

National Variation of ADHD Diagnostic Prevalence and Medication Use: Health Care Providers and Education Policies

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Objectives: Attention-deficit hyperactivity disorder (ADHD) diagnostic prevalence and medication use vary across U.S. census regions, but little is known about state-level variation. The purpose of this study was to estimate this variation across states and examine whether a state's health care provider characteristics and education policies are associated with this variation. **Methods:** Logistic regression models were estimated with 69,505 children aged four to 17 from the state-stratified and nationally representative 2003 National Survey of Children's Health, conducted by the Centers for Disease Control and Prevention. **Results:** Diagnostic prevalence was higher in the South (odds ratio [OR]=1.42, $p<.001$) than in the West; among children with ADHD diagnoses, medication use was higher in the South (OR=1.60, $p<.01$) and the Midwest (OR=1.53, $p<.01$) versus the West. On these measures, several states differed from the U.S. averages, including some states that, on the basis of the regional patterns found above, would not be expected to differ: Michigan had a high diagnostic prevalence; Vermont, South Dakota, and Nebraska had low diagnostic prevalences; and Connecticut, New Jersey, and Kentucky had low medication rates. Both diagnosis and medication status were associated with the number, age, and type of physicians within a state, particularly pediatricians. However, state education policies were not significantly associated with either diagnostic prevalence or medication rates. **Conclusions:** To better understand the association between a state's health care provider characteristics and both diagnostic prevalence and medication use, it may be fruitful to examine the content of provider continuing education programs, including the recommendations of major health professional organization guidelines to treat ADHD. (*Psychiatric Services* 60:1075–1083, 2009)

Attention-deficit hyperactivity disorder (ADHD) is one of the most common childhood mental health disorders in the United States. As of 2003, 4.4 million (7.8%) children aged four to 17 were estimated to have a diagnosis of ADHD (1). Children with this disorder often face long-standing problems with academic achievement, social relationships, life skills, risk of injury, and functional independence (2–5). Stimulant medications have been found to yield important behavioral improvements for children in this diagnostic category (6). In 2003 an estimated 56% of children diagnosed as having ADHD in the United States were taking medication for this condition (1), at a cost of \$2.2 billion (7). Although medication side effects are typically mild and manageable (associated with appetite and sleep patterns), there is potential for cardiovascular problems (8) and inhibited physical growth (9) as well as inappropriate use by nondiagnosed individuals for cognitive enhancement or recreational purposes (10).

Given the benefits of and concerns about medication use, it is essential that ADHD be appropriately diagnosed among children and that they receive appropriate medication when indicated. Notably, findings from national studies point to some variation in diagnostic prevalence and medication rates across geographic regions. It is therefore important to identify

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the factors that contribute to such variation, many of which have policy relevance at the state level.

Prior studies using multivariate approaches to estimate ADHD-related variation across regions have yielded mixed results. One study found lower diagnostic prevalence in the West versus the Midwest regions of the United States, but results for the South varied across model specifications (11). Another investigation did not find regional differences in whether an ADHD diagnosis was given during a visit to a physician or to a hospital outpatient department (12). Regarding medication use among children diagnosed as having ADHD, one study found more medication use in the West and South versus the Northeast (12), but an earlier study found more medication use in the South versus the West (13). These studies did not analyze state-level variation.

Aside from demographic differences, regional variation is likely to be influenced by several factors, including health and education systems (14). Yet these factors have not been analyzed together. Physicians and psychologists are typically responsible for the formal diagnosis and treatment of ADHD, but the number, ages, and types of these health care providers vary across states. A national study that used county-level medication data found that high-use counties were marked by more physicians per capita and a higher ratio of younger to older physicians (15).

Before and after the passage of the No Child Left Behind Act of 2001, states implemented standards-based reform strategies that linked accountability systems to student achievement benchmarks, placing greater focus on low-performing students (16,17). Because children affected by ADHD often have low academic achievement (18), state variation in accountability systems may be linked to diagnostic prevalence and medication use. An investigation revealed that state-level school accountability policies were positively associated with a child's diagnosis, but data were not available concerning medication (11).

Because of concern regarding

overmedication, including the potential for school personnel to become overly influential in recommending medication treatment for children with ADHD, nine states have passed legislation since 2001 and an additional 14 states have introduced legislation (hereafter referred to as "ADHD laws") that reduces the influence of school personnel regarding medication decisions or strengthens parental rights in such decisions (19,20). One study did not find an association between ADHD laws and diagnostic prevalence as of spring 2002, yet the investigation occurred just after initial state ADHD laws were passed (11).

Overall, evidence of regional differences in ADHD diagnostic prevalence and medication use is inconsistent, and state-level data have not been evaluated with a multivariate approach. Thus we used the largest and most recently available nationally representative data set to estimate variation in diagnostic prevalence and medication rates across census regions, to estimate parallel variation across states, and to examine whether state-level health care provider characteristics and education policies were associated with state-level variation.

Methods

To determine how diagnostic prevalence and medication rates varied with controls for demographic differences across geographical areas, we estimated two logistic regression models. In the first, the dependent variable indicated whether a doctor or health care professional had ever told the respondent (usually the child's parent or guardian) that the child had attention-deficit disorder or ADHD (hereafter, we refer to both conditions as simply ADHD). In the second, the dependent variable indicated whether the respondent reported that the child was taking medication for this condition at the time of the survey; this model included only children reported as having an ADHD diagnosis.

In both models, similar to other ADHD investigations (11–13), independent variables included child's sex, age, race, health insurance status,

and schooling status; family parental structure; number of children in the household; household income; highest level of education attained in the household; and geographic variables, by either census region or state. When census regions were used, West was the reference region. When states were used, to improve the interpretability of the results, we used an analytic technique that allowed comparison of the odds of being diagnosed (or taking medication) in a state versus the United States as a whole. Although the comparison state was within the United States as a whole, its influence on the nation's diagnostic prevalence and medication rate was minimal because all 50 states and the District of Columbia were included. In this approach, each state was represented by a dummy variable, and the model was constrained so that the sum of the state dummy parameter estimates was zero (21). This approach did not affect the statistical estimates of the nongeographical variables.

To examine state-level factors that may be associated with whether a child is diagnosed as having ADHD or is taking medication for it, we reestimated the models described above by including the following variables: number of physicians and psychologists per 10,000 children in each state, state-level school accountability policies, and whether a child resided in Connecticut, Illinois, or Virginia—the states that had enacted an ADHD law before 2003. Per-student expenditures by state were included because they are related to education system quality and likely to influence special education resources (22). Because of the inclusion of these state-level variables, the state dummy variables for these latter analyses were removed and replaced with census division dummy variables.

The child-level data are from the largest and most recently available survey on children, the 2003 National Survey of Children's Health (NSCH), which included 102,353 children, of whom 79,697 were aged four to 17. The NSCH is a telephone survey that was conducted by the Centers for Disease Control and Prevention between January 2003 and July 2004

(23). The state-stratified survey was administered to adults living in the United States within a household with one or more children aged 17 or under. Informed consent was obtained from each adult respondent with the use of approved procedures. Data were collected from the adult respondent about the child's physical and emotional health, utilization of health care services, and demographic characteristics. Because of missing data (addressed later in the Discussion section), our analytic sample included 69,505 children.

Our source for health care provider data was the Area Resource File (24). Health care providers who treat children who have ADHD primarily include pediatricians, family and general practitioners, child psychiatrists, and psychologists (25,26). Psychiatrists and neurologists also treat children with ADHD, but to a lesser extent (25,27); therefore, they were included only in our sensitivity analysis models. Following the methods of Schneider and Eisenberg (11), we based our analyses on the state-level school accountability policies listed in the Education Counts database (28). Expenditures per student were from the National Education Association (29).

To take into account the complex survey design of the NSCH, we used Stata 9.2 (30) for all analyses.

Results

The ADHD and demographic variables from our NSCH sample are presented in Table 1.

Table 2 shows the number of health care providers and education variable values for the United States and their variation across states. The health care provider statistics are reported per 10,000 persons (or per 10,000 children aged 0 to 17 when a provider primarily sees children).

We first estimated diagnosis and medication models with the demographic and census region variables. Compared with the West, diagnostic prevalence in the South was higher (odds ratio [OR]=1.42, $p<.001$). Compared with the West, the medication rate among children with ADHD was higher in both the South (OR=1.60, $p<.01$) and the Midwest

(OR=1.53, $p<.01$) and approached being significantly higher (OR=1.40, $p=.06$) in the Northeast.

Table 3 shows the results of the diagnosis and medication models with demographic and state variables. The demographic variable associations are consistent with the multivariate findings of a previous study that analyzed medication use with the NSCH (31). We highlight the state results, which differed from the previously reported crude rates (1). The state results were sorted by the diagnosis odds ratio, and the five states with a diagnostic prevalence lower than that of the United States as a whole included not only Western states (Colorado and Utah) but also Vermont, South Dakota, and Nebraska. Eight of the nine states with a diagnostic prevalence higher than that of the United States as a whole were in the South; the other was Michigan.

The five states with a medication rate lower than the U.S. rate included not only Western states (California and Nevada) but also Connecticut, New Jersey, and Kentucky. No state had a medication rate that was higher than that for the United States, although Texas and Delaware were higher at the .10 level.

For Figure 1 we used the results in Table 3 to plot each state's odds ratio for diagnosis (horizontal axis) and medication (vertical axis) of ADHD. As expected, Southern states constitute a majority of the states located in the quadrant indicating above-average diagnostic prevalence plus above-average medication rate (upper right), whereas Western states constitute a majority of the states in the quadrant indicating below-average diagnostic prevalence plus below-average medication rate (lower left).

To aid interpretation, we translated the odds ratios into probabilities using a boy and girl between age nine and 13 with the most common characteristics in the sample (see Table 1). The predicted diagnostic prevalence for the boy and girl for the United States was 10.7% and 4.1%, respectively, and the state diagnostic prevalence ranged from 6.9% and 2.6%, respectively, in Vermont to 14.5% and 5.7%, respectively, in Maryland. The predicted national medication rate

Table 1
Descriptive statistics of an analytic sample of children who participated in the 2003 National Survey of Children's Health (NSCH)

Variable	Proportion (%) ^a
Attention-deficit hyperactivity disorder	
Diagnosed ^b	
United States	7.7
Northeast	7.2
Midwest	7.8
South	9.1
West	5.9
Medication for those with diagnosis ^c	
United States	57.4
Northeast	58.2
Midwest	58.8
South	59.6
West	49.3
Demographic characteristic ^b	
Female	48.7
Age	
4–5	14.7
6–8	20.5
9–13	36.6
14–17	28.2
Race or ethnicity	
White	63.7
Black	13.7
Hispanic or Latino	15.5
Other	7.1
Health insurance	
None	8.7
Private	66.8
Public	24.5
School	
Home	6.7
Public	79.9
Private	13.4
Family structure	
2 parents (biological or adoptive)	60.5
2 parents (step-family)	10.8
Single mother	23.8
Other	4.8
1 child residing in household	19.6
Household income (% federal poverty level)	
<100	16.0
100–199	22.4
200–299	18.1
≥300	43.5
Education	
Less than high school	6.6
High school graduate	25.6
More than high school	67.8

^a All percentages are weighted with NSCH sample weights.

^b Based on an analytic sample of 69,505 children

^c Based on 5,670 children diagnosed as having attention-deficit hyperactivity disorder

Table 2

Health care providers across states and state education variables

Variable	State variation					
	U.S. mean	SD	Minimum ^a	25th percentile	75th percentile	Maximum ^a
Health care providers (as of December 31, 2003) ^b						
Pediatricians per 10,000 children (0–17 years old)	7.3	3.9	2.4	4.9	7.6	13.1
<45 years old	3.6	2.2	.9	2.6	3.9	6.7
≥45 years old	3.7	1.8	1.2	2.4	4.0	7.0
Family and general practitioners per 10,000 persons	3.0	1.0	1.7	2.7	3.9	5.8
<45 years old	1.2	.5	.6	1.1	1.8	2.8
≥45 years old	1.8	.5	1.0	1.5	2.3	3.0
Child psychiatrists per 10,000 children (0 to 17 years old)	.9	.8	.3	.5	1.0	2.4
<45 years old	.3	.2	.0	.2	.4	.9
≥45 years old	.6	.5	.2	.4	.7	1.5
Total	11.2	4.4	6.7	9.4	12.2	19.3
<45 years old	5.2	2.3	2.7	4.4	5.8	8.7
≥45 years old	6.0	2.2	3.6	4.7	6.6	11.2
Neurologists per 10,000 persons	.4	.2	.2	.3	.4	1.0
<45 years old	.2	.1	.0	.1	.2	.4
≥45 years old	.3	.1	.1	.2	.3	.6
Psychiatrists per 10,000 persons	1.3	.9	.4	.8	1.5	3.2
<45 years old	.4	.2	.1	.3	.4	.9
≥45 years old	.9	.7	.4	.5	1.0	2.3
Psychologists per 10,000 persons ^c	5.0	2.8	.6	2.2	5.6	11.9
Education						
State-level school accountability policies (1999–2003) ^d						
State sanctions low-performing schools	1.8	2.0	.0	.0	4.0	5.0
State rewards high-performing or improved schools	1.6	2.0	.0	.0	4.0	5.0
School report cards	4.2	1.5	.0	4.0	5.0	5.0
School ratings	2.5	2.2	.0	.0	5.0	5.0
Total	10.1	5.7	.0	5.0	15.0	20.0
Spending per student (2003–2004) (in \$1,000s)	8.2	1.8	5.1	6.9	9.5	12.1

^a The health care provider state minimum and state maximum exclude the District of Columbia because its health care provider statistics were often outliers; therefore, District of Columbia National Survey of Children's Health observations were excluded from the state-variable analyses presented in Table 4.

^b Because of rounding, health care provider totals may not equal the sum of the displayed numbers.

^c Based on 2000 data, which did not distinguish psychologists by age; 2003 data were not available.

^d State-level school accountability policy statistics are based on the number of years a state had the accountability policy in place between 1999 and 2003. Because of missing values, the District of Columbia is not included.

for the diagnosed boy and girl defined above was 74.1% and 73.4%, respectively, and the medication rate among states ranged from 56.7% and 56.2%, respectively, in California to 81.9% and 81.5%, respectively, in the District of Columbia.

Table 4 shows the results of our state-level variable analyses. When we aggregated pediatricians, family and general practitioners, and child psychiatrists into a single group and included them within the diagnosis and medication models, we found no associations. We then separated this group into six ten-year age groups to understand the influence of provider age. On the basis of this examination, we grouped the providers by those below 45 years of age and those 45 years of age or older (hereafter

“younger” and “older” providers, respectively). We still did not find an association between providers and a child's being diagnosed (model 1). However, we found a positive association between the number of younger providers and diagnosed children taking ADHD medication (OR=1.25, $p<.01$), but the parallel association was negative with the number of older providers (OR=.85, $p<.05$) (model 3). When psychiatrists and neurologists were also included within the two provider groups, the significance of these results did not change.

We then also separated the providers by specialty. An increase in the number of younger pediatricians approached being negatively associated with a child's diagnosis (OR=.89, $p=.06$), while an increase in the num-

ber of older pediatricians approached being positively associated with a child's diagnosis (OR=1.12, $p=.06$) (model 2). The difference between these two odds ratios was significant ($p<.05$). The difference between the parallel odds ratios predicting medication use among diagnosed children was also significant ($p<.05$); however, the odds ratio for younger pediatricians (OR=1.18, $p=.18$) was greater than the odds ratio for older pediatricians (OR=.75, $p<.05$) (model 4). Moreover, older pediatricians' association with a child's being diagnosed (OR=1.12, $p=.06$) significantly differed with the parallel association for family and general practitioners (OR=.74, $p<.05$) (model 2).

To aid in the interpretation of these odds ratios, we show a result in prob-

ability units using the following example. Consider a boy between ages nine and 13 with ADHD and having the most common characteristics in the sample. Consider also that the state-level and census division variables are at their means. An increase in the number of older pediatricians from 3.7 per 10,000 children (the U.S. mean) to 4.7 per 10,000 in a state decreases his probability of being on ADHD medication from 73% to 67%. For the boy's female counterpart, the decrease would be from 72% to 66%.

The state-level school accountability policies were not associated with a child's being either diagnosed or on medication (models 2 and 4, which are the preferred models because they incorporated provider type). We tested several specifications, including discretely including each accountability type, aggregating across types, and coding the number of years an accountability policy had been in place during the previous five years, which accounts for implementation time. ADHD laws were not associated with a child's diagnostic status; however, the laws approached being negatively associated with a diagnosed child's being on ADHD medication (OR=.72, p=.08) (model 4).

Discussion

The primary findings show that ADHD diagnostic prevalence was higher in the South than in the West, and among children with ADHD, medication use was higher in the South and the Midwest than in the West. Several states had a diagnostic prevalence or medication rate that differed from the U.S. averages. Second, having a diagnosis of ADHD or taking medication for it was associated with the number, age, and type of physicians within a state, particularly pediatricians. Third, state-level school accountability policies were not found to be associated with ADHD diagnosis or taking medication for ADHD, but ADHD laws concerning a school's influence in recommending medication use approached being negatively associated with diagnosed children's taking ADHD medication.

Although we discovered states that had a diagnostic prevalence or med-

Table 3

Logistic regression results for diagnosis of attention-deficit hyperactivity disorder and use of medication

Variable	Diagnosis (N=69,505) ^a			Medication (N=5,670) ^b		
	OR	SE	t	OR	SE	t
Child characteristic						
Female	.36	.02	-18.60***	.98	.10	-.21
Age (reference: 4-5)						
6-8	3.75	.56	8.84***	2.52	.77	3.04**
9-13	6.45	.92	13.13***	1.97	.56	2.41*
14-17	6.14	.87	12.78***	.86	.25	-.52
Race or ethnicity (reference: white)						
Black	.53	.05	-6.85***	.65	.11	-2.58*
Hispanic or Latino	.36	.05	-7.78***	.75	.16	-1.35
Other race or ethnic group	.66	.08	-3.28**	.96	.23	-.17
Health insurance (reference: none)						
Private	1.20	.15	1.50	3.05	.63	5.45***
Public	2.13	.27	5.87***	3.44	.74	5.72***
School (reference: home schooling)						
Public	.98	.14	-.15	1.85	.52	2.18*
Private	.99	.15	-.08	2.05	.66	2.24*
Household characteristic						
Household structure (reference: 2 parents, biological or adoptive)						
2 parents (step-family)	1.98	.15	8.86***	.74	.10	-2.20*
Single mother	1.64	.11	7.40***	.93	.12	-.58
Other household type	1.42	.14	3.56***	.68	.12	-2.12*
1 child residing in household	1.21	.06	3.97***	1.12	.10	1.29
Household income (% federal poverty level; reference: <100%)						
100-199	.83	.08	-2.03*	1.66	.27	3.09**
200-299	.94	.10	-.61	1.14	.20	.73
≥300	.81	.09	-1.93	1.77	.33	3.09**
Education (reference: less than high school)						
High school graduate	1.13	.17	.81	.75	.20	-1.06
More than high school	1.19	.18	1.19	.82	.23	-.71
State (reference: U.S. average)						
Vermont	.62	.08	-3.60***	1.04	.27	.13
Colorado	.65	.10	-2.93**	.94	.26	-.24
South Dakota	.70	.11	-2.38*	1.49	.50	1.19
Nebraska	.71	.10	-2.33*	1.45	.43	1.26
Utah	.75	.11	-1.96	.97	.29	-.09
Idaho	.78	.10	-1.83	1.28	.36	.88
Wyoming	.80	.10	-1.80	.92	.23	-.32
Maine	.80	.10	-1.79	.88	.21	-.53
District of Columbia	.82	.14	-1.17	1.58	.55	1.32
Illinois	.82	.11	-1.43	.67	.17	-1.53
Oregon	.85	.10	-1.37	1.07	.27	.28
New York	.85	.12	-1.18	1.11	.33	.33
Montana	.85	.11	-1.32	1.35	.34	1.18
Alaska	.85	.11	-1.30	.87	.22	-.57
Washington	.85	.11	-1.23	1.15	.32	.52
Arizona	.88	.13	-.87	.84	.25	-.60
Missouri	.89	.10	-1.07	.98	.22	-.09
Indiana	.89	.11	-.95	1.17	.29	.61
Oklahoma	.91	.11	-.81	.93	.23	-.30
California	.91	.13	-.69	.46	.12	-3.03**
Pennsylvania	.92	.11	-.65	1.27	.30	1.03
Kansas	.98	.12	-.18	1.50	.37	1.63
West Virginia	.98	.12	-.17	.89	.21	-.49
Minnesota	.98	.12	-.15	1.24	.30	.91
Hawaii	.99	.16	-.09	.73	.26	-.89
Connecticut	1.00	.12	-.03	.47	.12	-3.02**
New Mexico	1.03	.16	.19	1.00	.33	-.01
Ohio	1.07	.11	.62	1.02	.21	.11
New Hampshire	1.07	.12	.66	.96	.22	-.16

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Table 3

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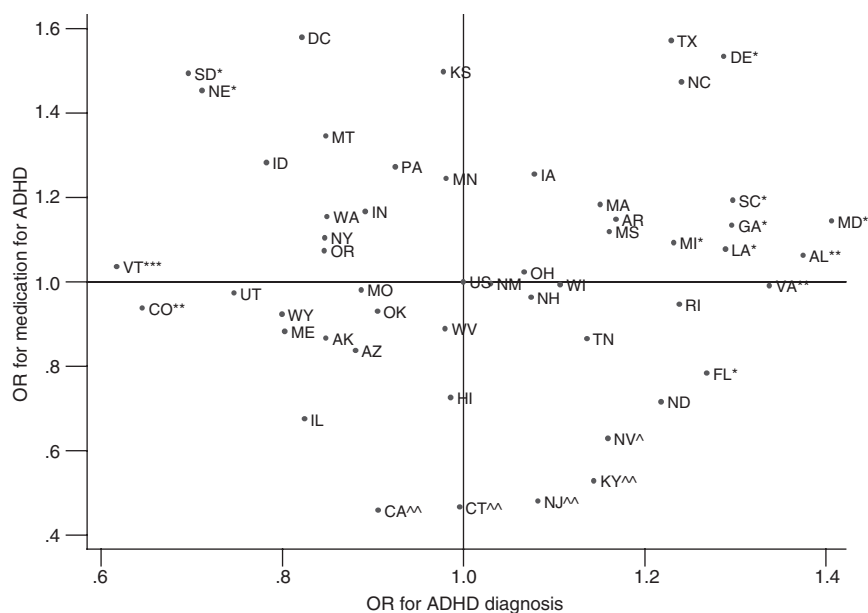
Variable	Diagnosis (N=69,505) ^a			Medication (N=5,670) ^b		
	OR	SE	t	OR	SE	t
Iowa	1.08	.13	.65	1.26	.31	.92
New Jersey	1.08	.15	.59	.48	.13	-2.66**
Wisconsin	1.11	.14	.80	.99	.24	-.03
Tennessee	1.14	.14	1.04	.87	.20	-.62
Kentucky	1.14	.14	1.13	.53	.12	-2.89**
Massachusetts	1.15	.13	1.23	1.18	.27	.73
Nevada	1.16	.14	1.23	.63	.15	-1.96*
Mississippi	1.16	.14	1.25	1.12	.27	.47
Arkansas	1.17	.13	1.37	1.15	.26	.60
North Dakota	1.22	.14	1.66	.72	.17	-1.38
Texas	1.23	.15	1.70	1.57	.37	1.94
Michigan	1.23	.13	1.97*	1.09	.22	.44
Rhode Island	1.24	.15	1.81	.95	.23	-.22
North Carolina	1.24	.14	1.94	1.47	.35	1.64
Florida	1.27	.15	1.97*	.78	.18	-1.07
Delaware	1.29	.15	2.12*	1.53	.39	1.68
Louisiana	1.29	.14	2.30*	1.08	.23	.35
Georgia	1.30	.16	2.05*	1.13	.28	.51
South Carolina	1.30	.14	2.48*	1.19	.24	.87
Virginia	1.34	.15	2.69**	.99	.20	-.04
Alabama	1.37	.15	2.88**	1.06	.22	.29
Maryland	1.41	.15	3.19**	1.14	.24	.64
Constant	.02	.00	-16.00***	.18	.08	-3.73***

^a Degrees of freedom from regression model design=78,718, F=17.30, p<.001^b Degrees of freedom from regression model design=78,701, F=3.25, p<.001

*p<.05

**p<.01

***p<.001

Figure 1Odds ratios of diagnosis of ADHD and medication rate among children, by state and in the United States as a whole^a^a Statistical significance of odds ratio for diagnosis of attention-deficit hyperactivity disorder (ADHD): *p<.05, **p<.01, ***p<.001. Statistical significance of odds ratio for medication of ADHD: ^p<.05, ^^p<.01

ication rate that differed from the U.S. averages, we do not conclude that they are states that under- or overdiagnose children or that under- or overmedicate children who have an ADHD diagnosis. Unfortunately, the United States still lacks a diagnostic prevalence estimate that is generated from clinicians evaluating a representative sample of children for ADHD. Furthermore, there is no objective test for a diagnosis of ADHD, as is the case with other mental disorders. A key question pertains to whether the diagnosis involves symptoms per se or whether some indicators of impairment are included. Also, without knowing the true diagnostic prevalence, the optimal medication rate is difficult to determine, because these two measures are likely to be linked.

Still, our results are important because they show geographic variation in diagnostic prevalence that is likely higher than the “true” variation that would be revealed from clinicians’ use of an objective standard to evaluate geographically representative samples of children for ADHD. Therefore, it is important to investigate factors that influence diagnostic prevalence as well as medication use. Thus we discuss the health provider characteristics in the states that not only had a diagnostic prevalence or medication rate that differed from the U.S. averages but also did not align with regional diagnostic prevalence and medication rate patterns.

The high diagnostic prevalence in Michigan is consistent with findings from a previous study (32). Older age of family practitioners and of general practitioners was negatively associated with a child’s being diagnosed, and the number of these older practitioners per 10,000 persons in Michigan (1.4) is lower than the U.S. average (1.8), even though Michigan’s number of younger practitioners is similar to the U.S. average.

The number of older pediatricians per 10,000 children in South Dakota (1.2) and Nebraska (2.1) was less than the U.S. average (3.7), and their ratios of older to younger pediatricians were also less than the U.S. average, all of which may have contributed to their lower diagnostic prevalences.

Table 4

Logistic regression results for state-level variables for diagnosis of attention-deficit hyperactivity disorder (ADHD) and use of medication^a

Variable	Diagnosis (N=66,238)						Medication (N=5,586)					
	Model 1 ^b			Model 2 ^c			Model 3 ^d			Model 4 ^e		
	OR	SE	t	OR	SE	t	OR	SE	t	OR	SE	t
Health care professionals												
Physicians per 10,000 children ^f												
Age <45	.99	.04	-.13				1.25	.11	2.59**			
Age ≥45	1.00	.04	.09				.85	.06	-2.15*			
Pediatricians per 10,000 children												
Age <45				.89	.06	-1.91				1.18	.15	1.35
Age ≥45				1.12	.07	1.85				.75	.09	-2.50*
Family and general practitioners per 10,000 persons												
Age <45				1.25	.21	1.38				1.29	.42	.78
Age ≥45				.74	.11	-2.06*				.98	.28	-.08
Child psychiatrists per 10,000 children												
Age <45				1.56	.41	1.70				.63	.34	-.86
Age ≥45				.85	.18	-.78				2.48	1.03	2.17*
Psychologists per 10,000 persons	1.01	.01	.65	1.00	.02	-.02	.99	.03	-.20	1.01	.03	.28
State education variable												
ADHD law	.88	.08	-1.36	.86	.08	-1.60	.66	.13	-2.20*	.72	.14	-1.74
State-level school accountability policy (1999–2003) ^g												
Sanctions on low-performing schools	.99	.02	-.51	.98	.02	-1.11	1.03	.04	.78	1.06	.04	1.49
Rewards for high-performing or improved schools	1.00	.01	-.08	1.00	.01	.05	.96	.03	-1.23	.95	.03	-1.64
School report cards	1.02	.02	1.12	1.03	.02	1.26	.98	.04	-.42	1.03	.05	.57
School ratings	1.00	.02	.16	1.01	.02	.62	.99	.03	-.18	.95	.04	-1.22
Spending per student (2003–2004)	.99	.03	-.55	.97	.03	-1.11	.96	.05	-.82	.96	.05	-.81

^a The child demographic characteristics (see Table 3) and census division dummy variables were included in the model, but their results are not presented. District of Columbia observations were excluded because its health care provider statistics were often outliers and some of its school accountability values were missing.

^b Degrees of freedom from regression model design=77,245, F=31.22, p<.001

^c Degrees of freedom from regression model design=77,245, F=28.35, p<.001

^d Degrees of freedom from regression model design=77,229, F=5.56, p<.001

^e Degrees of freedom from regression model design=77,229, F=5.10, p<.001

^f Physicians in models 1 and 3 include pediatricians, family and general practitioners, and child psychiatrists. The denominator is per 10,000 children because family and general practitioners were assumed to see children in proportion to their share of the total population.

^g State-level school accountability policy statistics are based on the number of years a state had the accountability policy in place between 1999 and 2003.

*p<.05

**p<.01

On the other hand, the number of older pediatricians per 10,000 children was significantly higher in Connecticut (5.7) and New Jersey (6.3) compared with the U.S. average (3.7), and their ratios of older to younger pediatricians were also higher than the U.S. average. These factors may contribute to the lower medication rates in these states; moreover, Connecticut was the first state to enact an ADHD law in 2001.

The associations of diagnostic prevalence and medication use with physician characteristics are noteworthy; they may result from factors such as differences in education and

training, referral practices, and patient case mix. The positive association between the number of older pediatricians and diagnosing ADHD is consistent with a 2004 national survey of pediatricians (33). Our finding of a negative association between the number of older pediatricians and a diagnosed child's taking ADHD medication may relate to these pediatricians' having little, if any, medical school education about the use of ADHD medications. Also, the American Board of Pediatrics does not have a recertification requirement for pediatricians certified before 1988.

The finding of a negative association between a child's being diagnosed with ADHD and the number of older family and general practitioners may reflect practitioners' referral of children to other professions for ADHD evaluation because of a lack of training, as found in Minnesota (34), but more research is needed nationally.

The finding that the number of older child psychiatrists was positively associated with a diagnosed child's taking ADHD medication is not easy to interpret. For example, it is not clear whether psychiatrists' case mix was similar to that in primary care

(35) or included children with more impairing ADHD who had a greater number of comorbid conditions (36). Also, the differences in medication practice between child psychiatrists and pediatricians need to be further studied (37).

In summary, to better understand the association between a state's health care provider characteristics and both diagnostic prevalence and medication use, it may be fruitful to examine the content of provider continuing education programs, including the recommendations of major health professional organization guidelines to treat ADHD (38–41), which primarily differ regarding the extent to which medication should be used to treat ADHD, especially over long periods. Studying ADHD-related referrals and patient case mix among provider specialties could be informative as well.

State-level school accountability policies were not associated with ADHD diagnosis or medication for it. The state ADHD laws also were not associated with diagnosis, but findings suggest that these laws are associated with less medication use. Because the laws were enacted just before the NSCH data were collected, these findings serve as a baseline measure for future studies.

Three limitations of the study warrant discussion. First, the NSCH telephone survey response rate was 55.3%; however, sampling weights were adjusted for nonresponse. Our analytic sample excluded 14% of the observations, primarily because of missing household income data. However, the excluded observations were not concentrated within a few particular states: exclusion rates by state ranged from 9.1% to 17.5% (and the rate was 19.9% in the District of Columbia).

Second, information on both ADHD diagnosis and medication status was determined by reports from adult respondents. This procedure could introduce measurement error, because some children with ADHD may have never received a diagnosis, and respondent reports may be influenced by stigma or recall bias. Future studies should investigate whether this potential measurement error ex-

plains any of the state-level diagnosis and medication variation.

Third, the NSCH lacked variables that may explain some of the variation, including ADHD subtype, degree of impairment of the ADHD symptoms, and whether the child received behavioral treatment for ADHD. Future surveys should include questions to capture these variables.

Conclusions

This study constitutes one step toward improving the diagnosis and treatment of children with ADHD. Although we did not conclusively identify states that under- or over-diagnose children or that under- or over-medicate children diagnosed as having ADHD, our results point to areas where additional research should be conducted, particularly for better understanding the reasons that provider characteristics are associated with diagnostic prevalence and medication use. Further investigation could help children with ADHD to have a better chance of achieving academic and social parity with their peers.

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