Eur Arch Psychiatry Clin Neurosci (2010) 260:287–296
DOI 10.1007/s00406-009-0076-3

ORIGINAL PAPER

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

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Received: 6 April 2009 / Accepted: 7 September 2009 / Published online: 6 October 2009

Abstract The goal of the study was twofold: (1) to investigate the effect of different diagnostic criteria on prevalence estimates of adult attention deficit hyperactivity disorder (ADHD), and (2) to provide prevalence estimates of adult ADHD for the first time in a Hungarian sample. Subjects between 18 and 60 years were included in the screening phase of the study ($N = 3{,}529$), conducted in 17 GP practices in Budapest. Adult self-report scale 6-item version was used for screening. Out of 279 positively screened subjects 161 subjects participated in a clinical interview and filled out a self-report questionnaire to confirm the diagnosis. Beside DSM-IV diagnostic criteria, we applied four alternative diagnostic criteria: 'No-onset' (DSM-IV criteria without the specific requirement for onset); full/Sx (DSM-IV "symptoms only" criteria); and reduced/Sx (DSM-IV "symptoms only" criteria with a reduced threshold for symptom count). Crude prevalence estimates adjusted for the specificity and sensitivity data of the screener were 1.35% in the 'DSM-IV' group, 1.64% in the 'No-onset' group, 3.65% in the 'Sx/full' group and 4.16% in the 'Sx/reduced' group. Logistic regression analysis showed that ADHD was significantly more prevalent with younger age and male gender [$\chi^2 = 14.46$; $P = 0.0007$]. Prevalence estimates corrected for the 'not-interviewed' subsample and adjusted for specificity and sensitivity data of the screener was 2.3% in males, 0.91% in females; 2.02% in the ≤40 years age group and 0.70% in the >40 years age group, based on DSM-IV diagnostic criteria. Prevalence rates found in this study are somewhat lower, but still are in line with those reported in the literature.

Keywords ADHD · Adult · Prevalence · Diagnostic criteria · Hungarian

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Introduction

A recent body of literature, including prospective longitudinal follow-up studies, suggests that attention deficit hyperactivity disorder (ADHD) is not only a common and disabling disorder in childhood but persists into adulthood in a high proportion of cases [8, 22, 33, 35, 45, 57, 62]. ADHD is a serious risk factor of comorbid psychiatric disorders (antisocial personality disorder, substance abuse, affective disorders) [9, 52], and also shows significant correlation with poor socioeconomic outcome and functional impairment (lower level of education, higher level of unemployment, higher rate of unsuccessful marriages, criminality and car accidents) [8, 10, 28, 31, 34]. Taking into consideration both the significant negative effects of this disorder and the fact that effective treatment tools exist in the management of ADHD both in childhood and in adulthood [41, 43], identifying and diagnosing ADHD is crucial.

Although many studies investigated the background and the consequences of adult ADHD [4, 10, 16, 28, 38, 49, 53, 54], as well as the effect of different therapeutic approaches [42, 46, 58], there is relatively small number of studies estimating the prevalence of adult ADHD. The majority of these studies directly estimated the prevalence

of ADHD in a narrowly selected sample such as community, university students, prisoners or special population of patients [1, 3, 5, 14, 17, 20, 24, 31, 39]. Most of the remaining studies used indirect estimation of prevalence in a relatively large, representative sample [18, 27, 37].

Population-based studies yielded highly variable estimates for the occurrence of adult ADHD: they estimated 1–7.3% prevalence applying DSM-IV criteria [1, 14, 17, 18, 24, 27, 31, 37, 39] and 2.5–42% when applying other, more inclusive diagnostic criteria than DSM-IV [14, 17, 24, 31].

Apart from the different methodological approaches adopted in these studies, resulting in the high variability of prevalence estimates [51], a fundamental point for estimating prevalence is the identification of cases. Differences in the applied diagnostic criteria result in major changes in the estimated prevalence rates. It has already been argued in the literature that the application of DSM-IV diagnostic criteria [2] in the diagnosis of adult ADHD might underestimate the true prevalence of the disorder [8, 24, 31]. In the literature, several approaches exist to this argument.

First, for the diagnosis of adult ADHD, it is necessary that in childhood a full diagnosis of ADHD has to be present. Furthermore, DSM-IV diagnostic criteria include the age-onset criterion, which requires that at least some of the symptoms of the disorder had to be present before the age of 7. However, an accurate symptom recall from early childhood is questionable in adults [8, 15, 26, 40, 48, 61, 63], especially when having a disorder that affects the neurobiological basis of self-reflection and self-awareness, specifically, the prefrontal cortex [8, 19, 25, 47, 50, 56, 60]. Thus, underestimation of the prevalence of adult ADHD might result from not detecting adults with ADHD who were simply not able to recall these early childhood data.

Second, considering ADHD as a developmental disorder entails that the specific behaviors affected by the disorder are manifested to a dysfunctional and inappropriate degree compared to the general population, as it is the case in childhood ADHD when applying DSM-IV criteria [8]. However, the presentation of symptoms change over time in ADHD, while the disabling feature of the disorder remains [7, 8, 10, 11, 44, 59]. As a result, the difference from the general population with regard to the presentation of these specific behaviors might be different across age groups. Therefore applying fixed diagnostic criteria in all age groups would mean that the diagnosis becomes less frequent with age [7, 8]. Barkley et al. referred to this phenomenon as adults with ADHD seem to "outgrow the diagnostic criteria" instead of outgrowing the disorder itself and suggested to adjust diagnostic criteria to the developmental differences [8, 39].

Third, according to Kooij et al. [31], the association between ADHD symptom count and functional impairment in adults was significant when at least four inattentive or hyperactive/impulsive symptoms were present [31]. This finding can serve as a rationale to relax the symptom threshold criterion for adults, which requires at least six symptoms to be present based on the current version of the DSM-IV.

Based on the emerging issues in the estimation of adult ADHD outlined above, one of the principal objectives of the present study was to investigate the effect of different diagnostic criteria on prevalence estimates of adult ADHD assessed in a large ($N = 3{,}529$) Hungarian community sample. Since to date no epidemiologic data on adult ADHD in Hungary is available, an important additional objective was to estimate the prevalence of adult ADHD in a Hungarian population.

Methods

This investigation was part of a larger study examining the epidemiology, neuropsychology, genetic background, psychopathology and clinical features of adult ADHD. The parent study was a multiphase, multicenter study including the Semmelweis University, Department of Psychiatry and Psychotherapy, and 17 general practitioners (GP) in Budapest. This paper reports on the prevalence data captured in two phases of the parent study: screening phase and phase of detailed clinical interviews.

Sample and data collection

Between June 2006 and June 2007, 3,529 patients of 17 GP practices entered the epidemiological study in the area of Budapest, Hungary. Data collection took place in the participating GP practices. Subjects between 18 and 60 years from both genders without major neurological disorder in their clinical history were included in the study. During the *screening phase,* consecutively arriving patients were entered in the study every office day of the GPs. The assistant distributed the ADHD screener to the subjects. Positively screened subjects ($n = 279$) were asked by the GP to further participate in the study. A total of 29.4% ($n = 82$) and 12.9% ($n = 36$) of this sample ($n = 279$) refused participation or failed to show up for the interview, respectively.

In the *interview phase*, positively screened subjects enrolled for this phase ($n = 161$) participated in a clinical interview and filled out a self-report questionnaire in order to confirm the diagnosis of adult ADHD. During the clinical interview, beside demographic data and diagnosis of adult ADHD, other potential comorbid psychiatric disorders and neuropsychological functioning were assessed, and samples for genetic studies were gathered. These latter data will be reported in upcoming publications.

GPs and assistants underwent training on the study protocol and basic information on adult ADHD. The

clinical interviews were conducted by one of the three trained interviewers, two psychologists and one psychiatrist resident. Inter-rater reliability of the clinical diagnosis of adult ADHD was assessed based on the DSM-IV symptom list and free clinical interview conducted in the study. Inter-rater reliability among the three raters with regard to the assessment of the DSM-IV clinical symptoms, estimated by intra-class correlation coefficient (ICC), was 0.85. Interrater agreement regarding the clinical impression of ADHD, as measured by coefficient kappa, exceeded 0.90.

All participants in the interview phase received a 2,000 HUF (~8 Euro) gift card as a compensation for providing genetic sample, according to the pertinent regulations in Hungary.

This investigation was carried out in accordance with the latest version of the Declaration of Helsinki. The study was approved by the local ethics committee and all included subjects provided written informed consent.

Estimation of the sample size

Estimation of the sample size for the study was based on the binomial model. The input parameters for the estimation were the type I error probability (alpha = 0.05), the confidence coefficient (95% confidence), the estimated baseline proportion of the prevalence of ADHD in the study population, and the required precision of the estimate (half the width of the 95% confidence interval). In particular, based on prior reports from the literature for the baseline proportion the value of 2.5% was posited; for the precision of the estimate, a value of 0.5% was adopted for the sample size computations [13, 23, 32]. Results of these computations indicated that 3,534 subjects would be sufficient to yield an estimate of prevalence with the required precision.

Measures

Adult ADHD self-report scale (ASRS)

ASRS is an 18-item self-report scale, based on the symptom list of DSM-IV, developed by the Workgroup on Adult ADHD in conjunction with the World Health Organization (WHO) [29]. Symptom frequency is measured on a 5-point Likert scale. In the screening phase of the study the 6-question, screener version of ASRS was applied. This short version of ASRS has good sensitivity and specificity as well as predictive value for the diagnosis of adult ADHD, as reported previously in the literature [29]. While during the interview phase subjects completed the full ASRS, this dataset was not included in the present analysis.

DSM-IV symptom list

A structured interview has been developed by the authors, using the symptom list of ADHD in DSM-IV (Hungarian version [12]), including functional impairment and onset criteria (i.e., whether some of the symptoms had caused problems before the age of seven) as well. The interview comprised two sections. The first section assessed the presence of ADHD in childhood and included 20 items: 18 symptoms, functional impairment and onset. The second section assessed the presence of adult ADHD based on the same items as in the first section (with the exclusion of onset, which has already been collected in the first section); functional impairment (yes/no) was established based on whether the symptoms were present and caused problems during the past half a year.

Free clinical interview

During the free clinical interview the interviewer had 20–30 min in order to collect relevant background information for supporting the validity of the clinical diagnosis. The type of information needed to be gathered was the same for all the participants, but the interview was conducted in an open-ended fashion while the interviewers were making detailed notes. The following issues had to be addressed: complications during pregnancy and delivery; developmental differences; family background (relationship with parents, siblings, brief family history); preschool nursing (problems with the other children, problems with the preschool teachers, adjustment problems); school years (studies, behavior, relationship with students/teachers); jobs (conflicts with colleagues/supervisors, frequent job and/or workplace changes); relationships; and whether the participant was satisfied with his/her life, if not what would she/he change?

Demographic and clinical characteristics

The following items were included in the assessment of demographic and clinical characteristics: age, gender, years of education, type of education, marital status, actual reason for visiting the GP (administrative or somatic), psychiatric and somatic history, family history, medications taken on a regular basis, smoking status, handedness.

Diagnosis of adult ADHD

Based on the documentation of the interview and the DSM-IV diagnostic criteria the interviewer team decided whether the participant fulfilled the criteria for the clinical diagnosis of adult ADHD. In addition, based on previous adult ADHD prevalence studies [17, 24, 31], alternative diagnostic criteria were also created. Below, we present these

alternative criteria based on their relation to the DSM-IV criteria:

1. *'ADHD_DSM-IV' diagnostic group* based on the full set of DSM-IV criteria for both childhood and adult ADHD (combined or inattentive or hyperactive/impulsive type) with supporting background information based on the clinical interview.
2. *'ADHD_No-onset' group* based on DSM-IV criteria for both childhood and adult ADHD (combined or inattentive or hyperactive/impulsive type), excluding onset criterion.
3. *'ADHD_full/Sx' group* based on DSM-IV symptom criterion only (6 symptoms had to be present out of the 9 symptoms of either inattention or hyperactivity/impulsivity, or both) for both childhood and adult ADHD.
4. *'ADHD_reduced/Sx' group* based on a reduced number of symptoms present from DSM-IV symptoms (4 out of 9 symptoms of either inattention or hyperactivity/impulsivity, or both) in adulthood, while in childhood original DSM-IV symptom criterion had to be present.

Statistical analysis

The Statistical Analysis System for Windows (version 9.1; SAS Institute, Cary, NC) was used for statistical analyses. All statistical analyses used the alpha error level of 0.05 (two-sided) and 95% confidence intervals. Demographic and basic background characteristics were summarized by descriptive statistics, including frequency tables for discrete variables and *n*, mean, SD and minimum and maximum for continuous variables. For the purpose of inferential statistical analyses, the group comparisons were based on the general linear model (GLM) approach. In the GLM model, each demographic and descriptive variable of interest served as a dependent variable (in separate analyses). The grouping variable (e.g., ADHD yes vs. no) served as an independent variable in the GLM analysis. Group differences in terms of categorical variables (e.g., gender distribution) were investigated by Chi-square analysis.

Estimation of prevalence from the study sample was based on the binomial model using the proportion of the subjects who screened positive on the ADHD screener test. For the estimation of 95% confidence interval around the sample proportion of positive cases, the sample estimate of the standard error was adopted. For the computation of the standard error, the following formula was applied:

$$\mathrm{SEp} = \sqrt{[p(1-p)/n]},$$

where n, p and SEp denote the sample size, the estimated proportion of cases (subjects with ADHD), and the standard error of the estimate, respectively.

Since screening tests are not ideal (i.e., are less than 100% accurate) in most practical applications, the estimated positive fraction of the sample from such tests cannot be directly applied for determining the true population prevalence of a disease. In order to determine the true population prevalence, one has to take into consideration the established specificity and sensitivity of the test under consideration. Adjusting for the screening test's specificity and sensitivity, Gart and Buck [21] provided an estimate of the true population prevalence using the following formula.

$$\mathrm{PREVp} = (\mathrm{POS} + \mathrm{Sp} - 1)/(\mathrm{Se} + \mathrm{Sp} - 1),$$

where PREVp, POS, Sp and Se denote, respectively, the true population prevalence, the proportion of positive cases in the sample, and the specificity and the sensitivity of the screening test. For the specificity and sensitivity of the ASRS screener that we used in our study, we adopted published values from the pertinent literature based on the investigation of large samples of subjects [29].

We note that in addition to the estimate of the overall prevalence of adult ADHD in the entire study population, separate estimates were derived for the males and females, respectively. The rationale for a separate estimation by gender was that the true positive fraction of population showed a significant difference between males and females (see below for details).

Results

Patient disposition and demographic data

During the screening phase 3,529 subjects were recruited for the study. Out of 279 subjects who had screened positive on the short version of ASRS, 161 gave informed consent and were interviewed. Basic demographic data and the ASRS mean scores of the study sample, as well as the 'positively screened', 'interviewed' and 'not-interviewed' subsamples are presented in Table 1.

The entire study sample and the subsamples did not differ significantly in age. With regard to gender distribution, there was a small difference between the 'positively screened' subsample (61.51% females) and the rest of the sample (70.25% females), which reached statistical significance due to the large sample size ($\chi^2 = 8.35$; $P = 0.0038$). We examined the association between gender and ASRS score in the study sample and found that females had slightly higher score on the screener (females, $M = 13.5$; SD = 3.6 vs. males, $M = 13.3$; SD = 3.5); the difference did not reach statistical significance [$F(1;3,510) = 3.41$, $P = 0.065$].

Table 1 Basic demographic data and ASRS screener score of the study sample

	Study sample ($N = 3,529$)	Positively screened ($n = 279$)	Interviewed ($n = 161$)	Not-interviewed ($n = 118$)
Gender [female n (%)]	2,195 (62.2)	196 (70.25)*	119 (73.91)	77 (65.25)
Age mean (SD)	40.47 (12.41)	40.95 (12.2)	41.45 (11.89)	40.26 (12.64)
ASRS[a] mean (SD)	13.46 (3.61)	20.12 (2.68)	20.6 (2.74)	19.48 (2.46)

* $p = 0.0038$; significant difference between positively screened subsample and the study sample

[a] Adult self-report rating scale; 6-item screener; score ranges between 0 and 24

Table 2 Association between basic demographic data, ASRS screener score and ADHD status of the interviewed subsample ($n = 161$)

	ADHD_DSM-IV ($n = 28$)	No ADHD_DSM-IV ($n = 131$)	Statistics
Gender [female, n (%)]	15 (51.72)	104 (78.79)	$\chi^2 = 9.03$ $p = 0.0027$
Age mean (SD)	35.31 (10.03)	42.81 (11.86)	$F(1;158) = 10.0$ $p = 0.0019$
Years of education Mean (SD)	12.55 (2.7)	12.81 (3.07)	$F(1;159) = 0.18$ $p = 0.68$
Marital status [n (%)]			
0 = single	12 (41.38)	28 (21.37)	$\chi^2 = 5.20$
1 = married	11 (37.93)	66 (50.38)	$p = 0.16$
2 = divorced	5 (17.24)	28 (21.37)	
3 = widow	1 (3.45)	9 (6.87)	
ASRS Mean (SD)	22.28 (2.87)	20.23 (2.58)	$F(1;152) = 13.93$ $p = 0.0003$

ASRS score was associated with age in the study sample indicating that higher score on ASRS tended to co-occur with younger age. However, the strength of the association was clinically rather modest (Pearson $r = -0.055$; $p = 0.0012$), and obtained statistical significance as a result of the large sample size.

Among positively screened subjects, the 'interviewed' and the 'not-interviewed' subsamples did not differ significantly concerning age and gender. Although a significant difference was found between these two subsamples on the mean score of the screener, this difference was characterized by rather small effect size [approximately 1 point difference on a scale (ASRS screener) with a range of 0–24 points]. The direction of the difference shows that the 'interviewed' subsample tended to have slightly higher screener score than the 'not-interviewed' subsample.

For the 'interviewed' subsample, further demographic characteristics including marital status and years of education were available; these variables were not associated with ADHD diagnostic status. Gender, age and ASRS score, however, showed significant association with ADHD status (Table 2). Results indicated that in the ADHD_DSM-IV diagnostic group, females were underrepresented and subjects were significantly younger compared with those without ADHD.

Separate analyses were conducted to evaluate the association between gender and ADHD diagnostic status in each diagnostic group. Females were consistently and significantly underrepresented in all diagnostic groups compared with the rest of the 'interviewed' subsample. Specifically, ADHD_DSM-IV ($n = 29$) had 51.72 females versus 78.79% in the rest of the 'interviewed' subsample ($n = 132$) [$\chi^2 = 9.03$; $p = 0.0027$]; similarly, ADHD_No-onset ($n = 33$) had 51.52 females versus 79.69% ($n = 128$) [$\chi^2 = 10.80$; $p = 0.0010$]; ADHD_Sx-full ($n = 61$) had 62.3 females versus 81% ($n = 100$) [$\chi^2 = 6.88$; $p = 0.0087$]; ADHD_Sx-reduced ($n = 68$) had 64.71 females versus 80.65% ($n = 93$) [$\chi^2 = 5.18$; $p = 0.0229$].

Logistic regression analysis was carried out for further investigation of the association between gender, age and ADHD diagnostic status. This analysis showed a significant effect of both demographic variables on ADHD diagnostic status [$\chi^2 = 14.46$; $p = 0.0007$]; however, there was no significant interaction between the effect of gender and age [estimate, -0.031; standard error, 0.043; $\chi^2 = 0.5124$; $p = 0.4741$].

Prevalence estimates

Observed (raw) data, crude prevalence and prevalence estimates adjusted for the sensitivity and specificity of the screener, are summarized in Table 3 for each of the diagnostic groups defined in our study.

Table 3 Crude prevalence rates and prevalence estimates after adjusting for sensitivity and specificity data of the screener ($n = 161$)

Diagnostic group	Raw data [n (%)]	Crude estimate[e] % (CI)	Crude estimate adjusted for specificity and sensitivity data of the screener %(CI)		
			Estimate based on expected value (%)	Estimate based on upper CI of expected value (%)	Estimate based on lower CI of expected value (%)
DSM-IV[a]	29 (18.01)	1.4 (1.0–1.81)	1.35 (0.4–2.86)	2.14 (1.0–3.89)	0.7 (0.15–2.0)
No onset[b]	33 (20.50)	1.62 (1.2–2.0)	1.64 (0.63–3.24)	2.46 (1.3–4.3)	0.95 (0.07–2.34)
Sx full[c]	61 (37.89)	3.0 (2.43–3.56)	3.65 (2.27–5.84)	4.58 (3.03–7.04)	2.78 (1.56–4.72)
Sx reduced[d]	68 (42.24)	3.34 (2.75–3.93)	4.16 (2.69–6.5)	5.09 (3.44–7.7)	3.26 (1.95–5.34)

[a] DSM-IV criteria for both childhood and adult ADHD with supporting background information based on the clinical interview

[b] DSM-IV criteria for both childhood and adult ADHD, excluding onset criterion

[c] DSM-IV symptom criterion only (6 of the 9 symptoms of either inattention or hyperactivity/impulsivity) for both childhood and adult ADHD

[d] Reduced number of symptoms present from DSM-IV symptoms (4 of 9 symptoms of either inattention or hyperactivity/impulsivity) in adulthood, while in childhood original DSM-IV symptom criterion had to be present

[e] Based on observed values on the 'interviewed' subsample

A corrected estimate of prevalence of adult ADHD was also calculated by accounting for the 'not-interviewed' subsample. In particular, since raw data were unavailable for those who did not participate in the interview phase of the study, crude prevalence of adult ADHD for this subsample was estimated using three alternative approaches. First, we adopted the crude prevalence estimate from the 'interviewed' sample as a default estimate for the 'not-interviewed' sample (positively screened with no observed data for the final diagnostic status). Second (and third), for the purpose of sensitivity analyses, for the latter group we applied, respectively, the lower and the upper values of the 95% confidence interval of the crude prevalence rate of the 'ADHD_DSM-IV' diagnostic group.

Using the crude (pooled) prevalence rates from the 'interviewed' subsample (based on available raw data) and the 'not-interviewed' subsample (based on estimation) adjusted prevalence estimate of adult ADHD was calculated for the entire study sample. These adjusted prevalence estimates are summarized in Table 4 and Fig. 1. The sample was stratified by age and gender because of the previously described effect of these variables on ADHD diagnostic status. For the purpose of age stratification we applied the median age of the sample (40.5 years), thus two strata were described: subjects ≤40 years old and subjects >40 years old.

Table 4 Crude and adjusted prevalence estimates after correction for 'not-interviewed' subsample, stratified by gender and age

	Male	Female	≤40 years	>40 years
Crude prevalence estimate based on expected value (%)	2.07	1.12	1.88	0.98
Crude estimate adjusted for specificity and sensitivity data of the screener, based on estimated value (%)	2.3	0.91	2.02	0.70

Discussion

This study provided the first estimates on the occurrence of ADHD among Hungarian adults, evaluating a population of Hungarian GP practices. Prevalence of adult ADHD in this population, based on full DSM-IV diagnostic criteria, is in line with the result of a recent meta-analysis of prevalence rates (based on data of population-based studies) [51], where 2.5% (95% CI 2.1–3.1) was calculated as the prevalence rate of adult ADHD. Our result is also comparable to the 1% prevalence estimate reported by Kooij et al. [31], applying DSM-IV diagnostic criteria in a similar setting.

However, prevalence rates found in the present study appear somewhat lower than those reported in two studies not providing crude prevalence estimates on their relatively large, representative samples but using indirect estimation for assessing the prevalence of adult ADHD in the general population [18, 27]. In these studies prevalence rates were 4.4 and 5.2% in the US and 3.4% cross-nationally [18, 27].

In the present study we applied different alternative diagnostic criteria, according to previously described approaches. Specifically, we defined an 'ADHD_No-onset' group, in which DSM-IV diagnostic criteria were relaxed with not applying the age of onset criterion (i.e., symptoms present before the age of 7); an 'ADHD_full/Sx' diagnostic group, in which we applied only the symptom threshold criterion of DSM-IV (≥6 symptoms, of either inattention or hyperactivity/impulsivity or both, present both in childhood and in adulthood); and an 'ADHD_reduced/Sx' diagnostic group, in which we applied a further relaxed

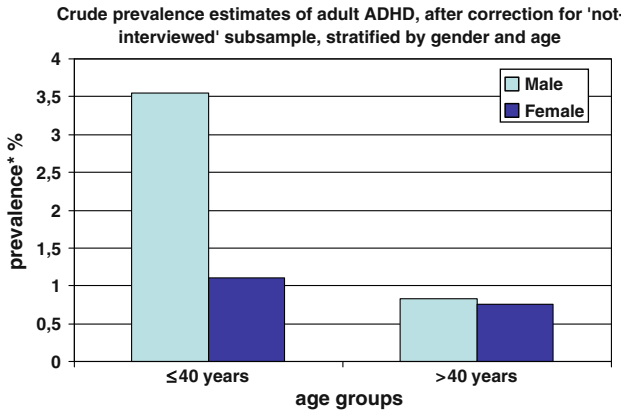

Fig. 1 Adjusted prevalence estimate of adult ADHD for the entire study sample, based on crude (pooled) prevalence rates from the 'interviewed' subsample (based on available raw data) and the 'not-interviewed' subsample (based on estimation); corrected for the sensitivity and specificity data of the screener and stratified by age and gender. For the purpose of age stratification we applied the median age of the sample (40.5 years), thus two stratum were described: subjects ≤40 years old and subjects >40 years old

DSM-IV symptom threshold criterion (≥4 symptoms, of either inattention or hyperactivity/impulsivity or both, present in adulthood, ≥6 symptoms present in childhood). Based on our results, these alternative diagnostic groups resulted in higher prevalence rates in the study sample, following the gradual relaxation of the diagnostic criteria.

In particular, the 'ADHD_No-onset' group showed the least and 'ADHD_reduced/Sx' group showed the highest increase in prevalence compared to the 'ADHD_DSM-IV' diagnostic group. Interestingly, although prevalence estimates increased substantially, they remained within the range of prevalence rates found in previous studies based on only DSM-IV criteria. The observed increase of prevalence estimates, parallel to modification of diagnostic criteria, in our study was comparable to what was found in the study of Kooij et al., in a similar setting. These authors found that after relaxing the diagnostic threshold from six symptoms to four symptoms, prevalence rate increased from 1 to 2.5% [31].

When comparing the prevalence rate found in this study based on the 'ADHD_full/Sx' diagnostic group, with studies in which only symptom-based DSM-IV criteria were applied, results were similar: specifically 3.78 in this study versus 4% in a study among university students [24] and 4.7% in a sample of subjects applying for driving license [39].

In the present study females were consistently and significantly underrepresented in all diagnostic groups. In the background of this phenomenon we found a significant effect of gender on ADHD diagnostic status. Additionally, significant association of ADHD status with age was also found, showing that in the present sample the prevalence rate of DSM-IV based diagnosis of adult ADHD was reduced in the >40 years stratum compared with the ≤40 years stratum. These observations together are in line with the result of a recent meta-analysis which found a complex effect of age and gender on the prevalence of adult ADHD when applying DSM-IV diagnostic criteria. Specifically, this meta-analysis reported that while in younger age groups prevalence increases, in older age groups prevalence decreases when females are underrepresented in the sample and vice versa [51]. Although results of our study seem to support these findings, the interaction model tested by logistic regression analysis did not show significant interaction between the effect of age and gender, which may be attributable, at least in part, to the small sample size available for this analysis. Furthermore, the effect of age on the prevalence of adult ADHD has to be interpreted cautiously as well, since this was a cross-sectional study and the sample size was small in the ADHD_DSM-IV subsample.

Nevertheless, the above described result, taken together with the findings of the previously referred meta-analysis provides a new approach toward the criticism of the DSM-IV diagnostic criteria, when applied in adults. The finding that prevalence might decrease with age when females are underrepresented in a sample, while prevalence might increase with age when females are predominant in a sample [51] suggests the emergence of "new" cases; a phenomenon which cannot be interpreted in the context of a developmental disorder. We think that this finding rather implies the inappropriateness of case identification. In particular, based on our finding regarding the association of prevalence estimate with age and gender, it is conceivable that the DSM-IV diagnostic criteria function differently across age groups, identifying lesser females in lower age groups and lesser males in the higher age groups.

As described in the "Results" section, while the ASRS screener showed a statistically significant association with age when examining the 'interviewed' versus 'not-interviewed' subsamples, the observed difference was characterized by rather small effect size. Therefore, the clinical significance of this association concerning prevalence estimates is considered to be negligible.

Our results have to be interpreted in light of certain limitations. First, since in the present study a sample of convenience was collected, prevalence estimates cannot be generalized for the entire population. Second, during the diagnostic procedure only self-report was available. Third, there was a relatively large refusal rate (29.4%) among positively screened subjects for further participation in the study. However, the refusal rate observed in our study is comparable to those reported in the literature [18], and its impact was addressed via sensitivity analyses. These analyses indicated that the prevalence estimates remained

robust to the changing of input parameters in a broad range (i.e., when we applied the upper and lower 95% confidence limits of the observed proportion prevalence for the 'not-interviewed' subsample in order to estimate the prevalence for the entire target population).

Another possible limitation of our study is that including subjects in GPs' office might introduce a selection bias. Based on the current data, it can not be inferred whether people with ADHD would be underrepresented in this population due to their difficulties in waiting hours in a waiting room because of their hyperactive and impulsive symptoms, or, conversely, people with ADHD would be overrepresented due to more frequent health problems. Based on published data about the outcome and impairments associated with adult ADHD it can be suggested that adults with ADHD are more prone for accidents, showing more health related problems and lower level of self-care compared with non-ADHD peers, which would result in more frequent visits at the GP [30, 55]. Notably, the prevalence estimates of Kooij et al. [31], which were also based on a GP population, similar to our results, are in the lower end within the prevalence range published in the literature.

In summary, prevalence rates found in the Hungarian study population are somewhat more conservative, but still are in line with those reported previously in the literature, providing further support for the validity of the diagnosis. Similar to other reports, results of the present study also showed that relaxing DSM-IV diagnostic criteria with regard to the age-onset criterion as well as the symptom threshold increases the prevalence estimates.

DSM-IV criteria have never been validated among adults. This fact taken together with previous findings indicating that DSM-IV might underestimate the prevalence of ADHD in adults, and with our finding that DSM-IV detects cases significantly differently across age groups and across genders, suggests a reconsideration of DSM-IV diagnostic criteria. For example, considering the change of the age of onset criterion to an older age limit as well as reducing the symptom threshold has already been suggested in the literature [36]. As pointed out also by Barkley et al. [6], in future research, targeting the improvement of ADHD diagnostic criteria in adults, ideally, two main issues should be taken into consideration: (1) developmental appropriateness with regard to the face validity of the symptoms and the occurrence of the symptoms (latter generally considered as being 1.5SD from the mean); (2) overall functional impairment, i.e., ADHD cases, identified by the different diagnostic criteria, demonstrate functional impairment, significant distress and poor outcome compared to non-ADHD peers.

Improving the potential for proper identification of patients with ADHD is a fundamental issue concerning treatment, outcome, as well as future studies on the better understanding of neurobiological background and other etiological factors of the disorder.

Acknowledgments Authors would like to express their gratitude to the 17 general practitioners and their assistants for the contribution in this study: Katalin Mohácsi, Enikő Zsoldos, Anikó Szűcs, Erzsébet Csibi, Gábor Karai, Péter Varjassy, Beáta Galló, Mária Mihály, Zsuzsanna Miskolczi, János Laky, Annamária Balogh, Zsuzsanna Kodák, Éva Fenyővári, Júlia Zolnay, Ferenc Fodor, Éva Kretz, Zsuzsanna Horváth. Especially, we really appreciate the professional support of Éva Gyarmathy who conducted the training of the interviewers.

Conflict of interest statement This study was supported by the Moravcsik Foundation and Eli Lilly and Company. Neither the Company nor the Foundation had further role in the design or conduct of the study, in analyses or interpretation of data, in writing of the report, or in the decision to submit the paper for publication.

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