insights into the topic. A large study from India reported an adjusted prevalence of diagnosed ADHD of 0.22% or lower for individuals aged 50 and older.47 This finding is in line with our pooled prevalence estimate based on clinical diagnosis. A longitudinal study from the Netherlands48, reported an adjusted prevalence of 2.8% (95% CI = 0.86, 4.64) in adults aged 60 and older, after a two-phase procedure of screening and a diagnostic interview of current and childhood symptoms. A study from Brazil49 provided an adjusted prevalence of 6.1% (4.50, 8.30) for adults older than 44 years of age based on an ADHD screener. These prevalence estimates are similar to or higher than our pooled prevalence based on research diagnosis and suggest a more pronounced prevalence of older adults with ADHD symptoms when taking into account population distribution of different socio-economic variables.

* 1. *Limitations and future lines of research*

All included studies showed a satisfactory level of study quality. This is particularly the case with registry-based studies, applied in large national-based samples, which provide a reliable estimate of the prevalence. The unequal female-to-male distribution observed in eight out of 20 included studies is a potential source of bias as we were unable to provide sex-stratified ADHD prevalence estimates. Additionally, the majority of included studies (13 out of 20) did not provide prevalence estimates in older adults stratified by sex. Such differences have been thoroughly investigated in younger age.43,46 Thus, future research of ADHD should consider potential differences in the prevalence of ADHD between female and male participants in older age.

Significant heterogeneity across studies has previously been identified in systematic reviews and meta-analyses of ADHD prevalence in children and adults, mostly due to methodological differences.4,6,8 The current study observed a substantial heterogeneity, despite pooling separate prevalence estimates for different assessment methods and conducting sensitivity analyses to address other potential sources of heterogeneity. Due to the lack of relevant data (i.e. mean age and SD) and relatively small number of studies per assessment method for ADHD clinical diagnosis (nine data-sets) and treatment (nine data-sets), we could not conduct more detailed sub-group analyses (e.g. for age and geographical region). A minimum of 10 studies per regressor is necessary for the meta-regression analysis, as recommended in the Cochrane handbook (p 284).50 More high-quality research, based on large samples and from regions other than Europe and North America, is needed to obtain more robust evidence regarding the prevalence of ADHD in older adults.

Another limitation in studies of ADHD in older adults is the use of retrospective reporting of childhood symptoms and recall bias, and a potential underestimation of the prevalence.6 Furthermore, self-report as the only source of information in studies with a research diagnosis of adult ADHD is a limitation given that previous research has shown an underestimation of symptoms severity by self-report in young adults compared to reports of parents/teachers.51 In order to somewhat mitigate the effects of recall bias and self-report, future studies of ADHD in older adults should aim to include relevant information from family members.

In conclusion, our findings indicate a substantial gap between the prevalence estimates of older adults with elevated ADHD symptoms assessed via validated scales in community samples and prevalence estimates based on ADHD clinical diagnosis and treatment. Furthermore, our results suggest that the prevalence of treated individuals is less than half of the prevalence of individuals with clinical diagnosis for ADHD. This study also highlights that ADHD is scarcely studied among older adults and that much more research is needed on the topic, in particular research that addresses the effects of different assessment methods, sex and age on the prevalence of ADHD after 50 years of age.

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**Declaration of competing interest**

SC declares honoraria and reimbursement for travel and accommodation expenses for lectures from the following non-profit associations: Association for Child and Adolescent Central Health (ACAMH), Canadian ADHD Alliance Resource (CADDRA), British Association of Pharmacology (BAP), and from Healthcare Convention for educational activity on ADHD.

HL has served as a speaker for Evolan Pharma and Shire and has received research grants from Shire; all outside the submitted work. All other authors have nothing to declare.

# **Supplementary material**

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Appendix 1. Detailed search strategy

1. Database: Pubmed; Date of search: 29-05-2019

Search terms:

((ADHD[Title/Abstract]) OR "Attention deficit"[Title/Abstract]) OR "attention-deficit"[Title/Abstract]) OR hyperkinetic disorder[Title/Abstract]) OR hyperkinetic syndrome[Title/Abstract]) AND Humans[Mesh])) OR (Attention deficit disorder with hyperactivity [MeSH Terms] AND Humans[Mesh])) AND Humans[Mesh])) AND (((((aged[MeSH Terms]) OR older adult\*[Title/Abstract]) OR life span[Title/Abstract]) OR lifespan[Title/Abstract])OR elderly[Title/Abstract])) Sort by: Best Match

Number of hits: 1,098

Publication dates: no restrictions

Updated search: 22-06-2020

Publication dates: 29-05-2019 to 22-06-2020

Number of hits: 40

2. Database: Psycinfo, through Ebsco; Date of search: 20-05-2019

Search terms:

( AB Attention deficit disorder with hyperactivity OR AB ADHD OR AB "attention deficit" ) AND ( AB aged OR AB older adults OR AB life span OR AB elderly )

Narrow by SubjectAge: - very old (85 yrs & older)

Narrow by SubjectAge: - middle age (40-64 yrs)

Narrow by SubjectAge: - aged (65 yrs & older)

Narrow by SubjectAge: - adulthood (18 yrs & older)

Number of hits: 1,411

Publication dates: no restrictions

Updated search: 26-06-2020

Published Date: 20190501-20200631

Hits: 179

3. Database: Medline, through Ebsco; Date of search: 22-05-2019

Search terms:

( AB ADHD OR AB hyperkinetic syndrome OR AB hyperkinetic disorder OR AB "Attention deficit" OR AB "attention-deficit" ) OR AB attention deficit disorder with hyperactivity) AND (AB older adult\* OR AB elderly OR AB life span)

Number of hits: 335

Publication dates: no restrictions

Updated search: 26-06-2020

Published Date: 20190501-20200631

Number of hits: 36

4. Database: Web of science; Date of search: 22-05-2019

Search terms:

|  |  |
| --- | --- |
|  | (TOPIC: (attention deficit disorder with hyperactivity)) OR TITLE: (ADHD) OR TITLE: ("attention-deficit") OR TITLE: ("Attention deficit") OR TITLE: (hyperkinetic syndrome) OR TITLE: (hyperkinetic disorder)Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=All years) AND (TITLE: (older adults) *OR* TITLE: (aging) *OR* TITLE: (elderly) *OR* TITLE: (life span)) Number of hits: 1,046 |

Available publication dates: 1974-2019

Updated search: 26-06-2020

Publication dates: May 2019 to 26-06-2020

Number of hits: 113

5. Database: Embase; Date of search: 2019-06-06

Search terms:

('aging'/exp OR lifespan:ti,ab,kw OR older:ti,ab,kw OR 'older adult\*':ti,ab,kw OR 'life span':ti,ab,kw OR adult:ti,ab,kw OR aged:ti,ab,kw) AND ('attention deficit disorder'/exp OR adhd:ti,ab,kw OR 'hyperkinetic disorder':ti,ab,kw OR 'hyperkinetic syndrome':ti,ab,kw OR 'attention deficit':ti,ab,kw) AND ([adult]/lim OR [aged]/lim OR [middle aged]/lim OR [very elderly]/lim)

Number of hits: 6,051

Available publication dates: 1972-2019

Updated search: 24-06-2020

Added to Embase AND [6-6-2019]/sd NOT [25-6-2020]/sd, and published in 2019-2020

Number of hits: 728

Preliminary search was conducted in January 2019 including the search term “prevalence”. In the second search, we excluded this search term in order not to exclude studies that reported the frequency of ADHD cases in older adults without mentioning the term “prevalence”.

Appendix 2. Reference list of studies identified in hand search

1 Wynchank D, Have M, Bijlenga D, Penninx BW, Beekman AT, Lamers F, et al. The association between insomnia and sleep duration in adults with attention-deficit hyperactivity disorder: Results from a general population study. Journal of Clinical Sleep Medicine. 2018;14(3):349-57.

2 Geirs DP, Pottegård A, Halldórsson M, Zoëga H. A nationwide study of attention-deficit/hyperactivity disorder drug use among adults in Iceland 2003-2012. Basic & clinical pharmacology & toxicology. 2014;115(5):417-22.

Appendix 3. Full text references excluded with reasons

Out of 124 full text papers which were reviewed, 20 studies were included in the meta-analysis, while 104 studies were excluded from further analysis with the following reasons:

|  |  |  |
| --- | --- | --- |
|  | **Author (year)** | **Reason** |
| 1 | Aduen et al. (2015)1 | Prevalence not reported; population: drivers (not representative of the general population) |
| 2 | Agosti et al. (2011)2 | ADHD assessed in the 18-44 age range  |
| 3 | Alkan et al. (2015)3 | Childhood only symptoms; dental patients (not representative of the general population) |
| 4 | Amador-Campos et al. (2014)4 | Prevalence not reported |
| 5 | Anker et al. (2018)5 | Prevalence estimate is not reported; study is done in patients with ADHD only (not representative of the general population) |
| 6 | Axmon et al. (2018)6  | Overlapping sample with Chen et al.105 (included in the meta-analysis). Number of events < 5 |
| 7 | Barkley (2012)7 | Pevalence not reported |
| 8 | Bijlenga et al. (2018)8 | Prevalence of ADHD not reported; Prevalence of sexual disorders in patients with ADHD |
| 9 | Bilder et al. (2017)9  | Population: adults with PKU. Authors contacted on the information on general population; no access |
| 10 | Bitter et al. (2010)10  | Separate prevalence in older adults not reported; corresponding authors contacted for additional results; no reply |
| 11 | Brinker et al. (2007)11 | Separate prevalence in older adults not reported; corresponding authors contacted for additional results; no reply |
| 12 | Burcu et al. (2016)12 | Separate prevalence in older adults not reported; corresponding authors contacted for additional results; no reply |
| 13 | Caci et al. (2014)13 | ASRS score based on the 18-44 age group |
| 14 | Callahan and Plamondon (2018)14 | Prevalence not reported |
| 15 | Calver et al. (2007)15 | Prevalence not reported |
| 16 | Carlsson et al. (2013)16 | Prevalence not reported |
| 17 | Castano et al. (2018)17 | Population exposed to violence (non-general population)  |
| 18 | Cepeda et al. (2014)18 | Prevalence in the population of people with ADHD medication, not general population |
| 19 | Chamorro et al. (2012)19 | No separate prevalence for older adults; age-range not reported; same data-set (population) as Bernardi et al., 2012 |
| 20 | Chang et al. (2018)20 | Prevalence estimate presented for ADHD and learning disability together  |
| 21 | Chen et al. (2014)21 | Non-medical users – non-prescribed or not clear ADHD medication; substance abuse |
| 22 | Cheng et al. (2017)22 | Incidence without prevalence data |
| 23 | Combs et al. (2015)23 | Prevalence not reported |
| 24 | Conners et al. (1999)24 | Prevalence not reported |
| 25 | Cortese et al. (2013)25 | Overlapping with Bernardi et al.,106 (included in the meta-analysis); later publication  |
| 26 | Cortese et al. (2016)26 | Overlapping population with Bernardi et al.,106 ; later publication  |
| 27 | Cumyn et al. (2009)27 | Prevalence estimate is not reported; prevalence of other mental health condition in adults with ADHD |
| 28 | Das et al. (2015)28 | Overlapping with Das et al.,107(included in the meta-analysis); later publication  |
| 29 | De Jonge et al. (2012)29 | Age-range not reported |
| 30 | Dinn et al. (2001)30 | Prevalence not reported; neuropsychological performance in people with ADHD and controls  |
| 31 | Distel et al. (2011)31 | Prevalence not reported; twin study  |
| 32 | Dowson (2008)32 | Prevalence not reported; adults with ADHD (non-general population) |
| 33 | Dowson and Blackwell (2010)33 | Prevalence not reported; adults with ADHD (non-general population) |
| 34 | Dunne et al. (2014)34 | No separate prevalence estimate for older age group; drug users (non-general population) |
| 35 | El-Tallawy et al. (2013)35 | Separate ADHD prevalence estimate is not reported; authors contacted, no reply  |
| 36 | Fasmer et al. (2011)36 | Prevalence not reported, only ratio; population overlapping with Karlstad et al.,108 for Norway |
| 37 | Fasmer et al. (2012)37 | Prevalence not reported, only ration; population overlapping with Karlstad et al.,108 for Norway |
| 38 | Fairman et al. (2018)38 | Missing relevant data; authors contacted and replied, but without access to data |
| 39 | Faraone and Biederman (2005)39 | No separate prevalence for older age, authors contacted and replied, but without access to data |
| 40 | Fayyad et al. (2017)40 | Prevalence estimated does not include older adults |
| 41 | Frauger et al. (2011)41 | Total population size of older people not reported; methylphenidate use; abuse/prescription based: no clear distinction  |
| 42 | Gadow et al. (2007)42 | Prevalence not reported |
| 43 | Geirs et al. (2014)43 | Overlapping population with Karlstad et al.108 for Iceland; earlier publication, however Karlstad108 provided more comprehensive data. |
| 44 | Giacobini et al. (2018)44 | Prevalence estimate does not include older adults |
| 45 | Golimstok et al. (2011)45 | Prevalence estimate is not reported; a case-control study |
| 46 | Groen et al. (2018)46 | Prevalence not reported; subclinical ADHD |
| 47 | Gross et al. (1999)47 | Childhood symptoms only  |
| 48 | Guldberg-Kjar and Johansson (2009)48 | Childhood symptoms only; data linked to Guldberg-Kjar et al.109 (included) |
| 49 | Guldberg-Kjar and Johansson (2015)49 | Same dataset as Guldberg-Kjar et al.109 |
| 50 | Hansen et al. (2018)50 | No separate prevalence for older adults; contacted authors, relevant data not provided |
| 51 | Hennig et al. (2017)51 | Prevalence not reported |
| 52 | Hesson and Fowler (2018)52 | Missing data; contacted authors, no reply |
| 53 | Huang, et al. (2016)53 | No separate prevalence for older age; overlapping with Huang et al.110, later publication and missing relevant data |
| 54 | Ilie et al. (2015)54 | No separate prevalence for older adults; overlapping population with Vingilis et al.111(included) but missing relevant data |
| 55 | Ito et al. (2017)55 | No separate prevalence for older age; contacted authors, no reply |
| 56 | Ivanchak et al. (2011)56 | Only childhood symptoms  |
| 57 | Jacob et al. (2018)58 | Overlapping population with Jacob et al.112 (included) |
| 58 | Jensen and Steinhausen (2015)58 | Incidence without prevalence data; abstract only |
| 59 | Kawatkar et al. (2014)59 | Prevalence not reported; overlapping population with Knight et al.113 (included),but missing relevant data |
| 60 | Kessler et al. (2006)60 | Prevalence estimate does not include older age group (included age range 18-44) |
| 61 | Kim et al. (2016)61 | No separate prevalence estimate for older adults; Overlapping population with Park et al.114(included), but later publication and missing relevant data |
| 62 | Kivisaari et al. (2012)62 | Childhood symptoms only  |
| 63 | Kolla et al. (2016)63 | Prevalence not reported; same data set as Vingilis et al.111, missing relevant data |
| 64 | Kristiansen et al. (2015)64 | Incidence without prevalence data |
| 65 | Kronenberg et al. (2014)65 | Qualitative study  |
| 66 | Marcus et al. (2012)66 | Psychometric properties of the scale; relevant data missing  |
| 67 | Marwaha et al. (2015)67 | No separate prevalence for older adults; overlapping population with Jacob et al.112, but missing relevant data |
| 68 | Michielsen et al. (2012).  | A smaller sample of participants was selected for the interview based on the screening score, and prevalence estimates were weighted against general population, thus crude prevalence estimates could not be acquired |
| 69 | Mohr Jensen and Steinhausen (2015)69 | Same data set as Karlstad et al., 2016, for Denmark, but less comprehensive  |
| 70 | Montejano et al. (2011)70 | Missing relevant data; authors contacted and reminded, no reply |
| 71 | Murphy and Barkley (1996)71 | Missing relevant data – no separate prevalence estimate for older adults; authors contacted, replied, no access |
| 72 | Ormhoj et al. (2018)72 | New users; Only incidence without prevalence  |
| 73 | Pakyurek et al. (2017)73 | Abstract only; potentially same population as Karlstad et al.108, for Norway  |
| 74 | Panagiotidi and Overton (2018)74 | Prevalence not reported |
| 75 | Panagiotidi et al. (2018)75 | Prevalence not reported |
| 76 | Philip et al. (2015)76 | Highway drivers, not representative of general population |
| 77 | Philipp-Wiegmann et al. (2015)77 | Control participants: excluded participants with previous ADHD and scores higher than 30 on the scale |
| 78 | Pohl et al. (2009)78 | Total population size of older people not reported; prevalence of combination therapy |
| 79 | Polanczyk et al. (2010)79 | Prevalence weighted against general population; authors contacted for crude data, no reply |
| 80 | Pottegård et al. (2012)80 | Population covered in the paper is overlapping with Karlstad et al.108, for Denmark |
| 81 | Robison et al. (2005)81 | Incident cases of ADHD diagnosis; prevalence not reported; no sample size of older adults  |
| 82 | Rosler, M. and W. Retz (2006).  | A review; non-original study  |
| 83 | Sadeghi et al. (2017)83 | Prevalence not reported  |
| 84 | Santiago and Cohen (2008)84 | Young adults only; abstract  |
| 85 | Schoeman and Klerk (2017)85 | No separate prevalence for older age; authors contacted, no reply  |
| 86 | Sclar et al. (2012)86 | Proportion of office based visits; prevalence of individual cases not reported  |
| 87 | Semeijn et al. (2016)87 | A smaller sample of participants was selected for the interview based on the screening score, and prevalence estimates were weighted against general population, thus crude prevalence estimates could not be acquired |
| 88 | Simon (2011)88 | No separate prevalence for older adults; authors emailed, no reply |
| 89 | Slawik and Rudolph (2008)89 | No separate prevalence for older age; abstract; contact not available  |
| 90 | Steinhausen and Bisgaard (2014)90 | Prevalence not reported, excluded |
| 91 | Stickley et al. (2016)91 | Same population as Jacob et al.112; relevant data not reported (no separate prevalence estimate for older adults) |
| 92 | Stickley et al. (2016)92 | Same population as Jacob et al.112; relevant data not reported (no separate prevalence estimate for older adults)  |
| 93 | Stickley et al. (2018)93 | Same population as Jacob et al.112; published same year |
| 94 | Stickley et al. (2017)94 | Same population as Jacob et al.112; relevant data not reported (no separate prevalence estimate for older adults) |
| 95 | Strom et al. (2016)95 | Prevalence is not reported; population: adults without eczema |
| 96 | Sundquist et al. (2017)96 | No separate prevalence for older adults; authors emailed, no reply |
| 97 | Tan et al. (2016)97 | Patients with OCD (non-general population) |
| 98 | Tzeng et al. (2017)98 | Overlapping with Huang et al.110, later publication  |
| 99 | Wagner et al. (2004)99 | Prevalence of ADHD in restless leg syndrome; case-control study  |
| 100 | Weissenberger et al. (2018)100 | No separate prevalence for older adults; authors emailed, no reply |
| 101 | Vingilis et al. (2014)101 | Population: drivers (not-representative of general population); a sample from the same survey (CAMH Monitor), but not only drivers, was used in Vingilis, et al.111 |
| 102 | Zetterqvist et al. (2013) 102 | Prevalence estimate does not include older age group (age 6-45) |
| 103 | Zhang and Markon (2018)103 | Prevalence not reported |
| 104 | Hoeffding et al. (2018)104 | Blood donor population, not representative of the general population  |

Updated search:

|  |  |  |
| --- | --- | --- |
| 105 | Sagar et al. (2020)115 | Not original source of data; data from multiple sources, including other studies  |
| 106 | Chung et al. (2019)116 | Overlapping population as Knight et al.113 that provided relevant data; later publication  |
| 107 | Connolly, Speed and Hesson (2019)117 | No separate prevalence estimates for older adults; same data set as Hesson and Fowler (2018)52 who we contacted in the original search, without reply |
| 108 | Huang, Wang and Ho (2020)118 | No separate prevalence estimate for older adults; overlapping population with Huang, et al.110 that provided relevant data; later publication and missing relevant data |
| 109 | Hvidberg et al. (2020)119 | Prevalence estimate not provided  |
| 110 | Li et al. (2019)120 | No separate prevalence estimate for older adults, same geographical region of Nijmegen and partially overlapping population as included in study by Kooij123 that provided relevant data |
| 111 | Morkem et al. (2020)121 | No separate prevalence estimate for older adults, overlapping population in Canada as included in study by Vingilis et al.111 that provided relevant data |
| 112 | Vogel et al. (2019)122 | No separate prevalence estimate for older adults; overlapping population as Wynchank123 that provided relevant data |

Appendix 4. Forest plot for individual studies and pooled prevalence estimates based on assessment method

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Study/data-set (age range)** | **Prevalence (%)** | **Lower CI** | **Upper CI** | **Weight**  |  |
| Das (68-72) | 2.21 | 1.59 | 3.08 | 7.45 |  |
| Jacob (≥60) | 2.19 | 1.63 | 2.94 | 7.54 |
| Guldberg-Kjar (65-80) | 1.00 | 0.61 | 1.63 | 6.99 |
| Bernardi (≥65) | 0.49 | 0.35 | 0.69 | 7.44 |
| De Zwaan (55-64) | 3.54 | 2.10 | 5.88 | 7.37 |
| Park (50-59) | 1.35 | 0.80 | 2.27 | 6.85 |
| Vingilis (≥65) | 0.60 | 0.22 | 1.58 | 6.87 |
| Wynchank (58-70) | 1.82 | 1.27 | 2.61 | 5.17 |
| Kooij (60-75) | 2.28 | 1.19 | 4.32 | 6.38 |
| Das (48-52) | 6.14 | 5.14 | 7.30 | 7.85 |
| Bernardi (45-64) | 2.14 | 1.90 | 2.42 | 7.09 |
| De Zwaan (45-64) | 4.55 | 2.92 | 7.02 | 7.58 |
| Vingilis (45-64) | 3.56 | 2.70 | 4.68 | 7.65 |
| Wynchank (48-57) | 5.35 | 4.20 | 6.79 | 7.77 |
| **Research diagnosis** (N=14) | **2.18** | **1.51** | **3.16** |  |
|  |  |  |  |  |
| Zhu (≥55) | 0.16 | 0.14 | 0.18 | 11.11 |
| Knight (≥50) | 0.12 | 0.11 | 0.13 | 11.13 |
| Chen (55-64) | 0.24 | 0.24 | 0.25 | 11.14 |
| Polyzoi (≥65) | 0.01 | 0.01 | 0.01 | 11.06 |
| Bachmann (50-69) | 0.12 | 0.12 | 0.13 | 11.14 |
| Adler (≥50) | 1.07 | 0.90 | 1.28 | 11.05 |
| Bogdan (≥50) | 1.54 | 1.34 | 1.76 | 11.09 |
| Zhu (46-55) | 0.34 | 0.32 | 0.36 | 11.13 |
| Chen (45-54) | 0.66 | 0.64 | 0.67 | 11.14 |
| **Clinical diagnosis** (N=9) | **0.23** | **0.12** | **0.44** |  |
|  |  |  |  |  |
| Huang (≥49) | 0.00 | 0.00 | 0.00 | 8.53 |
| Castle (≥65) | 0.20 | 0.19 | 0.21 | 11.53 |
| Karlstad, Denmark (45-64) | 0.24 | 0.23 | 0.24 | 11.55 |
| Karlstad, Finland (45-64) | 0.03 | 0.03 | 0.03 | 11.51 |
| Karlstad, Iceland (45-64) | 0.70 | 0.64 | 0.76 | 11.52 |
| Karlstad, Norway (45-64) | 0.19 | 0.18 | 0.19 | 11.55 |
| Karlstad, Sweden (45-64) | 0.26 | 0.25 | 0.27 | 11.56 |
| McCarthy (>45) | 0.00 | 0.00 | 0.00 | 10.69 |
| Castle (45-64) | 0.70 | 0.68 | 0.72 | 11.56 |
| **Treatment** (N=9) | **0.09** | **0.06** | **0.15** |  |

Appendix 5. Relevant information gathered from contacted authors

1. For Kooij et al.124: 11-06-2019 Dr Sandra Kooij <s.kooij@psyq.nl> (with Denise Bijlenga) who sent the requested information.

There were 420 persons in the age category 60-75, of which 395 persons also had complete data on the current and childhood ADHD symptoms.

Of these 395:

n=3 (0.75%) had 6 or more current, plus 3 childhood ADHD symptoms

n=9 (2.28%) had 4 or more current, plus 3 childhood ADHD symptoms

1. For Zhu et al.125; Emailed almut@cop.ufl.edu on 13-02, who directed me to Zhu, Y (yzhu15@bwh.harvard.edu), who replied on 14-02 and sent me the required data on 02-03 (tables with prevalences) and 11-03-2019 (tables with means and SD for both older age groups).

|  |  |  |  |
| --- | --- | --- | --- |
| age | Year | ADHD diagnosis prevalence, % | No. of diagnosed patients |
| 46-55 | 2009 | 0.32 | 939 |
| 56+ | 2009 | 0.15 | 329 |
| 46-55 | 2010 | 0.34 | 1003 |
| 56+ | 2010 | 0.16 | 352 |

|  |  |  |  |
| --- | --- | --- | --- |
| **age** | **Year** | **Age mean** | **SD** |
| 46-55 | 2009 | 50.03 | 2.86 |
| 56+ | 2009 | 59.08 | 2.52 |
| 46-55 | 2010 | 50.06 | 2.86 |
| 56+ | 2010 | 58.89 | 2.45 |

1. For Bachmann et al.126:03-06-2019, contacted via the form on the website <http://www.christian-achmann.info/impressum.html>. Replied the same day, sent additional data. Sent requested information in a separate excel file: number of insurees and age stratified prevalence of ADHD for each year of age. Based on the provided data, number and prevalence of individuals with ADHD aged 50-69 were calculated.

Appendix 6. List and description of validated scales assessing symptoms of ADHD used in the studies included in the meta-analysis

|  |  |  |
| --- | --- | --- |
| Questionnaire/scale | Abbreviation | Description  |
| Adult ADHD self-report scale screener version 1.1 (ASRS)127 | ASRS-6  | 6-item version; DSM-IV Criterion A ADHD symptoms in adults; self-report |
| Wender Utah Rating Scale (German version)128 | WURS-k | Retrospective self-rating of childhood symptoms; 21 items |
| Wender Riktad ADHD Symtom Skala; a Swedish version of the Targeted Attention Deficit Disorder Rating Scale (TADDS)129 | WRASS | Utah criteria – both childhood and adult symptoms; self-report |
| Alcohol Use Disorder and Associated Disabilities Interview Schedule–DSM-IV version130 | AUDADIS-IV | DSM-IV 20 items; lifetime and childhood symptoms; self-report |
| ADHD self-rating scale131 | ADHD-SR | Adults symptoms; 18 items DSM-IV-TR; self-report |
| Dutch version of the ADHD DSM-IV rating scale constructed using the 18 DSM-IV items for ADHD 132 | ADHD rating scale-IV | 26 items; current and childhood items; DSM-IV; self-report |

Appendix 7. Study quality assessment of included studies

We did not exclude studies based on their study quality/risk of bias. Instead, overall appraisal of study quality/risk of bias was considered satisfactory when over five items were positively assessed.

Item 8 (“Was there appropriate statistical analysis?”)133 was not relevant for the purposes of the current review.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| First author (year)\* | 1. Was the sample representative of the target population? | 2. Were study participants recruited in an appropriate way? | 3. Was the sample size adequate? | 4. Were the study subjects and the setting described in detail? | 5. Was the data analysis conducted with sufficient coverage of the identified sample?  | 6. Were objective, standard criteria used for the measurement of the condition?  | 7. Was the condition measured reliably? | 9. Are all important confounding factors/subgroups/differences identified and accounted for? | 10. Were subpopulations identified using objective criteria? | Study quality score |
| Das (2014) | Yes | Yes | Unclear | Yes | Yes | Yes | Yes | Yes | Yes | 8 |
| Jacob (2018) | Yes | Yes | Unclear | Yes | Yes | Yes | Yes | Noa | Yes | 7 |
| Guldberg-Kjar (2013) | Yes | Yes | Unclear | Yes | Yes | Yes | Yes | Yes | Yes | 8 |
| Bernardi (2012) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Noa | Yes | 8 |
| De Zwaan (2012) | Yes | Yes | Unclear | Yes | Yes | Yes | Yes | Noa | Yes | 7 |
| Park (2011) | Yes | Yes | Yes | Yes | Yes | Unclearb | Unclearb | Noa | Yes | 6 |
| Vingilis (2015) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Noa | Yes | 8 |
| Wynchank (2018) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Noa | Yes | 8 |
| Kooij (2005) | Yes | Yes | Unclear | Yes | Yes | Yes | Yes | Noa | Yes | 7 |
| Zhu (2018)  | Yes | Not applicablec | Yes | Yes | Yes | Yes | Yes | Noa | Yes | 7 |
| Knight (2014) | Yes | Not applicablec | Yes | Yes | Yes | Yes | Yes | Noa | Yes | 7 |
| Chen (2018) | Yes | Not applicablec | Yes | Yes | Yes | Yes | Yes | Noa | Yes | 7 |
| Polyzoi (2018) | Yes | Not applicablec | Yes | Yes | Yes | Yes | Yes | Noa | Yes | 7 |
| Bachmann (2017) | Yes | Not applicablec | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 8 |
| Adler (2019) | Yes | Yes | Yes | Yes | Yes | Nod | Nod | Noa | Yes | 6 |
| Bogdan (2018) | Yes | Yes | Yes | Yes | Yes | Nod | Nod | Noa | Yes | 6 |
| Huang (2014) | Yes | Not applicablec | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 8 |
| Karlstad (2016) | Yes | Not applicablec | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 8 |
| McCarthy (2012) | Yes | Not applicablec | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 8 |
| Castle (2007) | Yes | Not applicablec | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 8 |

\*References for the included studies are provided in the reference list in the main text.

1. Prevalence estimates are not reported separately for female and male participants in the older age group;
2. Assessment for childhood symptoms not described appropriately;
3. Secondary data collected from national or health insurance registers;
4. Self-reported clinical diagnosis

Appendix 8. List of contacted experts

We contacted experts in the field in order to identify potentially additional relevant published and/or unpublished studies.

Correspondence details with dates:

1. 07-05-2019

Emailed: Sandra Kooij <s.kooij@psyq.nl>; Steve Faraone <sfaraone@childpsychresearch.org>replied the same day, no additional data; Luis Augusto Rohde <lrohde@terra.com.br>; Wong, Ian <i.wong@ucl.ac.uk>; Dave Coghill <david.coghill@unimelb.edu.au>

1. 08-05-2019

Prof Dave Coghill replied: no additional data available ; Prof Luis Augusto Rohde, MD, PhD replied, no additional data available

1. 09-05-2019

Dr Sandra Kooij replied, sent the study Kooij, J. J. S., et al. (2005). "Internal and external validity of Attention-Deficit Hyperactivity Disorder in a population-based sample of adults." Psychol Med 35(6): 817-827. I replied back and asked about separate prevalence estimates for older adults.

04-06-2019 Dr Sandra Kooij replied and asked for clarification;

11-06-2019 Dr Sandra Kooij (with Denise Bijlenga) sent the requested information.

Appendix 9. Authors contacted with request for additional results

1. Bitter et al. (2010)10 simonviktoria@psych.sote.hu, 13-02-2019, no reply, reminder sent on 07-03-2019, no reply.

What is the samples size of the >40 group in the screened participants (n = 3529) and how many participants have been determined as adults ADHD based on the screener and the interview (second phase). What is the mean and SD of the 40+ group.

2. Brinker et al. (2007)11 allen.brinker@fda.hhs.gov, 13-02-2019, no reply, reminder sent on 07-03-2019, no reply

What is the samples size in the age groups 40 to 59 (mean age and SD) in general population and what is the overall prevalence of the medication use and general population sample size used for the calculation for the age group 50 to 64.

3. Burcu et al. (2016)12 jzito@rx.umaryland.edu, 13-02-2019, no reply, reminder sent on 07-03-2019, no reply

What samples size of the general population was used to calculate the prevalence of the medication use in the age group 40 to 64 (mean age and SD).

4. El-Tallawy et al. (2013)35 redaalbadry02@gmail.com , 13-02-2019, no reply, reminder sent on 07-03-2019, no reply

What is the number of events (ADHD diagnosis) and the samples size of the age group.

5. Fairman et al. (2018)38  kfairm@midwestern.edu , 12-02-2019, the author replied but could not find the needed additional data in the Truven dataset.

In the group of patients aged 45–54 years (n = 12,801), and in patients aged 55–64 years (n = 5237): what is the prevalence in general population in 2014-2015.

6. Hesson and Fowler (2018)52 jhesson@mun.ca , 12-02-2019, the author replied that they will check the data, however no reply afterwards, reminder sent on 07-03-2019, no reply. What is the overall sample size for the age groups: 55-59, events 34, and 50-64, events 28.

7. Ito et al. (2017)55  inoue@somnology.com , 12-02-2019, no reply, remainder sent on 07-03-2019, no reply

In the group of participants aged 50 and older – what is the number of events of possible ADHD (ASRS screener) and samples size in this age group.

10. Montejano et al. (2011)70 Leslie.Montejano@thomsonreuters.com , 12-02-2019, no reply, reminder 07-03-2019, no reply

Find information on sample size for and prevalence for the age groups: 45–54 events (diagnosis and treatment of ADHD)=6233. In the group aged 55–64 Events= 2710. Same data set as Fairman et al, 2018, which contains data from 2014-2015 but without general population information.

10. Polanczyk et al. (2010)79 lrohde@terra.com.br , 12-02-2019, the author and forwarded email to Polanczyk, who did not reply.

For the age group older than 44: what is the mean age and SD; wat is the number of events and samples size, and what is the crude prevalence estimate before weighting.

11. Schoeman and Klerk (2017)85 renata@renataschoeman.co.za 12-02-2019, no reply, reminder 07-03-2019, no reply

What is the sample size and number of events for participants older than 50; what is the prevalence of older age group > 50 (mean age, SD), sample size and event number.

12. Sundquist et al. (2017)96  jan.sundquist@med.lu.se 13-02-2019 no reply, reminder sent on 07-03, no reply

What is the prevalence in older age group, mean age and SD.

13. Zhu et al.124 almut@cop.ufl.edu, 13-02-2019, directed to Zhu, Y, who replied on 14-02-2019 and then sent me the needed data on 02-03 (tables with prevalences) and 11-03-2019 (tables with means and SD for both older age groups).

What is the sample size and prevalence for these age groups for 2010.

14. Faraone and Biederman (2005)39 faraones@upstate.edu on 13-02-2019, replied no access, emailed again as an expert on 07-05-2019, replied: no new studies.

15. Barkley (2012)7 drbarkley@russellbarkley.org, 13-02-2019, replied on 14-02 no access

16. Bachmann et al.126 03-06-2019, contacted via the form on the website <http://www.christian-achmann.info/impressum.html>. Replied the same day, sent additional data.

17. Hansen et al. (2018)50 Hansen, T. F., et al. (2018). "Comorbidity of migraine with ADHD in adults." 18(1): 147.

Emailed on 03-06-2019, replied 19.06.2019; provided another article: Hoeffding LK, Nielsen MH, Nissen J, Didriksen M, Burgdorf K, et al. Symptoms of ADHD are highly common in undiagnosed adults – A cross-sectional study in a large population of Danes. J Psychiatry Behav Sci. 2018; 1: 1004.

18. Weissenberger et al. (2018)100 Emailed ptacek@neuro.cz on 05-06-2019, no reply

Appendix 10. Deviations from the published PROSPERO protocol

In the protocol available online <https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=135062>, registration number: CRD42019135062; the assessment methods were defined as following: ADHD symptoms/syndromes in community samples assessed with a validated scale; ADHD diagnosis as reported in population-based registries/self-reported medical history; and, ADHD treatment as reported in population-based registries/self-reported medical history. In the manuscript, the corresponding assessment methods were defined as: ADHD research diagnosis acquired via validated scales in community samples; ADHD clinical diagnosis; and rate of ADHD treatment, as reported in registers/medical files or self-reported medical history.

Also, we planned to conduct a fifth sensitivity analysis by excluding potentially unpublished studies, however, we have not identified any relevant unpublished studies in the selection process.

Appendix 11. Supplemental references

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5 Anker E, Bendiksen B, Heir T. Comorbid psychiatric disorders in a clinical sample of adults with ADHD, and associations with education, work and social characteristics: a cross-sectional study. *BMJ open* 2018;**8**:e019700.6

6 Axmon A, Bjorne P, Nylander L, Ahlstrom G. Psychiatric diagnoses in older people with intellectual disability in comparison with the general population: a register study. *Epidemiol Psychiatr Sci* 2018;**27**:479-91.

7 Barkley RA. Distinguishing sluggish cognitive tempo from attention-deficit/hyperactivity disorder in adults. *J Abnorm Psychol* 2012;**121**:978-90.

8 Bijlenga D, Vroege JA, Stammen AJM, Breuk M, Boonstra AM, van der Rhee K, et al. Prevalence of sexual dysfunctions and other sexual disorders in adults with attention-deficit/hyperactivity disorder compared to the general population. *Atten Defic Hyperact Disord* 2018;**10**:87-96.

9 Bilder DA, Kobori JA, Cohen-Pfeffer JL, Johnson EM, Jurecki ER, Grant ML. Neuropsychiatric comorbidities in adults with phenylketonuria: A retrospective cohort study. *Molecular Genetics and Metabolism* 2017;**121**:1-8.

10 Bitter I, Simon V, Balint S, Meszaros A, Czobor P. How do different diagnostic criteria, age and gender affect the prevalence of attention deficit hyperactivity disorder in adults? An epidemiological study in a Hungarian community sample. *Eur Arch Psychiatry Clin Neurosci* 2010;**260**:287-96.

11 Brinker A, Mosholder A, Schech SD, Burgess M, Avigan M. Indication and use of drug products used to treat attention-deficit/hyperactivity disorder: A cross-sectional study with inference on the likelihood of treatment in adulthood. *Journal of Child and Adolescent Psychopharmacology* 2007;**17**:328-33.

12 Burcu M, Zito J, Metcalfe L, Underwood H, Safer DJ. Trends in stimulant medication use in commercially insured youth and adults 2010-2014. *J Am Acad Child Psy* 2016;**55**:S164.

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------------------------Tables and Figures to be inserted in the main text------------------------------

FIGURE 1



**Fig. 1:** Flow-chart of the meta-analysis selection process

\* Reasons for exclusion of full-text articles are provided in the Appendix 3

TABLE 1

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | First author(year) | Population/Study design  | Year of data collection | Female/male(%)  | Country | Age range | Events (N) | Sample size (N) | Prevalence (%) 95% CI | Study quality score(0-9) |
|  | **Research diagnosis** |
| 1 | Bernardi (2012)18 | NESARC, 2004−2005/Cross-sectional | 2004−2005 | 41∙3/58∙7 | US | ≥65 | 33 | 6704 | 0.49 (0.35−0.69)a,d | 8 |
|  |  |  |  |  |  | 45−64 | 257 | 11995 | 2.14 (1.90−2.42) a,d |  |
| 2 | Das (2014)19 | PATH through life/Longitudinal  | 2009 | 52∙4/47∙6 | Australia  | 68−72  | 34 | 1536 | 2.21 (1.59−3.08) d | 8 |
|  |  |  |  |  |  | 48−52 | 117 | 1907 | 6.13 (5.14−7.30) d |  |
| 3 | De Zwaan (2012)20 | Representative sample/Cross-sectional | 2009 | 55∙1/44∙9 | Germany | 55−64 | 14 | 396 | 3.53 (2.10−5.88)a,d | 7 |
|  |  |  |  |  |  | 45−54 | 19 | 418 | 4.55 (2.92−7.02) a,d |  |
| 4 | Guldberg-Kjar (2013)21 | Hässleholm, south Sweden/Cross- sectional | 2004 | 52∙7/47∙3 | Sweden | 65−80  | 16 | 1599 | 1.00 (0.61−1.63)a | 8 |
| 5 | Jacob (2018)22 | Adult Psychiatric Morbidity Survey 2007/Cross-sectional | 2006−2007 | 51∙4/48∙6 | UK | ≥60  | 43 | 1963 | 2.19 (1.63−2.94)a | 7 |
| 6 | Kooij (2005)23 | Nijmegen Health Area Study-2 (NHA-2)/Cross-sectional  | 1997−1998 | 55∙3/44∙7 | The Netherlands | 60−75 | 9 | 395 | 2.28 (1.19−4.32)b | 7 |
| 7 | Park (2011)24 | Korean epidemiologic catchment area study stud (KECA)/Cross-sectional | 2006−2007 | 49∙5/50∙5 | Korea | 50−59 | 14 | 1036 | 1.35 (0.80−2.27)a | 6 |
| 8 | Vingilis (2015)25 | Centre for Addiction andMental HealthMonitor /Cross-sectional | 2011−2012 | 47∙6/52∙4 | Canada | ≥65 | 4 | 670 | 0.60 (0.22−1.58) a,d | 8 |
|  |  |  |  |  |  | 45−64 | 49 | 1375 | 3.56 (2.70−4.68) a,d |  |
| 9 | Wynchank (2018)26 | NEMESIS-2/Cross-sectional | 2013−2015 | 50∙2/49∙8 | The Netherlands | 58−70 | 29 | 1594 | 1.82 (1.27−2.61) a,d | 8 |
|  |  |  |  |  |  | 48−57 | 63 | 1178 | 5.35 (4.20−6.79) a,d |  |
|  | **Clinical diagnosis** |
| 1 | Adler (2019)27 | National Health and Wellness Survey | 2013 | 54∙5/45∙5 | US | ≥50 | 125 | 11661 | 1.07 (0.90−1.28)a | 6 |
| 2 | Bachmann (2017)28 | Health insurance company, AOK | 2014 | 50∙1/49∙9 | Germany | 50−69 | 7332 | 5982881 | 0.12 (0.12−0.13)b | 8 |
| 3 | Bogdan (2018)29 | National Health Interview Survey | 2012 | 55∙2/44∙8 | US | >50 | 207 | 13446 | 1.54 (1.34−1.76)a | 6 |
| 4 | Chen (2018)30 | Swedish National Patient register | 2013 | 43∙7/56∙3 | Sweden | 55–64 | 2681 | 1096007 | 0.24 (0.24−0.25)d | 7 |
|  |  |  |  |  |  | 45−54 | 8007  | 1215426 | 0.66 (0.64−0.67)d |  |
| 5 | Knight (2014)31 | Kaiser Permanent Southern California | 2009 | 52∙2/47∙8 | US California | ≥50  | 1272 | 1072554 | 0.12 (0.11−0.13)c | 7 |
| 6 | Polyzoi (2018)32 | Swedish National Patient register | 2011 | 44∙8/55∙2 | Sweden | ≥65 | 142 | 1798034 | 0.01 (0.01−0.01) | 7 |
| 7 | Zhu (2018) 33 | Medicaid database | 2010 | 60∙1/39∙9 | US | ≥55  | 352 | 219333 | 0.16 (0.14−0.18)b,d | 7 |
|  |  |  |  |  |  | 46−55 | 1003 | 296954 | 0.34 (0.32−0.36) b,d |  |
|  | **Treatment**  |
| 1 | Castle (2007)34 | Commercially insured | 2005 | 51∙5/48∙5 | US | ≥65 | 828 | 413987 | 0.20 (0.19−0.21)a,d | 8 |
|  |  |  |  |  |  | 45−64 | 5655 | 807901 | 0.70 (0.68−0.72) |  |
| 2 | Huang (2014)35 | National Health Insurance Research Database (NHIRD) | 2005 | NA | Taiwan | ≥49 |  5 | 264550 | 0.002 (0.000−0.004)a | 8 |
| 3 | Karlstad (2016)36 | Prescription registry | 2012 | NA | Denmark | 45−64 | 3498 | 1487727 | 0.24 (0.23−0.24)c,d | 8 |
|  |  |  |  |  | Finland |  | 432 | 1440000 | 0∙03 (0.03−0.03)c,d |  |
|  |  |  |  |  | Iceland |  | 544 | 78271 | 0.69 (0.64−0.76)c,d |  |
|  |  |  |  |  | Norway |  | 2303 | 1244444 | 0.19 (0.18−0.19) c,d |  |
|  |  |  |  |  | Sweden |  | 6311 | 2423929 | 0.26 (0.25−0.27) c,d |  |
| 4 | McCarthy (2012)37 | Health Improvement Network (THIN) | 2008 | 51∙1/48∙9 | UK | >45 | 22 | 1100000 | 0.002 (0.001−0.003)a | 8 |

**Table 1**

Descriptive data for studies included in the meta-analysis

1. Relevant data calculated based on the data given in the original article for the purposes of this meta-analysis
2. Relevant data gathered from the authors (Appendix 5)
3. Relevant data provided in the supplementary material of the original study
4. Datasets available for subsamples (i.e. different countries/or age categories) as separate datasets

TABLE 2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type of analysis | N of datasets | Pooled prevalence estimate (%) | 95% CI | Heterogeneity |
| **Q** | **I² (%)** |
| Research diagnosis – all | 14 | 2.18 | 1.51−3.16 | 273.05\* | 95.24 |
| 1. Limited to the symptoms present both in childhood and adulthood  | 7 | 1.75 | 1.01−3.03 | 93.77\* | 93.60 |
| 2. Limited to geographical regions other than North America | 10 | 2.66 | 1.78−3.97 | 121.78\* | 92.61 |
| 3. Limited to age cut off ≥50 | 9 | 1.49 | 0.96−2.30 | 72.36\* | 88.94 |
| Clinical diagnosis – all | 9 | 0.23 | 0.12−0.43 | 14643.63\* | 99.94 |
| 1. Limited to registries | 7 | 0.14 | 0.07−0.29 | 13769.97\* | 99.96 |
| 2. Limited to geographical regions other than North America  | 4 | 0.11 | 0.04−0.32 | 12752.78\* | 99.98 |
| 3. Limited to age cut off ≥50 | 7 | 0.19 | 0.11−0.32 | 3834.47\* | 99.84 |
| Treatment – all | 9 | 0.09 | 0.06−0.15 | 8399.43\* | 99.90 |
| 1. Limited to geographical regions other than North America  | 7 | 0.06 | 0.04−0.10 | 3280.56\* | 99.82 |
| 2. Limited to age cut off ≥50 | 2 | 0.02 | 0.00−1.88 | 108.10\* | 99.07 |

**Table 2**

Summary of results in main meta-analyses and sensitivity analyses

\*P<0.0001