

Prevalence and Predictors of Medication use in Children with ADHD: Evidence from a Community-based Longitudinal Study

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ABSTRACT

Objectives: To determine, in a community-based sample of primary school-aged children meeting diagnostic criteria for attention-deficit/hyperactivity disorder (ADHD), 1. the proportion of children with ADHD treated with medication; 2. predictors of medication use; and 3. the association between medication use and psychological service utilization.

Methods: Grade 1 children with ADHD were recruited through 43 schools in Melbourne, Australia, using a two-stage screening and case confirmation procedure. Parent report of medication treatment, clinician diagnosis and psychological service use were collected at ages 7 and 10 years. Medication use was analyzed by ADHD subtype. Predictors of medication treatment examined included ADHD symptom severity and persistence, externalizing comorbidities, poor academic performance and social disadvantage. Unadjusted and adjusted logistic regression were used to identify the predictors of medication status.

Results: 179 children with ADHD were recruited. At baseline 17.3% had been clinically diagnosed with ADHD, increasing to 37.7% at age 10 years. At baseline 13.6% were taking ADHD medications, increasing to 25.6% at age 10. Children with the combined and hyperactive-impulsive subtypes were more likely to be taking medication than those with inattentive subtype (age 7 $p=0.002$; age 10 $p=0.03$). ADHD symptom severity (Conners 3 ADHD Index) at baseline was concurrently and prospectively associated with medication use at both ages (both $p=0.01$), and ADHD symptom severity at age 10 was also associated with medication use at age 10 ($p=0.01$). Baseline area-level disadvantage was associated with medication use at age 7 ($p=0.04$). At 10 years, children receiving

medication were more likely than those who were not, to be receiving psychological services ($p=0.001$).

Conclusions: In this study only a minority of children meeting diagnostic criteria for ADHD were diagnosed clinically or treated with ADHD medication by age 10. The strongest predictors of medication treatment were ADHD symptom severity and area disadvantage.

INTRODUCTION

Attention-deficit/hyperactivity disorder (ADHD) is the most common neurodevelopmental disorder of childhood, with an estimated prevalence in the order of 6-7% (Polanczyk et al. 2014). While stimulant medication is the most effective symptomatic treatment (Jensen 1999a), and is recommended for children with significant ADHD (American Academy of Pediatrics 2011) which persists after non-pharmacological approaches have been offered (NICE 2018), the prescribing of stimulant medication for children with ADHD remains a controversial subject (Dunlop and Newman 2016).

The important question of whether stimulant medications are overprescribed has been of concern to the community and researchers since prescribing for ADHD became widespread in the US in the 1970s. In the US the proportion of children for whom ADHD medications are prescribed has increased incrementally, and was estimated as 6.1% in 2011 (Visser et al. 2014). Factors suggested to have contributed to increased rates of prescribing include changes in diagnostic criteria, increasing awareness, and better access to services particularly for low income families (Garfield et al. 2012). Safer has discussed some practice changes needed to improve the reliability of diagnosis and inform sound prescribing decisions, such as multi-source data collection and greater communication between physicians and teachers (Safer 2000).

However, to address the question of overprescribing at a population level, the prevalence of ADHD and rate of medication prescription needs to be examined in samples which include non-referred children. Using epidemiological survey data from 4

U.S. communities, Jensen et al found that only 12.5% of children meeting DSM-III-R ADHD diagnostic criteria had been treated with stimulant medications in the preceding 12 months (Jensen et al. 1999b). While this finding suggests undertreatment rather than overtreatment, more current data are needed, including from countries outside the US.

Various methods have been used to measure the extent of stimulant medication prescribing in Australia. Studies using data derived from state government regulatory authorities (Salmelainen 2002) and Pharmaceutical Benefits Scheme databases (Hollingworth et al. 2011) have found the prevalence of prescription of stimulant medication to be approximately 1-2% of the childhood population, and a recent study of a nationally representative sample of children and adolescents obtained a similar result (Sawyer et al. 2017). Although there is considerable regional variation in prescribing of stimulant medications in Australia (Berbatis et al. 2002), overall the percentage receiving stimulant medication in Australia has been estimated to be between those of North America and Europe (Berbatis et al. 2002). However, population-level estimates are not able to inform about variation across sub-groups of patients, nor about predictors of medication use, as they lack the patient-level data required for such analysis.

The variables associated with the prescription of ADHD medication are not well understood. Studies examining this question are either dated or restricted to children who are being managed by a pediatrician. An Australian study conducted in 1998 identified three factors associated with stimulant medication use in the general population (Sawyer et al. 2002). In this study 1.8% of children were prescribed stimulant medication, and only 1 in 8 children with ADHD were taking stimulants. The

main predictors of medication use were male sex, attending a pediatrician, and having high levels of inattention or aggression (Sawyer et al. 2002). In a recent audit of Australian pediatricians' practice 80% of children with ADHD were treated with medication (Efron et al. 2013), a similar proportion to that reported in the United States (Visser et al. 2014). Medication prescription in these children was predicted by age, but not by sex or socio-economic status (SES) (Efron et al. 2013). There has been little investigation of other potential child (e.g. ADHD symptom severity, academic and social function) and family level (e.g. parent mental health) predictors of medication use in children with ADHD. Additionally, it is unknown whether children who receive medication have different patterns of use of recommended non-pharmacological management e.g. psychological services.

Therefore, we investigated these issues using a community-based sample of primary school-aged children meeting Diagnostic and Statistical Manual of Mental Disorders 4th edition (DSM-IV) diagnostic criteria for ADHD (including cross-situational impairment). Specifically, we aimed to determine:

1. proportion of children with ADHD treated with ADHD medication (stimulant or non-stimulant) at ages 7 and 10 years in a community sample of children with ADHD (overall and by subtype);
2. predictors of prescribing including ADHD symptom severity, ADHD persistence, presence of comorbidities, sex, academic performance, social functioning, primary caregiver mental health, and family- and area-level indicators of SES; and

3. whether receipt of ADHD medication was associated with different patterns of use of psychological services.

We hypothesized that contrary to popular belief only a minority of children meeting criteria for ADHD would be treated with medication. We further hypothesized that those factors that are most strongly indicative of functional impairment in children with ADHD, namely ADHD symptom severity and persistence, the presence of externalizing comorbidities, and poor academic performance would be the strongest predictors of medication prescription. In the absence of prior data, we offered no hypotheses regarding the prevalence of use of psychological services by children who were and were not receiving ADHD medication.

METHOD

We analyzed data from the Children's Attention Project (CAP), a longitudinal community-based cohort study of children with ADHD and non-ADHD controls (Sciberras et al. 2013). Only those children who were identified as having ADHD at baseline were included for the current paper (i.e. non-ADHD controls were excluded). Participants were recruited from 43 government primary schools in metropolitan Melbourne, Australia. Schools were recruited via Victorian Department of Education and Training regions selected for representation of diverse socioeconomic communities. Participants were recruited via a two-stage screening and case-confirmation procedure. The first stage involved parent and teacher Conners 3TM ADHD Index score (Conners 2008) completed for all grade one children in participating schools. Those children who screened positive by both parent and teacher ratings, and/or whose parents reported

previous ADHD diagnosis were invited into the longitudinal study. A structured diagnostic interview (National Institute of Mental Health Diagnostic Interview Schedule for Children Version IV [DISC-IV]) (Shaffer et al. 2000) was then completed with parents who consented in order to confirm or refute ADHD caseness and to identify comorbid disorders. Children who met criteria for ADHD on the DISC-IV made up the ADHD cohort for this study. Exclusion criteria were intellectual disability, severe medical conditions, genetic disorders, moderate-severe sensory impairment, neurological problems, and parents with insufficient English to complete the interviews or questionnaires (for details of participant flow, see Efron et al. 2014). Measures were collected via detailed parent surveys at baseline (age 7 years) and 3 year follow-up (age 10 years). An additional report of medication status was also collected by parent survey midway (at 18 months) between the main data collections.

Study approval was granted by the Human Research Ethics Committees of the Royal Children's Hospital, Melbourne (#31056), and the Victorian Department of Education and Training (#2011_001095).

Measures:

Medication status (yes/no) was determined by parent response to the survey question “*Is your child currently taking medication to assist with learning, behaviour or emotional difficulties?*” If they responded *yes*, the parent was asked to indicate which medication(s) their child was taking from a list which included both generic and trade names for all available methylphenidate and dexamphetamine products, and atomoxetine, as well as “other please specify”. Other medications which may have been used to treat ADHD but which can also be used for other indications (e.g., clonidine,

tricyclic antidepressants) were excluded from the ADHD medication category, as we did not have data on indication for use and so could not say whether these medications were being used to treat ADHD.

Clinical diagnosis of ADHD (independent of the study) and *Use of psychology services* were ascertained in the parent survey with the questions ‘*Has your child ever been diagnosed with ADHD by a health professional?*’ and ‘*Have you sought professional help from a psychologist for any concerns about your child’s learning, behaviour or emotions in the last 12 months?*’

ADHD subtype and persistence were ascertained using the DISC-IV (Shaffer et al. 2000) conducted face-to-face with parents. *Persistence* was defined as meeting diagnostic criteria for ADHD at both ages. *ADHD symptom severity* was measured using the parent-reported 10-item Conners 3 ADHD Index (Conners 2008). Items are rated from “0: Not true at all (Never, Seldom)” to “3: very much true (Very often, Very frequent)”. Scores are transposed from 0-3 to 0-2 as follows: the two less severe responses (0 + 1) are combined to 0, 2 to 1, and 3 to 2. Transposed scores are then added to create summary scores (range 0 - 20), with higher scores indicating greater ADHD symptom severity. This measure has excellent test-retest reliability (Pearson’s $r = 0.71-0.98$) and internal consistency (parent $\alpha = 0.92$) (Conners 2008).

Mental health comorbidities were assessed using the DISC-IV (Shaffer et al. 2000). Children were classified as having an *internalizing disorder* if they met criteria for separation anxiety disorder, social phobia, generalized anxiety disorder, post-traumatic

stress disorder, obsessive-compulsive disorder, major depressive disorder, dysthymia, hypomania, or manic episode, and an *externalizing disorder* if they met criteria for oppositional defiant disorder or conduct disorder.

Academic achievement was assessed using the word reading and math computation subtests of the Wide Range Achievement Test 4 (Wilkinson and Robertson 2006). Age-based standard scores were derived for all measures (normative mean [SD] = 100 [15]).

Social functioning was assessed by using the 5-item parent-reported peer problems scale of the Strengths and Difficulties Questionnaire (Goodman 1997). Items are rated from “Not True” (0) to “Certainly true” (2), and summed to give scores with a range of 0-10. Higher scores indicate poorer functioning.

Primary caregiver variables were ascertained by parent survey. *Primary caregiver ADHD symptoms* were measured using the 12-item Conners Adult ADHD Rating Scale (CAARS: internal consistency $\alpha = 0.76$) (Conners et al. 1999). Respondents indicate how much/frequent each statement applies to them recently from “Not at all” (0) to “Very much, very frequently” (3), and scores are summed to derive a total score.

Primary caregiver mental health problems was measured using the Kessler 6, a 6-item validated and widely used self-report screen for psychological symptoms. Responses range from “None of the time” (0) to “All of the time” (4), and scores are summed to derive a total score (Furukawa et al. 2003). *Family demographic characteristics*, collected by parent-report, included highest primary caregiver educational level, family income, and area-level SES, measured by the Socioeconomic Indexes for Areas

Disadvantage Index (SEIFA) for the child's postcode of residence (mean [SD] = 1000 [100]; higher scores reflect less disadvantage) (Australian Bureau of Statistics 2011).

Statistical analyses:

Descriptive statistics were used to describe sample characteristics and frequency of medication use (Aim 1). Logistic regression analyses were conducted at each time point to examine the relationships between medication use (outcome) and the following a priori identified potential predictors: child sex, ADHD symptom severity and persistence, internalizing and externalizing comorbidities, academic performance, peer problems, primary caregiver ADHD and mental health, parent level of education, family income, and area-level SES (Aim 2). Crude (unadjusted) models with one predictor only and adjusted models with only predictors that were statistically significant at 5% level in the crude model were fitted. Baseline predictors were considered in models fitted to medication status at 7 years of age and both baseline and follow-up predictors were considered in models fitted to medication status at 10 years. The squared Pearson correlation measure was reported to quantify explained variation (R squared) for the adjusted models. All regression analyses allowed for clustering within schools using multilevel (mixed-effects) logistic regression. Chi squared tests were conducted to compare medication use and psychology service utilization by ADHD subtype (Aim 3). For comparison, all continuous predictors in the logistic regression models were converted to standardized scores to have a mean of 0 and a standard deviation of 1. Analyses were performed using Stata 15.0 (Stata Corp, College Station, TX).

RESULTS

The cohort characteristics and baseline functional status have been reported previously (Efron et al. 2014). There were 179 children with ADHD in the cohort at baseline, of which 144 (80.4%) participated in the 3 year follow-up. Compared to those who participated in the 3 year follow-up, parents who did not participate were less likely to have completed high school (41.9% [13/31] vs 67.6% [92/136] or university (6.5% [2/31] vs 28.7% [39/136]). There were no differences in income between participants and non-participants at the 3 year follow up.

Almost one third (45/144, 31%) did not meet diagnostic criteria for ADHD on the DISC-IV at follow-up (“remitted”). At baseline, 17.3% (31/179) had received an independent clinical diagnosis of ADHD, which increased to 37.7% (49/130) at 3 year follow-up (Table 1). At baseline, 13.6% (23/169) of children were taking ADHD medications. This increased to 25.6% (35/137) at follow-up and included 6 of the 46 children (13%) who no longer met ADHD diagnostic criteria. Methylphenidate represented all of the ADHD medication at age 7, and 91.4% at age 10.

ADHD medication continuity

Data on medications were collected at 3 time-points (baseline, 18 month and 3 year follow-up), with complete data available for 104 children. Eight (7.7%) children were taking ADHD medication at one time point, nine (8.7%) at two time-points (8 of whom were taking ADHD medication at both 18 months and 3 year follow-up), and ten (9.6%) at all three time points.

Medication and psychology service use by subtype (Table 2)

Children with either the combined or the hyperactive-impulsive ADHD subtype were more likely to be taking medication than those with inattentive subtype at both 7 years ($p=0.002$) and 10 years ($p=0.03$). These children were also more likely to access psychology services at age 7 ($p=0.04$), but not age 10 years, compared to children with the inattentive subtype.

Predictors of ADHD medication use at ages 7 and 10 years (Tables 3 and 4)

ADHD symptom severity at age 7 was associated with medication use at both ages 7 and 10, and ADHD symptom severity at age 10 was also associated with medication use at age 10 (all $p=0.01$). Low area-level SES at age 7 was also associated with medication use at age 7 ($p=0.04$) but not at age 10 in cross-sectional ($p=0.40$) or prospective ($p=0.06$) analyses. Household income below \$30,000 was associated with medication use at age 7 in the unadjusted analysis, but this association was no longer statistically significant at the 5% level in the adjusted analysis ($p=0.43$).

Psychology treatment by medication status

Overall 39% of the ADHD cohort had sought help from a psychologist in the previous 12 months at age 7, and 33% at age 10. At both waves, just over half of those taking ADHD medication were seeing a psychologist. Children who were taking ADHD medication were more likely to have seen a psychologist than those who were not (56.5% (13/23) vs 37.0% (54/146); $p=0.08$ at 7 years, (55.9% (19/34) vs 25.3% (24/95); $p=0.001$ at age 10 years).

DISCUSSION

In this community study of children, all of whom met diagnostic criteria for ADHD (including impairment criteria) at age 7 years, we found that only one in six had received a clinical diagnosis by age 7, and one in three by age 10. Approximately one in seven had been prescribed ADHD medication at age 7, and one quarter at age 10. Six children continued to take medication at age 10 years despite no longer meeting criteria for ADHD. The main predictor of medication use was ADHD symptom severity, and medication use was associated with higher use of psychology services.

Children with combined or the hyperactive-impulsive ADHD subtype were more likely to be taking medication than those with inattentive subtype. This finding is consistent with an American study which found that children with inattentive sub-type ADHD (known as “presentation” in DSM-5 (American Psychiatric Association 2013)) are less likely to be receive medication treatment than those with combined type ADHD (Weiss et al. 2003). It also aligns with our finding that the effect of the child’s behavior on the family (generally related to hyperactive-impulsive symptoms) is one of the main drivers of parental help-seeking for children with ADHD (Efron et al. 2016).

The presence of comorbid externalizing disorders was a predictor of ADHD medication use in the unadjusted analysis, but not in the adjusted analysis. This result suggests that, while the presence of externalizing disorders (predominantly ODD in this age category) may bring children to clinical attention, the main driver for medication prescribing is the ADHD symptoms. This is consistent with the evidence regarding the symptomatic efficacy of ADHD medications (Jensen 1999a).

In this study lower area-level SES at baseline was associated with an increased likelihood of being prescribed ADHD medication. Similarly, in a nationally representative sample Sawyer et al. found highest prevalence of stimulant prescribing in the lowest household income bracket (Sawyer et al. 2017), and Calver et al (2007) found highest prevalence of stimulant prescribing to Western Australian in the lowest SES group (Calver et al. 2007). Reasons for the association between SES status and ADHD medication prescribing are unknown. We sampled across diverse communities making systematic referral bias unlikely. Powers et al (2008) proposed that children from low SES groups are more likely to be recommended stimulant treatment for their ADHD because they have less access to resources commonly employed both within and outside of the home by middle and high SES families to promote academic success (Powers et al. 2008). This is unlikely to explain our findings as poor academic performance was not a predictor of ADHD medication use in this study. Alternatively, higher SES status parents may be more prepared to wait to see if symptoms improve, or more inclined to seek non-pharmacological management for their children's ADHD. The finding of an association between the area-level SES indicator and medication use suggests that community service characteristics may be important in determining whether children with ADHD are assessed and treated. The 2015 Australian Atlas of Healthcare Variation identified substantial variation by area in the prevalence of prescribing of psychotropic medications for children and adolescents, suggesting a potential target for practice improvement (Australian Commission on Safety and Quality in Health Care and National Health Performance Authority 2015). Further research is needed to better understand the factors influencing access to care for Australian children with ADHD.

In relation to non-pharmacological management, at each data collection point in this study approximately one third of children with ADHD had seen a psychologist in the last year. Children were more likely to have seen a psychologist if they had been treated with ADHD medications. This suggests that parents who sought a medical diagnosis were also more likely to seek psychology support, and/or that prescribers identified and addressed comorbidities alongside medication treatment for ADHD, in accordance with clinical practice recommendations (American Academy of Pediatrics 2011).

The finding of a higher prevalence of ADHD medication use in our cohort at age 10 (26%) than at age 7 (13%) is consistent with previous Australian data showing the peak age for stimulant medication use is 9-11 years (Salmelainen 2002). Sawyer et al reported that 14% of Australian children and adolescents aged 4-17 years meeting DSM-IV criteria for ADHD had taken stimulant medication in the previous two weeks (Sawyer et al. 2017). This figure reflects an average prevalence across childhood, whereas our findings are more specifically indicative of the prevalence of ADHD medication use in early and mid-primary school. Sawyer et al (2017) identified some children in their cross-sectional study who did not meet diagnostic criteria for ADHD yet were receiving ADHD medication, and discounted treatment response as the reason (Sawyer et al. 2017). In the present study, the six children taking medication at age 10 years who did not meet ADHD diagnostic criteria had all met criteria at age 7, and remitted in the interim.

Our finding of substantial differences between the true prevalence (percentage of individuals in a representative sample meeting research criteria) and “administrative prevalence” (rate of clinical diagnosis) is consistent with previous research in childhood ADHD. Large studies of representative samples in the US (Froehlich et al. 2007) and Europe (Ford et al. 2003) have found that less than half of affected children are identified. Taylor (2017) has postulated a range of factors which may underpin underdiagnosis of ADHD, including concern about stigmatization from use of diagnostic labels, lack of teacher training in recognition of ADHD symptoms, concern that diagnosis will inevitably lead to medication treatment, and under-recognition of ADHD by health services who assess referred children (Taylor 2017).

This study had some limitations which need to be considered in the interpretation of the findings. As with all cohort studies we had some participant attrition. Participants in the 3 year follow-up were more highly educated than non-participants, which may have biased some findings. Our measure of medication use was parent report, as we did not have an objective measure such as prescription or dispensing data. This may not always have been reliable. As surveys were completed by the family’s nominated primary caregiver our data are predominantly from biological mothers, but only a small percentage of biological fathers and other parents/guardians, who may have reported some outcomes differently. Finally some analyses are likely to have lacked power, resulting in type II errors. The confidence interval width informs the degree of precision of our findings.

In summary, the majority of children in the Melbourne community who meet ADHD criteria are not being medically diagnosed by age 10. Those who receive a clinical diagnosis are likely to be treated with medication, and also likely to be referred for other interventions such as psychology. These data suggest that overall children with ADHD in this community are not being overmedicated.

CLINICAL SIGNIFICANCE

There is widespread concern that too many children are treated with ADHD medications. In contrast, this community-based study found that only a minority of children meeting criteria for ADHD at age 7 were treated with ADHD medication by age 10. The findings suggest that ADHD medications are not overprescribed in this community. On the contrary, the data suggest that more children with impairing ADHD symptoms should be referred for assessment and treatment.

DISCLOSURES

Prof Hazell or his employer has received payment from Shire for participation in advisory boards; Eli Lilly and Shire for speaker's bureau. All other authors declare that there are no conflicts of interest.

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