

Attention-Deficit/Hyperactivity Disorder in Children

Excess Costs Before and After Initial Diagnosis and Treatment Cost Differences by Ethnicity

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Objectives: To estimate the excess costs for children in the years surrounding initial diagnosis of attention-deficit/hyperactivity disorder (ADHD) and to estimate differences in treatment costs by ethnicity.

Design: We identified children diagnosed with ADHD and estimated their health service costs in the 2 years before and 2 years after initial diagnosis of ADHD. Costs were compared with those for children without ADHD. We adjusted for age, sex, ethnicity, pharmacy co-pay, estimated family income, coexisting mental health disorders, and chronic medical conditions.

Setting: Nonprofit, integrated health care delivery system in northern California from January 1, 1996, to December 31, 2004.

Participants: Children aged 2 to 10 years with (n=3122) and without (n=15 899) ADHD.

Main Exposure: Attention-deficit/hyperactivity disorder.

Main Outcome Measures: Health care costs and use

in the years before and after initial ADHD diagnosis as well as costs of ADHD-related services.

Results: Compared with children without ADHD, children with ADHD had mean costs that were \$488 more in the second year before their ADHD diagnosis, \$678 more in the year before their diagnosis, \$1328 more in the year after their diagnosis, and \$1040 more in the second year after their diagnosis. Asian Americans diagnosed with ADHD had lower total ADHD-related mean costs per year than white Americans diagnosed with ADHD (\$221 lower), and Asian Americans, African Americans, and Hispanic Americans all had lower ADHD-related pharmacy mean costs than white Americans (\$95, \$63, and \$77 lower, respectively).

Conclusions: Children with ADHD use significantly more health services before and after their diagnosis than children without ADHD. Among children diagnosed with ADHD, nonwhite Americans (especially Asian Americans) use fewer ADHD-related services than white Americans.

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ATENTION-DEFICIT/HYPERactivity disorder (ADHD) is one of the most common psychiatric disorders of childhood, with an estimated prevalence of nearly 8% in US children aged 4 to 17 years.¹ It is known to have significant morbidity affecting academic achievement, social behaviors, and work success.^{2,3} Treatment to help ameliorate those problems includes medication and behavioral approaches,^{4,5} both of which can be costly.^{6,7}

Although there have been a number of cost studies related to ADHD,⁶⁻¹² we are aware of no studies that indicate the pattern of excess health service cost and use both before and after initial diagnosis of ADHD, and few have analyzed cost or use differences by ethnicity—none of which included significant numbers of Asian

Americans. Excess use of services prior to an ADHD diagnosis may signal an existing problem for which the family may be seeking a diagnosis and may indicate that assessment protocols are not identifying these children early enough. Ethnic differences in the use of ADHD services among children who are diagnosed may lead to determining whether there is undertreatment or overtreatment of certain groups.

METHODS

SETTING

Kaiser Permanente (KP) of Northern California (KPNC), Oakland, is a nonprofit, integrated health care delivery system providing care to more than 3 million members, about 700 000 of whom are younger than 18 years.

Kaiser Permanente of Northern California provides comprehensive health services in more than 15 counties throughout northern California. The guideline for all providers at KP is to use the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*¹³ criteria for diagnosing ADHD. An assessment should take place, but there is some diversity with respect to the tools used. Generally, an ADHD-specific questionnaire is filled out by parents and the child's teacher(s), a developmental history questionnaire (usually with a KP-developed tool) is filled out by the parents, and the parents and children are interviewed. Patients generally receive medication treatment from either their primary care pediatrician or a child psychiatrist.

SELECTION OF STUDY POPULATION

Using KPNC electronic databases, we selected all of the children from January 1, 1996, to December 31, 2004, who either were dispensed an ADHD-related medication (psychostimulants or atomoxetine) in a KPNC outpatient pharmacy or had an outpatient visit at a KPNC facility that included the diagnosis or management of ADHD (*International Classification of Diseases, Ninth Revision, Clinical Modification*¹⁴ code 314.0). The first date that the child was seen for ADHD or had a prescription filled for an ADHD medication within this 9-year period was considered the diagnosis or index date for that child. Our goal was to identify the first time that children in the health plan were diagnosed with or treated for ADHD. Therefore, our study population was restricted to children who were no older than 2 years on January 1, 1996 (when KPNC began capturing outpatient visit diagnoses electronically) and were born in a KP hospital (so as to capture race, which is recorded in the KP hospitalization database). We further required that all of the study children were continuous members of the health plan from age 2 years until their index date. As a result of these selection criteria, children in this study were between ages 2 and 10 years on their index date. Although our primary study population included children with ADHD who were seen or treated for ADHD at least once, we also identified the subset of these children who met the more stringent requirement of having 2 or more ADHD-related visits or 2 or more ADHD-related medication prescriptions within a 1-year period.

For each ADHD case, we selected approximately 6 children who met all of the criteria stated earlier but were not diagnosed or treated for ADHD between January 1, 1996, and December 31, 2004. These children were matched to the cases by age and sex. Each child in the comparison group was assigned a pseudoindex date that was the same as that of the matched case.

For each year period in relation to the index date, we determined the child's pharmacy co-pay and the family's estimated median income based on census block group according to 2000 US Census data.

COST AND USE DATA

Costs for services provided by KPNC were obtained from the Cost Management Information System, an automated system that integrates use and financial databases. Costs (including program and facility overhead) are generated for services using standard accounting methods and program-specific relative value units. From these data, we estimated the average cost of the following: (1) hospitalizations by diagnosis-related group and by length of stay within the diagnosis-related group; (2) emergency department visits; and (3) outpatient office visits by department and provider type (eg, physician, registered nurse). Hospitalizations, emergency department visits, and office visits were extracted from the health plan's automated databases and were assigned the costs described earlier. Visits were con-

sidered to be ADHD-related if at least 1 of the diagnoses assigned by the provider as relating to the cause of the visit was *International Classification of Diseases, Ninth Revision, Clinical Modification* code 314.0.

Pharmacy costs were obtained from KPNC's Pharmacy Information Management System, which records information on all of the prescription drugs dispensed at KPNC outpatient pharmacies, including dose, days' supply, and acquisition cost of the medications dispensed. Medication costs were separated into 3 categories: (1) ADHD-related medications (psychostimulants and atomoxetine); (2) non-ADHD-related psychotropic medications (some of which may occasionally be used to treat ADHD, but most of which—eg, antidepressants, anxiolytics, antipsychotics, and mood stabilizers—are primarily used for other psychiatric conditions); and (3) all other medications. Medication quantity was measured by the days' supply dispensed.

For services covered by KPNC but provided by non-KPNC vendors, we used the payments made to those vendors as the cost of those services. This study does not include any patient out-of-pocket costs. The Consumer Price Index was used to adjust all costs to 2004 dollars.

COEXISTING MENTAL HEALTH DISORDERS AND OTHER CHRONIC CONDITIONS

Using outpatient visit diagnosis codes, we identified (in each year) whether the child was seen for any of the following mental health disorders (MHDs): substance abuse disorder, psychoses, unipolar mood disorders, bipolar mood disorders, pervasive developmental disorders, anxiety disorders, obsessive-compulsive disorders, tic or Tourette syndrome, posttraumatic stress disorder, conduct disorder, oppositional or defiant disorder, or learning disorders (excluding speech and language problems). Because the health plan's system for capturing diagnoses made it somewhat more difficult for pediatricians (as opposed to psychiatrists) to record this information and because KPNC providers do not generally assess for learning disabilities, MHDs may have been underestimated.

We used the Johns Hopkins Ambulatory Care Group case-mix system software¹⁵ to identify children with other chronic medical conditions. This software assigns diagnosis codes into 32 mutually exclusive diagnostic morbidity clusters known as ambulatory diagnostic groups (ADGs). We considered children whose diagnoses fell into 1 or more of the following ADGs to have a chronic condition: ADG06 ("asthma"), ADG10 ("chronic medical: stable"), ADG11 ("chronic medical: unstable"), ADG12 ("chronic specialty: stable orthopedic"), ADG13 ("chronic specialty: stable ear, nose, throat"), ADG14 ("chronic specialty: stable eye"), ADG16 ("chronic specialty: unstable orthopedic"), ADG17 ("chronic specialty: unstable ear, nose, throat"), and ADG18 ("chronic specialty: unstable eye"). This classification scheme includes relatively common conditions such as myopia and obesity. In addition, we included ADG32 ("malignancy") because of the potential severity and costliness of that condition. These ADGs were assigned to each child in each year of the study based on diagnoses received in that year.

ANALYSES

Our analytic data set consisted of 1 observation per child per year for each of the 2 years before and after the index date as long as the entire year fell between January 1, 1996, and December 31, 2004. *Year -1* was defined as the year prior to the index date. *Year 1* was defined as the year starting with the index date. Yearly records were only included in analyses if the child was a continuous member throughout that year and had pharmacy benefits in that year (more than 95% of KPNC mem-

bers have pharmacy benefits). Thus, a child whose index date was June 15, 1997, could contribute to year -1 but not year -2 because cost data only went back to 1996. Likewise, a child whose index date was June 15, 2004, could contribute to the analysis of year -1 but not year 1 because we did not include cost data after 2004. This algorithm allowed us to retain the maximum number of complete annual records.

To estimate the annual excess costs to the health plan of children with ADHD as compared with children without ADHD in relation to when they were first diagnosed with ADHD, we ran a general linear model in which cost was the dependent variable and all of the years for all of the eligible children were included. We included an interaction term for the ADHD-non-ADHD indicator by year in relation to index date. Because we had yearly repeated cost measures on the children, we used a generalized estimating equation approach with an autoregressive covariance structure to account for correlation among records for the same child. We also adjusted for sex, race or ethnicity (white, black, Hispanic, Asian, and other), age (continuous), income (categories), pharmacy co-pay (yes or no), the presence or absence of a non-ADHD MHD, and the presence or absence of any chronic medical conditions. All but sex and ethnicity were time-changing covariables. The subgroups of costs assessed were hospital-related costs, emergency department costs, psychiatry department costs where the visit included a diagnosis code for ADHD, pediatric department costs where the visit included a diagnosis code for ADHD, other psychiatric department costs, other pediatric department costs, other clinic-related costs (specialty department visits such as neurology as well as outpatient services provided by non-KP vendors), costs of medications used to treat ADHD, costs of other psychotropic medications, and other medication costs. In an auxiliary analysis, we ran the model described earlier but did not adjust for coexisting MHDs or chronic medical conditions. To test the model's sensitivity to very high-cost children, we ran a sensitivity analysis in which the 15 most costly children (those with costs greater than \$100 000) were excluded.

A separate model was run to examine whether the cost of ADHD-related services varied depending on the race or sex of the child. To increase power in this analysis, we combined the 2 years following the index date and estimated the mean annual costs during those 2 years. All of the statistical analyses were performed using SAS version 9 software (SAS Institute, Inc, Cary, NC).

RESULTS

SUBJECT CHARACTERISTICS

There were 3122 children with ADHD and 15 899 children without ADHD who met the study criteria. By design, each child had at least 1 year of continuous KP membership during the 4 years being analyzed, although only a subset had continuous membership in any given year. **Table 1** describes the characteristics of the children with ADHD (n=2014) and the children without ADHD (n=9342) who had continuous KP membership during the year after the index date. Because we matched by age and sex, children with ADHD had age and sex distributions similar to those without ADHD. The average age at the index date was 6.7 years, and the majority of study children were male. Children with ADHD were more likely than children without ADHD to be white American (69% vs 53%, respectively) and to have lower pharmacy co-pays. They were also more likely than children without ADHD to be seen for a coexisting MHD (30% vs 2%, re-

Table 1. Demographic Characteristics of Children With and Without Attention-Deficit/Hyperactivity Disorder in the Year After the Index Date*

Characteristic	Children With ADHD (n = 2014)†	Children Without ADHD (n = 9342)‡
Age at index date, mean, y	6.7	6.7
Sex		
Male	1569 (78)	7141 (77)
Female	445 (22)	2102 (23)
Race‡		
Asian American	123 (6)	1590 (17)
African American	186 (9)	817 (9)
Hispanic American	277 (14)	1713 (18)
White American	1381 (69)	4941 (53)
Other or unknown	47 (2)	281 (3)
Pharmacy co-pays, \$‡		
0	277 (14)	880 (9)
1-7	834 (41)	3794 (41)
10-25	282 (14)	1293 (14)
5 Generic + 10-20 brand	244 (12)	1198 (13)
10 Generic + 10-20 brand	190 (9)	1006 (11)
10 Generic + 25 brand	118 (6)	720 (8)
Other	69 (3)	451 (5)
Income based on census block group, quintile		
First (bottom)	285 (14)	1208 (13)
Second	362 (18)	1678 (18)
Third	385 (19)	1721 (18)
Fourth	444 (22)	2125 (23)
Fifth (top)	461 (23)	2268 (24)
Unknown	77 (4)	342 (4)
Diagnosed with a non-ADHD mental health condition‡	614 (30)	164 (2)
Diagnosed with a non-mental health, chronic condition‡	696 (35)	2553 (27)

Abbreviation: ADHD, attention-deficit/hyperactivity disorder.

*For ADHD cases, the index date was the date that the child was first seen or treated for ADHD. Each comparison non-ADHD case was assigned an index date equivalent to that of the matched ADHD case. Because of selection criteria, all of the children in this study were between ages 2 and 10 years.

†Values are expressed as number (percentage) unless otherwise indicated.

‡The ADHD group was significantly different from the non-ADHD group at $P \leq .05$.

spectively) and to be diagnosed with a chronic medical condition (35% vs 27%, respectively).

Table 2 indicates the numbers of children contributing to the analysis in each year as well as the baseline unadjusted mean annual total costs. Children with ADHD were nearly twice as costly as children without ADHD in the year prior to their initial diagnosis of ADHD (mean cost, \$1456 vs \$751, respectively) and nearly 3 times as costly in the year after their initial ADHD diagnosis (mean cost, \$2091 vs \$701, respectively). Only 387 (13%) of 3067 children with ADHD were diagnosed with a coexisting MHD in the year before they were diagnosed with ADHD compared with 614 (30%) of 2014 children and 275 (23%) of 1215 children in the first and second years, respectively, after being diagnosed with ADHD.

Children with ADHD who had coexisting MHDs were much more costly than children with ADHD who did not

Table 2. Sample Size and Mean Unadjusted Cost by Year in Relation to Index Date

Variable*	All Children		Children With ADHD	
	Children With ADHD	Children Without ADHD	Children With Coexisting Mental Health Conditions	Children Without Coexisting Mental Health Conditions
Children meeting study criteria in each year, No.				
Year -2	2950	15 036	125	2825
Year -1	3067	15 572	387	2680
Year +1	2014	9342	614	1400
Year +2	1215	4679	275	940
Annual total cost per child by year, mean, \$†				
Year -2‡	1340	839	2335	1296
Year -1‡	1456	751	2432	1315
Year +1‡	2091	701	3018	1685
Year +2‡	1859	742	3366	1418

Abbreviation: ADHD, attention-deficit/hyperactivity disorder.

*For ADHD cases, the index date was the date that the child was first seen or treated for ADHD. Each comparison non-ADHD case was assigned an index date equivalent to that of the matched ADHD case. Year -2 indicates the second year before the index date; year -1, the year before the index date; year +1, the year after the index date; and year +2, the second year after the index date.

†Costs are unadjusted mean values. However, because the non-ADHD comparison group was matched by age and sex to the ADHD group, cost differences between the 2 groups reflect similar age and sex distributions.

‡Costs for the ADHD group were significantly different from the non-ADHD group at $P \leq .05$, and costs for children with ADHD with coexisting mental health conditions were significantly different from children with ADHD without coexisting mental health conditions at $P \leq .05$.

have coexisting MHDs. Mean costs in the year after initial ADHD diagnosis, for example, were \$3018 for children with ADHD who had coexisting MHDs and \$1685 for children with ADHD who did not have coexisting MHDs.

EXCESS COST AND USE

Children with ADHD were substantially more costly than children without ADHD—both before and after their initial diagnosis of ADHD—after adjusting for all of the covariables (**Table 3**). In the second year prior to the index date, children with ADHD cost an average of \$302 more than children without ADHD, and in the year prior, they cost an average of \$383 more. During these years, emergency, pediatric, and psychiatric department costs were all higher for children with ADHD, as were other kinds of outpatient visit costs and pharmacy costs. In the year prior to their initial ADHD diagnosis, children with ADHD averaged 1.7 more outpatient visits per year and 29 more days' use of outpatient medications than children without ADHD.

After the index date, children with ADHD incurred substantial costs for ADHD-specific visits and medications as well as somewhat higher costs for psychiatric-related visits and psychotropic medications (**Table 3**). In the first year after the index date, children with ADHD had excess mean costs of \$860, which fell to \$672 in the second year. The decrease in the second year was due to a tapering off of ADHD-related visits that were somewhat offset by increased cost of medications.

Excess costs associated with ADHD were approximately 50% higher when coexisting MHDs and chronic medical conditions were not included in the model. For example, in the year after initial diagnosis, the excess mean cost of children with ADHD was \$860 when adjusting for these other conditions and \$1328 when not adjusting for them. When the 15 children with the highest costs were excluded (those with costs >\$100 000), the ex-

cess mean costs in year -2, year -1, year +1, and year +2 were \$274, \$284, \$959, and \$783, respectively, compared with \$302, \$383, \$860, and \$672, respectively, in the primary analysis. When we included only those children with ADHD who met the more stringent requirement of having at least 2 ADHD-related visits or 2 ADHD-related medication prescriptions within 1 year (74% of the children with ADHD), the excess mean costs in year -2, year -1, year +1, and year +2 were \$315, \$447, \$1052, and \$862, respectively.

Sixty-seven percent of the children with ADHD were dispensed ADHD-related medications during the year after the initial diagnosis whereas a significantly smaller number (57%) were dispensed such medications during the second year after diagnosis ($P < .001$). Among children who were dispensed ADHD-related medications, the average total days' supply dispensed increased from 275 days' supply in year 1 to 294 days' supply in year 2 ($P = .01$).

Girls with ADHD had lower annual ADHD-related psychiatry department visit mean costs than boys with ADHD (\$72 lower), but their other ADHD costs were similar (**Table 4**). Asian Americans, African Americans, and Hispanic Americans all had lower yearly mean costs for ADHD medications compared with white Americans (\$95, \$63, and \$77 lower, respectively). Nonwhite Americans were less likely than white Americans to receive any ADHD-related medications in year 1 (61% vs 70%, respectively; $P < .001$), and among those who did receive them, they tended to receive fewer days' supplies (250 days' supply vs 285 days' supply, respectively; $P < .001$). Only 57% of Asian Americans with ADHD received ADHD-related medications in the year after their index date compared with 70% of white Americans ($P = .004$). Asian Americans also had lower ADHD-related psychiatry department mean costs compared with white Americans (\$105 lower) as well as lower overall ADHD-related mean costs (\$221 lower). The annual ADHD-related mean

Table 3. Adjusted Excess Costs and Use for Children With vs Without Attention-Deficit/Hyperactivity Disorder by Year in Relation to Index Date

Variable	Year -2*	Year -1*	Year +1*	Year +2*
Children contributing to analysis, No.				
Children with ADHD	2950	3067	2014	1215
Children without ADHD	15 036	15 572	9342	4679
Adjusted excess costs for children with ADHD compared with costs for children without ADHD, mean (95% CI), \$				
All hospital-related costs	65 (-45 to 175)	84 (-80 to 248)	-72 (-200 to 56)	-72 (-361 to 218)
ED-related costs	20 (9 to 31)	19 (9 to 28)	9 (-2 to 20)	13 (-1 to 27)
Psychiatry department ADHD visit costs	†	†	384 (355 to 413)	219 (194 to 245)
Pediatric department ADHD visit costs	†	†	201 (190 to 211)	97 (88 to 106)
Psychiatry department other costs	34 (26 to 43)	133 (121 to 146)	58 (42 to 75)	18 (1 to 35)
Pediatric department other costs	111 (95 to 128)	115 (100 to 130)	31 (15 to 48)	36 (14 to 57)
Other clinic-related costs	75 (52 to 99)	51 (30 to 71)	25 (-7 to 57)	48 (13 to 83)
ADHD-related pharmacy costs	†	†	186 (173 to 198)	222 (205 to 239)
Other psychotropic pharmacy costs	-1 (-2 to 0)	1 (-1 to 4)	24 (17 to 32)	46 (33 to 60)
Other pharmacy costs	25 (5 to 46)	31 (10 to 51)	43 (22 to 64)	76 (40 to 111)
Total‡	302 (166 to 437)	383 (206 to 560)	860 (708 to 1013)	672 (354 to 991)
Total excess cost without adjusting for coexisting conditions, mean (95% CI), \$\$				
Excess use by children with ADHD compared with that of children without ADHD, mean (95% CI)				
Outpatient visits, No.	1.2 (1.1 to 1.3)	1.7 (1.6 to 1.8)	3.8 (3.6 to 4.0)	2.1 (1.9 to 2.4)
Days' supply of all outpatient drugs	29 (20 to 37)	29 (21 to 37)	237 (224 to 251)	240 (224 to 257)

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; CI, confidence interval; ED, emergency department.

*Year -2 indicates the second year before the index date; year -1, the year before the index date; year +1, the year after the index date; and year +2, the second year after the index date. For ADHD cases, the index date was the date that the child was first seen or treated for ADHD. Each comparison non-ADHD case was assigned an index date equivalent to that of the matched ADHD case.

†Because children with ADHD were identified by virtue of ADHD-related use, neither children with ADHD nor those without ADHD had ADHD-related costs prior to the index year, and children without ADHD had no ADHD-related costs in any year of the study.

‡Owing to the use of the generalized estimating equation modeling approach, total excess costs are not precisely the sum of the component costs.

§Excess costs after adjusting for all of the covariables except those indicating the presence or absence of mental health disorders and chronic medical conditions.

Table 4. Adjusted Differences in Mean Annual Attention-Deficit/Hyperactivity Disorder-Related Costs by Race or Ethnicity and Sex in 2 Years After Index Date Among Children Diagnosed With Attention-Deficit/Hyperactivity Disorder*

Cost Type	Race or Ethnicity†			Girls vs Boys, Mean (95% CI)
	Asian American, Mean (95% CI)	African American, Mean (95% CI)	Hispanic American, Mean (95% CI)	
Psychiatry department ADHD visit cost difference, \$	-105 (-191 to -18)	-8 (-92 to 75)	99 (18 to 180)	-72 (-128 to -16)
Pediatric department ADHD visit cost difference, \$	-23 (-54 to 9)	-11 (-40 to 17)	-36 (-62 to -11)	1 (-19 to 21)
ADHD-related pharmacy cost difference, \$	-95 (-140 to -51)	-63 (-103 to -23)	-77 (-109 to -44)	8 (-23 to 38)
All outpatient ADHD-related cost difference, \$	-221 (-335 to -109)	-82 (-194 to 30)	-112 (-113 to 89)	-63 (-138 to 12)

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; CI, confidence interval.

*The index date was the date that the child was first seen or treated for ADHD. Confidence intervals that do not cross 0 indicate that cost differences are significant at $P < .05$. Costs are reported in 2004 US dollars.

†The reference group was white American.

cost for white Americans was about \$750. Thus, among children diagnosed with ADHD, per-person ADHD-related costs for Asian Americans were about 70% of those for white Americans. When this analysis was restricted to children who were prescribed an ADHD-related medication at least once, the differences remained, although they were somewhat attenuated. Excess mean costs for Asian Americans as compared with those for white Americans went from \$221 less to \$184 less ($P = .04$). The mean age at first diagnosis was the same for children in each ethnicity. To account for the possibility that the racial

differences might be confounded by the site where the different groups most commonly received care, we also ran the model adjusting for clinic and found no substantial change to the results.

COMMENT

Parents commonly state that behavioral problems predate their child's ADHD diagnosis, often by several years,^{16,17} and these problems may affect their use of health services. In

our study sample, costs were significantly higher in the 2 years before the index date among children subsequently diagnosed with ADHD, and costs remained higher for at least 2 years following the initial ADHD diagnosis. Much of the excess cost was due to increased pediatric and psychiatric services, which were higher in the first year after diagnosis than in the second year. Medication treatment visits for ADHD tend to be more frequent in the first year after diagnosis, as that is the time when determining the correct medication and making the most dosage adjustments tend to occur.⁴ Behavioral treatments for ADHD also tend to be short term. The majority of treatments are less than 2 months in duration^{18,19} and may result in increases in costs for ADHD care in the first year of treatment with a decline during the second year.

Our finding of higher costs and use for children with ADHD who have coexisting MHDs has been reported by others.^{10,12} Children with ADHD and coexisting MHDs have more complex problems, have a poorer long-term prognosis, commonly require more care, and may need more medications.²⁰⁻²²

Our study also found that after being diagnosed with ADHD, Asian Americans, African Americans, and Hispanic Americans use fewer ADHD-related medications than white Americans and that Asian-American children have lower overall ADHD-related costs. Although some of these per-person differences are modest, the total differences summed across the population may be substantial. Our results indicate that alongside the case-mix factor, ethnicity is another important factor contributing to cost differences. A number of studies²³⁻²⁷ have shown that rates of ADHD diagnosis or treatment are lower for African Americans and Hispanic Americans, although not all agree on the disparity of medication use. Stevens et al²⁵ found no ethnic differences in the likelihood of receiving a stimulant during a visit in which the child had been diagnosed with ADHD. However, Rowland et al²⁶ and Stevens et al²⁴ found that among children diagnosed with ADHD, African Americans^{24,26} and Hispanic Americans²⁶ were less likely than white Americans to receive stimulants. To our knowledge, though, our study is the first to look at ethnic differences in all types of medical use and costs among children diagnosed with ADHD and the first to look at any use and costs among Asian Americans with ADHD. These findings of lower use and cost are not confounded by differences in health insurance coverage or by the age at which the children were diagnosed, and differences in income have also been accounted for to some extent. Given the evidence that response to treatment does not vary by ethnicity²⁸ and that our population had similar medical coverage and access to care, our data suggest that lower use of medications among ethnic minorities may be explained in part by cultural differences in the acceptance of ADHD diagnoses and treatment.²⁸⁻³⁰ Future studies, particularly those involving interviews of the parents of children with ADHD and their health care providers, could shed light on the reasons for these differences.

Although no study to our knowledge has analyzed costs over time in relation to the initial ADHD diagnosis, our study is comparable in design to the study by Guevara et al,¹⁰ who also studied members of an integrated health plan. Our findings of excess mean costs of \$860 in the

year following the initial ADHD diagnosis are higher than the \$495 (when children with and without coexisting conditions are combined) reported by Guevara and colleagues. This difference is likely owing in part to differences in methods—that study adjusted for non-mental health-related comorbidities using a different method, restricted the category of children without ADHD to those who used some medical services in the study year, and included children up to age 17 years. It is possible that the excess costs for older children are lower than those for younger children, although some evidence suggests that this may not be so.⁷ Differences in study findings may also be owing in part to recent increases in the cost of ADHD drug formulations. Studies by Swensen et al⁸ and Birnbaum et al¹¹ (using fee-for-service claims) found excess costs of \$1033 and \$1265, respectively, although again, these studies included older children and had somewhat different sample selection criteria.

Our estimate of excess cost for children with ADHD may underestimate true excess costs seen today and in the future. New, more expensive ADHD medications and formulations have been introduced in recent years, but our cost estimates represent a blending of the older, less expensive medications and newer medications. Because this was a study of children who were diagnosed with or treated for ADHD, we cannot make conclusions about those children who have ADHD but are not diagnosed with it. However, by analyzing years prior to diagnosis, we do provide some data, to our knowledge unavailable in the current literature, on health care costs among undiagnosed children. We did not independently assess the validity of the ADHD diagnoses made by providers; thus, there may be some misclassification. Nevertheless, the children with ADHD in our sample were considered by the health system (and probably by the family) to have ADHD. Diagnosis of ADHD is likely to drive physician prescribing patterns and behavioral treatments and thus be important from the health system perspective. Our cohort reflects the actual way that ADHD diagnoses are given, and the percentage of all of the children receiving medication treatment in KPNC is similar to that recently reported for California by the Centers for Disease Control and Prevention, Atlanta, Ga (about 2%).¹ Rates of ADHD diagnosis and treatment with medication are lower in California than in other states.¹ If the children who are diagnosed in California tend to be the more severe cases, excess costs associated with these children may be higher than in other states.

It is possible that once a child is diagnosed with ADHD, he or she may be more likely to be assessed for and diagnosed with other medical disorders and MHDs. In our main analysis, we chose to adjust for coexisting mental health conditions and chronic medical conditions; thus, excess cost estimates derived from those analyses might be considered conservative.

Our estimates of excess cost may be high if families who are more likely to seek a diagnosis for and treatment of their child's ADHD are also prone to seeking treatment in general. This propensity to use services may partly explain the excess costs for these children. Because of data constraints, this study was limited to children younger than 11 years. Older children may have different excess costs.

CONCLUSIONS

Children with ADHD have excess medical costs compared with similar children without ADHD. Our study shows that these excess costs precede the initial diagnosis of ADHD by at least 2 years, indicating the presence of problems well in advance of the initial diagnosis. Once these children are diagnosed, the excess costs for them are even higher owing primarily to increased psychiatric and pediatric care as well as increased costs for medication. Consistent with prior studies, we found that African-American and Hispanic children with ADHD have lower ADHD-related medication costs than white children with ADHD. Our study extends this finding to Asian Americans and also shows that compared with white Americans, not only are they less likely to use ADHD-related medications after their diagnosis but their total use of ADHD services (medications and visits) during this period is less than that of white Americans. Future evaluation should be considered to determine the reasons for these differences.

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