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Assessing Tic Disorders in Children with ADHD from a Nationally Representative Sample

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ABSTRACT

Successful treatments exist for both ADHD and tics, but minimal research has been done on treatments that treat tics in children with ADHD. The purpose of this study was to analyze data from a nationally representative sample of children with ADHD to determine characteristics and demographic factors that maximize tic prevalence and find the most beneficial treatments for those with tics. The data used was from the 2014 National Survey of the Diagnosis and Treatment of ADHD and Tourette Syndrome, a follow-up to the National Survey of Children's Health, conducted by the CDC. The focus of data analysis was to assess tic prevalence in children with ADHD and different demographic characteristics as well as treatment prevalence among demographics and their effects on children with tic disorders. Males seven years or younger and in families at or below the federal poverty level were most likely to have tics. Rates of tic decline were highest in older children and children in families with income substantially above the poverty line. Antipsychotic medications, peer intervention and dietary supplements were found to be significantly more beneficial to school performance of children with ADHD and tic disorders than children without tics. Based on the sample, a combination of antipsychotics, peer intervention and dietary supplements is likely the best option for children with ADHD and tics. Future clinical studies should prioritize treating comorbid disorders before the perceived primary disorder. Comorbid disorders are often the root cause of problems that can exacerbate symptoms and require intense treatment and care.

Introduction

Tic Disorders

One out of every five school-age children suffer from tic disorders (Scahill, 2014). Tics are involuntary movements or sounds that are preceded by a sensation or urge-like feeling, and they can be extremely disruptive to both school and social activity. A chronic tic disorder is characterized by multiple interchanging tics present for over a year, while transient tics are significantly more short-lived, disappearing in less than a year (Shprecher, 2009). Chronic tic disorders affect a little over 2% of children (Pringsheim, 2018), and are four times as likely to occur in boys than girls. Tics tend to reach peak severity around a child's early teenage years, and in the majority of cases they fade as a child develops into adulthood (Cox, 2015).

The specifics of tic disorders' underlying neurological causes are still unknown, though research and findings are constantly being published and discussed to learn more. There is general evidence that the neurotransmission of dopamine is abnormal in people with tic disorders, in addition to other neurotransmitters like GABA and serotonin. It is highly suspected that the abnormalities presented in these disorders are genetic, but no specific genes have been identified as the root cause, making the process of treating these disorders challenging (Cox, 2015).

Treatment of Tic Disorders

Several treatment options have been thoroughly researched for tic disorders, both pharmaceutical and behavioral. Most medications used to treat tics are dopamine-blocking agents like antipsychotics and alpha-adrenergic agonists such as clonidine and guanfacine (Shprecher, 2009), but many recently published and ongoing studies have looked and are still investigating other medications, such as stimulants, that have the potential to be successful. Stimulants have been known to sometimes exacerbate tics and this is thought to be related to the fact that they increase dopaminergic brain activity. However, new research and literature present evidence that stimulants may exacerbate tics and even reduce tics in some children (Ogundele, 2018). Behavioral therapy is often a common treatment route for children with tics and has had high success rates in many cases. The most effective therapy is habit reversal training, which attempts to shift the patient's focus to other bodily actions other than the tics when an urge is felt in an attempt to counter the urge. Deep brain stimulation is a treatment option only for the most severe cases of tics, and not enough research has been conducted to fully understand how it works (Shprecher, 2009). Unfortunately, treatments for tics do not always reduce symptom severity, and determining the proper treatment is extremely difficult when the primary causes of tics are unknown.

ADHD

One of the most common neurobehavioral disorders, ADHD, affects between 4% and 12% of school-aged children worldwide. ADHD is traditionally characterized by mild to severe cognitive impairment in addition to uncontrollable hyperactivity and impulsivity. These symptoms can make functioning in school, work, and even home environments very difficult. Having both an extremely high comorbidity rate and a heritability rate of around 75% (Wilens, 2010), this disorder is the primary target of research for many doctors around the globe. Currently diagnosed in about 11% of children between 4 to 17 years of age in the United States (Danielson, 2017), ADHD diagnoses have increased dramatically over the past few decades, growing by over 30% from 1997 to 2008 (Visser, 2015) and further engaging scientists in research for a better understanding and successful treatments.

For many years, scientists have debated whether ADHD is caused by a delay in brain maturation or a deviation from a normal path of development. As more research has been conducted, evidence suggests that ADHD is actually created by a lag in brain development. In a study done to record and assess the brain's cortical thickness in several ADHD patients, findings suggest that this developmental delay in ADHD is most prolonged in the prefrontal cortex, a region of the brain strongly associated with functions such as attention control, higher-order motor function, and the restraint of inappropriate actions and words, all of which are impaired in patients with ADHD. The primary motor cortex was found to develop faster in those with ADHD than in healthy individuals, and this in combination with a delay in higher-order motor function development provides a potential reason for the poor and uncontrolled motor function typical to that of ADHD (Shaw, 2007). A similar study measuring brain volume in those with ADHD found that all major regions in the cerebral cortex and the cerebellum were smaller in those with ADHD compared to controls. These smaller regions developed in a pattern parallel to that of the controls, but all remained lower in volume, excluding the caudate nucleus, which relates to movement planning, learning and memory. The caudate nucleus grew to normal size during adolescence (Castellanos, 2002).

ADHD has one of the highest comorbidity rates of any neurobehavioral disorder and a multitude of possible comorbid disorders (Wilens, 2010). These disorders include but are not limited to learning and language disorders, anxiety and mood disorders, sleep disorders, seizures and tics. Sometimes these disorders will fade as a result of successful ADHD treatment, but in other cases they will require their own separate treatment apart from ADHD. This extra treatment may be easily administered at the same time as an ADHD treatment, and occasionally one disorder will be treated before the other due to higher levels of severity and impairment or the potential for multiple treatments to interfere with one another (AAP, 2011).

Treatment of ADHD

Different ADHD treatment approaches are recommended depending on the age of the patient. If a child is in pre-kindergarten, they are recommended to receive a form of behavioral therapy. Medications are avoided unless proven necessary, as minimal research has been done on the effect of these medications on children of this age and the harm they may pose to a child's health. Elementary-aged children and adolescents are recommended to receive medication over behavioral therapy, primarily a stimulant, which tends to be the first and most successful medication for most ADHD patients. Some studies have also shown potential in using stimulants in combination with behavioral therapy to treat ADHD (AAP, 2011).

When treating ADHD with medication, stimulants are the primary option given the large amount of available research, their high rates of success with treating ADHD, and their mild and uncommon adverse effects (Wilens, 2010). The most common stimulant used is methylphenidate, and there are others that can be used if there is an issue, such as a harmful side effect. Aside from stimulants, norepinephrine reuptake inhibitors like atomoxetine and alpha-adrenergic agonists such as clonidine and guanfacine have been shown to be effective in treating ADHD, though usually not as a first option (AAP, 2011).

Behavioral treatment for ADHD often begins with forms of parent training and classroom management. Parent training is an option in which the parents of a child with ADHD are educated on behavioral training strategies that they can utilize at home. These strategies involve aspects of rewards and praise as well as punishments for certain behaviors. Classroom management is similar, but instead of parents, teachers are informed about a child's ADHD's condition as well as strategies to use in the classroom. In addition to these training strategies, seating arrangements, assignments and other aspects of the classroom may be changed to benefit a child with ADHD (AAP, 2011). Cognitive behavioral therapy, or CBT, is a way of retraining the brain to change certain habits and behaviors. CBT can involve relaxation techniques, behavioral experimentation and other therapeutic methods to achieve the goal of the patient. For ADHD, CBT is a relatively new non-pharmaceutical treatment option and not much is known about the magnitude of the benefits it will have (Wilens, 2010).

Treatment of Tics and ADHD

Several of the medications used to treat ADHD also have been found to decrease tic severity, such as methylphenidate, clonidine and guanfacine. These medications have very minimal adverse effects in the majority of users and have been found to significantly reduce both ADHD and tic symptom severity. The combination of the stimulant methylphenidate and the alpha-adrenergic agonist clonidine has shown stronger treatment results than either of the two medications alone (Pringsheim, 2018). Non-pharmaceutical treatments for ADHD and tics such as behavioral therapy have been researched and utilized much less commonly, but given the success behavioral therapy tends to have in reducing tic severity, it may be a promising treatment for ADHD as well (Poncin, 2007) and should be more thoroughly researched. Though there are a number of existing studies on the treatment of coexisting tics and ADHD, there are several considerations to be made before administering treatment to a patient with both disorders. Tic and ADHD severity, as well as the initial disorder, past and present treatments, and other comorbid disorders should all be accounted for prior to treatment (Ogundele, 2018).

NS-DATA

The National Survey of the Diagnosis and Treatment of ADHD and Tourette Syndrome was a follow-up survey to the National Survey of Children's Health (NSCH), conducted in 2011 and 2012 by the CDC (Danielson, 2017). NSCH was a very large random telephone survey, and the respondents with children who had ADHD and/or Tourette syndrome were called back in 2014 for further questioning on the details of their child's diagnosis, disorder

characteristics and treatments (Walls, 2017). The data from the sub-survey contains the responses of 2,966 households with a child who has ADHD, and the survey itself contained a multitude of questions, some about basic demographics relating to the people in each household, others about the types of treatments that had been administered and/or were currently being administered.

A few studies using this data have been conducted, but since it is relatively new, more are likely to come. One study used the data to determine the rates at which each treatment was used among different demographics and child characteristics to find associations between the two variables. It was found that younger children were more likely to receive treatment in general than older children and that high poverty decreases rates of medication and increases rates of behavioral therapy (Danielson, 2017). Another study looked for relationships between child and family characteristics and demographics and whether the child was receiving medication, behavioral therapy, both or neither for ADHD. The study presented evidence that children of non-white ethnic backgrounds were less likely to be on medication and that older children were less likely to receive behavioral therapy (Walls, 2017). A different study used the prevalence of each treatment usage to see whether or not the AAP guidelines for treating ADHD were being followed. Consistent with the guidelines, results showed that behavioral therapy is much less common than medications for treating ADHD and that comorbid disorders increase the rate of behavioral therapy and combination treatments while decreasing the prevalence of medication alone (Visser, 2015). All of these findings demonstrate the potential this data possesses for further analysis, as it may lead to the discovery of additional treatment disparities and effective treatment plans for many ADHD patients.

Gap In Research

The National Survey of the Diagnosis and Treatment of ADHD and Tourette Syndrome contains a very large amount of data. Much of it is unused, as it is too much to use in one study and the survey is relatively new. No currently published studies used this survey to focus on the comorbid diagnoses accompanying ADHD, such as tics, and whether or not they influenced the type of treatment used and its effectiveness.

Purpose

The purpose of this research was to (1) determine tic prevalence in children with ADHD and different demographic characteristics and (2) compare the data from the ADHD patients that do not have tics to the data from the ADHD patients with comorbid tic disorders to identify treatments that are more beneficial to the children with tics. In addition, the data was used to see how these children with ADHD and tics function in an educational environment on each treatment as compared to ADHD children without tics in order to determine whether there is a way to single out children with ADHD and tics for a more effective treatment plan.

Hypotheses

It was hypothesized that the findings on tic prevalence would be consistent with findings from the prior literature, such as tics being more common in males and in younger children. Specific hypotheses tested are of the following form:

(1) H_0: Tic frequency is the same across groups (defined by gender, age, race/ethnicity, and poverty level)
H_1: Tic frequency is different across groups

In addition, antipsychotics, anticonvulsants, and central nervous system stimulants were medications hypothesized to be most effective in reducing tics in children with ADHD and all included non-pharmaceutical treatments were predicted to be beneficial as well. Specific hypothesis tested are of the following forms:

(2) H_0: Treatment (for various treatments) has no effect on the persistence of tics
H_1: Treatment has an effect on the persistence of tics
(3) H_0: Treatment (for various treatments) has no effect on school performance (defined by overall school performance and type of student)
H_1: Treatment has an effect on school performance
(4) H_0: Treatment (for various treatments) effect is the same for those who have had tics and those who never have had tics (based on changes in school performance)
H_1: Treatment effect is different for those who have had tics and those who neve have had tics.

Methods

National Survey Description

The survey utilized in this study was the National Survey of the Diagnosis and Treatment of ADHD and Tourette Syndrome (https://www.cdc.gov/nchs/slaits/ns_data.htm), a publically released 2014 follow-up survey to the 2011-2012 National Survey of Children's Health (NSCH), conducted and funded by the Center for Disease Control and Prevention. This study was focused on the ADHD portion of the survey. The people included in this secondary survey were those who reported a child with an official ADHD diagnosis during the NSCH survey. The new survey contains a collection of parent-reported data answering a series of questions related to the diagnosis and treatment of ADHD occurring in these households. It had a 47% response rate and 2,966 respondent households.

Study Design

This study of the National Survey data (NS-DATA) focused primarily on those who had or previously had comorbid tic disorders in addition to ADHD. All data from the children included in the survey who fit this requirement were observed and no other sample specifications were used for this study. Using SAS University Edition, the target data was organized and cleaned, removing inconsistent observations, such as current tics reported for children also reported to have never had tics. Uninformative cases where the respondent refused to or could not answer a relevant question were excluded. "Legitimate skip" responses were recoded according to their implied meaning (e.g., those who responded "no" to "ever tics" were recorded as a legitimate skip for "current tics"). Missing data cases were dropped. Comparisons were made across demographic characteristics, including sex (male, female), age group at the time of the interview (7 and younger, 8-11, 12-17), household poverty status in relation to the federal poverty level (≤100%, 100%-200%, 200%-400%, >400%), and race and ethnicity (White Non-Hispanic, Black Non-Hispanic, Hispanic, Other Non-Hispanic).

To determine tic prevalence, those who had ever had tics and those who had tics at the time of the survey were observed against these demographics and against school performance ratings. Treatment prevalence was evaluated for all medications and non-pharmaceutical treatments included in the survey. The medications include anticonvulsants, antidepressants, antiemetics, antiparkinsonians, antipsychotics, anxiolytics, central nervous system agents, central nervous system stimulants, and musculoskeletal medications; anticonvulsants, antiemetics, antiparkinsonians, anxiolytics, and musculoskeletal medications were cited with insufficient frequency for analysis (≤20 cases). The non-pharmaceutical treatments included were educational support, classroom management, peer intervention, social skills training, cognitive behavioral therapy (CBT), dietary supplements, and biofeedback. Outcomes

of medication treatment were assessed for those with and without tics in order to establish whether they uniquely impact those with tics. School performance ratings were also looked at for each treatment for children with and without tics to determine if any treatments were more effective when used for those with tics.

Statistical Analyses

Statistical significance for comparisons in the data was tested with chi-squared tests and linear regressions using SAS University Edition. Linear regressions controlled for the demographic characteristics previously mentioned to eliminate the influence of possible confounding variables. Statistical tests of the impact of treatments on school performance for children with tics against those without tics were calculated. Specifically, the differences in average performance between those receiving and not receiving treatment were compared between those with and without tics using a t-test. The SAS statistical software was directly used to build and export the tables presented in this study.

Results

Tic Prevalence

The final sample included data on 2,966 children with ADHD, where 676 had ever had tics and 423 had tics at the time of the survey. Males were found to be significantly more likely than females to have had a tic disorder, with a prevalence of 26.11%, compared to 17.87%. Gender was not found to be associated with the rate of tic decline (percent of those who had ever had tics that did not have tics at the time of the survey). 40.43% of children 7 years old or younger had ever had comorbid tics, while older children from age 12 to 17 were much less likely to have ever had tics. Tic prevalence also increased as families approached the federal poverty line, as 28.03% of children in households at or below the line had ever had tics compared to 19.42% in households 400% or more above the federal poverty line. Age and poverty level did seem to have associations with the rate of tic decline, as older children and children in households higher above the poverty line had higher rates of tic decline than younger children and children in households closer to the poverty line. Race and ethnicity were not found to be associated with tic prevalence, though Black children with tics showed a lower rate of tic decline than other races and ethnicities (see Table 1).

Table 1. Tic Prevalence among Different Demographics

Demographics	Case Count	Ever Tics^ (N=676)	Current Tics^ (N=423)	Rate of Decline^^
Male / Female	2097 / 869	26.11% / 17.87% **	16.45% / 10.91% **	37% / 39%
≤ Age 7 / Age 8-11 / Age 12-17	101 / 747 / 2118	40.43% / 27.92% / 21.42% **	29.79% / 18.98% / 12.65% **	26% / 32% / 41%
Poverty Line: ≤100% / >100% and ≤200% / >200% and ≤400% / >400%	414 / 556 / 873 / 962	28.03% / 25.28% / 26.08% / 19.42% **	21.21% / 16.29% / 16.63% / 10.41% **	24% / 36% / 36% / 46%
White / Black / Hispanic / Other ^	2154 / 261 / 254 / 291	23.61% / 22.71% / 25.62% / 24.10%	14.41% / 17.13% / 16.53% / 14.75%	39% / 25% / 35% / 39%

^ indicates significance level of α=0.05 was used, a starred p-value indicates significance. * Indicates $p<0.05$, ** indicates $p<0.01$, and ^^Shows the rate at which tics decline within each demographic characteristic.

Table 2. Tic Effect on School Performance

School Performance Variables		Case Count	Ever Tics = Yes (N = 676)	Ever Tics = No (N = 2176)	Linear Regression^ (p-values^^)
Overall School Performance	Problematic	633	29.57%	19.98%	0.0003**
	Somewhat Problematic	640	21.65%	21.87%	
	Average	853	25.91%	30.91%	
	Above Average	514	15.09%	18.38%	
	Excellent	247	7.77%	8.86%	
Type of Student	A	560	19.25%	19.23%	0.0352*
	B	1140	35.79%	40.20%	
	C	883	29.17%	30.44%	
	D	240	10.68%	7.42%	
	F	94	5.11%	2.71%	
School Performance Variables		**Case Count**	**Current Tics = Yes (N = 423)**	**Current Tics = No (N = 2429)**	**Linear Regression^ (p-values^^)**
Overall School Performance	Problematic	633	32.45%	20.47%	0.0002**
	Somewhat Problematic	640	20.82%	21.99%	
	Average	853	25.91%	30.40%	
	Above Average	514	13.32%	18.35%	
	Excellent	247	7.51%	8.79%	
Type of Student	A	560	17.59%	19.52%	0.0292*
	B	1140	34.46%	39.97%	
	C	883	31.81%	29.85%	
	D	240	11.57%	7.61%	
	F	94	4.58%	3.05%	
School Performance Variables		**Case Count**	**Lost Tics = Yes (N = 253)**	**Lost Tics = No (N = 423)**	**Linear Regression^ (p-values^^)**
Overall School Performance	Problematic	633	24.69%	32.45%	0.1255
	Somewhat Problematic	640	23.05%	20.82%	
	Average	853	25.93%	25.91%	
	Above Average	514	18.11%	13.32%	
	Excellent	247	8.23%	7.51%	
Type of Student	A	560	22.00%	17.59%	0.4985
	B	1140	38.00%	34.46%	
	C	883	24.80%	31.81%	
	D	240	9.20%	11.57%	
	F	94	6.00%	4.58%	

^ Linear regressions account for the effect of gender, age, poverty level, and race/ethnicity.

^^ A significance level of α=0.05 was used, a starred p-value indicates significance. * indicates $p<0.05$, ** indicates $p<0.01$.

Treatment Prevalence

Of all the medications included in the survey, antidepressants, antipsychotics and central nervous system agents were the most commonly used among children who had ever had or still had tics. All non-pharmaceutical treatments included in the survey were received significantly more often by children who had ever had or still had tics, with the exception of biofeedback. Educational support, classroom management and social skills training were the only three treatments included in the survey that had a significant positive association with children who had lost their tics (see Tables 3a-3c).

Table 3a. Treatment Prevalence

Treatment		Case Count	Ever Tics = Yes (N = 676)	Ever Tics = No (N = 2176)	Linear Regression^ (p-values^^)
Pharmaceutical Treatments	**Antidepressant**	173	11.96%	9.22%	0.0939
	Antipsychotic	104	8.13%	5.19%	0.1195
	CNS Agent	283	21.67%	14.18%	0.0031**
	CNS Stimulant	1503	84.42%	86.37%	0.4601
Non-Pharmaceutical Treatments	**Educational Support**	1768	68.59%	57.16%	<0.0001**
	Classroom Management	817	39.28%	24.39%	<0.0001**
	Peer Intervention	274	13.23%	8.07%	0.0013**
	Social Skills Training	581	29.54%	16.82%	<0.0001**
	CBT^^	225	12.50%	6.09%	<0.0001**
	Dietary Supplement	251	10.95%	7.82%	0.022*

^ Linear regressions account for the effect of gender, age, poverty level, and race/ethnicity.
^^ A significance level of α=0.05 was used, a starred p-value indicates significance. * Indicates p<0.05, ** indicates p<0.01. ^^^ CBT: Cognitive Behavioral Therapy

Table 3b. Treatment Prevalence

Treatment		Case Count	Current Tics = Yes (N = 423)	Current Tics = No (N = 2429)	Linear Regression^ (p-values^^)
Pharmaceutical Treatments	**Antidepressant**	173	10.07%	9.89%	0.9473
	Antipsychotic	104	8.27%	5.49%	0.4172
	CNS Agent	283	21.22%	15.11%	0.1029
	CNS Stimulant	1503	82.37%	86.54%	0.1608
Non-Pharmaceutical Treatments	**Educational Support**	1768	73.76%	57.45%	<0.0001**
	Classroom Management	817	43.61%	25.20%	<0.0001**
	Peer Intervention	274	15.46%	8.22%	0.0004**
	Social Skills Training	581	35.80%	17.04%	<0.0001**
	CBT^^	225	14.25%	6.45%	<0.0001**
	Dietary Supplement	251	11.35%	8.07%	0.0453*

^ Linear regressions account for the effect of gender, age, poverty level, and race/ethnicity. ^^ A significance level of α=0.05 was used, a starred p-value indicates significance. * Indicates p<0.05, ** indicates p<0.01.
^^^ CBT: Cognitive Behavioral Therapy

Table 3c. Treatment Prevalence

Treatment		Case Count	Lost Tics = Yes (N = 253)	Lost Tics = No (N = 423)	Linear Regression^ (p-values^^)
Pharmaceutical Treatments	Antidepressant	173	15.15%	10.07%	0.1618
	Antipsychotic	104	7.88%	8.27%	0.8466
	CNS Agent	283	22.42%	21.22%	0.4341
	CNS Stimulant	1503	87.88%	82.37%	0.1596
Non-Pharmaceutical Treatments	Educational Support	1768	59.92%	73.76%	0.0003**
	Classroom Management	817	32.14%	43.61%	0.0258*
	Peer Intervention	274	9.56%	15.46%	0.1949
	Social Skills Training	581	18.95%	35.80%	0.0001**
	CBT^^	225	9.56%	14.25%	0.2582
	Dietary Supplement	251	10.28%	11.35%	0.8488

^ Linear regressions account for the effect of gender, age, poverty level, and race/ethnicity.
^^ A significance level of α=0.05 was used, a starred p-value indicates significance. * Indicates p<0.05, ** indicates p<0.01. ^^^ CBT: Cognitive Behavioral Therapy

Table 4a. Effect of Medication Treatments on Overall Behavior

Outcome Variables		Case Count	Ever Tics = Yes (N = 676)	Ever Tics = No (N = 2176)	Linear Regression^ (p-values^^)
Do Medications Help Schoolwork?	Not At All	21	2.03%	0.78%	<0.0001**
	A Little	98	9.03%	4.44%	
	Some	353	21.67%	19.61%	
	A Lot	1274	67.27%	75.18%	
Do Medications Help Behavior?	Not At All	57	2.27%	3.59%	0.244
	A Little	133	8.86%	7.34%	
	Some	473	29.77%	26.02%	
	A Lot	1075	59.09%	63.05%	
Do Medications Help Interactions?	Not At All	57	2.27%	3.59%	0.244
	A Little	133	8.86%	7.34%	
	Some	473	29.77%	26.02%	
	A Lot	1075	59.09%	63.05%	
	A Little	133	9.15%	8.70%	
	Some	473	25.00%	32.61%	
	A Lot	1075	64.02%	56.16%	

^ Linear regressions account for the effect of gender, age, poverty level, and race/ethnicity. ^^ A significance level of α=0.05 was used, a starred p-value indicates significance. * indicates p<0.05, ** indicates p<0.01.

Treatment Outcomes

For children who had past or present experience with tics, medication was less likely to help with schoolwork than for children who had never had tics. Interestingly, children who had lost their tics were more likely to have medication help them "a lot" with schoolwork (see Tables 4a-4c).

Table 4b. Effect of Medication Treatments on Overall Behavior

Outcome Variables	Case Count		Current Tics = Yes (N = 423)	Current Tics = No (N = 2429)	Linear Regression^ (p-values^^)
Do Medications Help Schoolwork?	**Not At All**	21	2.88%	0.76%	<.0001**
	A Little	98	7.91%	5.17%	
	Some	353	25.90%	19.03%	
	A Lot	1274	63.31%	75.03%	
Do Medications Help Behavior?	**Not At All**	57	2.54%	3.39%	0.0947
	A Little	133	8.70%	7.55%	
	Some	473	32.61%	25.90%	
	A Lot	1075	56.16%	63.16%	
Do Medications Help Interactions?	**Not At All**	57	2.54%	3.39%	0.0947
	A Little	133	8.70%	7.55%	
	Some	473	32.61%	25.90%	
	A Lot	1075	56.16%	63.16%	
	A Little	133	9.15%	8.70%	
	Some	473	25.00%	32.61%	
	A Lot	1075	64.02%	56.16%	

^ Linear regressions account for the effect of gender, age, poverty level, and race/ethnicity.
^^ A significance level of α=0.05 was used, a starred p-value indicates significance. * indicates p<0.05, ** indicates p<0.01.

Treatment Effect on School Performance

Medication use at the time of the survey appeared to decrease the chance of getting failing grades in school more for children who had ever had tics than for those who had not. Antidepressants were found to be more harmful to children who had ever had tics, decreasing their chance of getting A's in school while increasing that chance for those who had never had tics. Antipsychotics, on the other hand, appear to support excellence in school uniquely for children who have had tics.

For non-pharmaceutical treatments, peer intervention seemed to increase the chance of getting A's in school for those who had ever had tics, though it was related to a lower chance for those who had not. The findings on dietary supplements were the most positive for treating tics, as they seemed to increase excellence and the chance of getting A's in school uniquely for children who had ever had tics (see Table 5). Results related to biofeedback are not included due to lack of significant findings.

Table 4c. Effect of Medication Treatments on Overall Behavior

Outcome Variables		Case Count	Lost Tics = Yes (N = 253)	Current Tics = No (N = 423)	Linear Regression^ (p-values^^)
Do Medications Help Schoolwork?	**Not At All**	21	0.61%	2.88%	0.436
	A Little	98	10.91%	7.91%	
	Some	353	14.55%	25.90%	
	A Lot	1274	73.94%	63.31%	
Do Medications Help Behavior?	**Not At All**	57	1.83%	2.54%	0.5278
	A Little	133	9.15%	8.70%	
	Some	473	25.00%	32.61%	
	A Lot	1075	64.02%	56.16%	
Do Medications Help Interactions?	**Not At All**	57	1.83%	2.54%	0.5278
	A Little	133	9.15%	8.70%	
	Some	473	25.00%	32.61%	
	A Lot	1075	64.02%	56.16%	

^ Linear regressions account for the effect of gender, age, poverty level, and race/ethnicity.

^^ A significance level of α=0.05 was used, a starred p-value indicates significance. * Indicates $p<0.05$, ** indicates $p<0.01$.

Discussion

Findings on tic prevalence suggest that in children with ADHD, tic disorders are most common in males who are 7 years old or younger and living in a low income family at or below the poverty level. Race and ethnicity were not found to be related to tic prevalence. These findings on tic prevalence among children with ADHD are consistent with past research on tics, rejecting the first null hypothesis (1). The difference between males and females in tic prevalence is smaller than that in other tic disorder research, but this could be the result of a population in which everyone has or has had ADHD; tics are very common in children with ADHD, and this may increase tic prevalence in females in this data set. Tics occurring more commonly in those who are younger and more often declining in those who are older is likely primarily due not to treatment success but to the common occurrence of tic disorders fading with age. The higher rates of tics in low-income families and the higher rates of decline in high-income families may be caused by disparities in treatment access, potentially more limited to those who cannot afford it. The lower rate of tic decline for Black children could be connected to the factors previously mentioned relating to poverty level.

Children who had ever had tics or had tics at the time of the survey tended to be problematic in school and get lower grades to a greater degree than those who did not have tics. This finding illustrates the significance of treating tic disorders in children with ADHD. Tics on their own can be a distraction and something to make a child feel self-conscious in an educational environment. Finding the most effective way to eliminate tics in children with ADHD will certainly improve the educational experience for these children.

Antidepressants, antipsychotics and central nervous system agents were found to be the most common medications used for treatment of children who had ever had or still had tics. All non-pharmaceutical treatments were very common for these children as well, except for biofeedback. This information is consistent with prior literature and supports the idea on which the second alternative hypothesis is based; These treatments will be the most

effective in treating tics in children with ADHD since they are the most commonly administered options for children with tics.

Being on medication at the time of the survey was beneficial to school grades in those with tics, especially when it was an antipsychotic medication, which strongly supported excellence in an educational setting. This finding rejects the third and fourth null hypotheses (3,4), which stated that antipsychotics would not have any effect on tics in ADHD cases, but fails to reject the second null hypothesis (2), which stated that the persistence of tics would be unaffected. However, central nervous system stimulants did not result in a significant educational benefit for children with tics, failing to reject null hypotheses two, three, and four for these medications (2,3,4). Dietary supplements and peer intervention were non-pharmaceutical treatments that significantly benefited school performance and grades specifically for children who had ever had tics, dietary supplements more so than peer intervention. These findings reject null hypotheses two, three, and four for these two non-pharmaceutical treatments (2,3,4). All of these observations provide clear guidance for tic treatment in children with ADHD.

These results support and strengthen the findings in past literature and provide specific treatment options that are more effective in treating children with ADHD and tics. Antipsychotics, peer intervention and dietary supplements appear to be the most effective treatments for tics in children with ADHD, supported by classroom performance-based evidence. Prior research utilizing this survey data was primarily conducted by one group of researchers, several of whom were from the Centers for Disease Control and Prevention. These studies used the data for a more general application, summarizing receipt of treatment among children with ADHD (Danielson, 2018), determining ADHD prevalence in children and adolescents across the country (Walls, 2017), and assessing the alignment of administered treatments with the American Academy of Pediatrics ADHD treatment guidelines (Visser, 2015). This study's novel use of the nationally representative survey data allowed for new observations on disorder prevalence and the creation of treatment recommendations for a more specific, but still large, category of patients, those with both ADHD and tics.

Conclusion

The purpose of this study was to assess the prevalence of tics and the treatments used for tics in children with ADHD in order to find the most successful treatment plan for these children. Antipsychotics, paired with peer intervention, dietary supplements or both is likely the best option for children with ADHD and tics, based on this study's findings. Further research on this topic, especially clinical trials assessing medications such as antipsychotics and other non-pharmaceutical treatments, will be needed to most accurately provide treatment recommendations from the wide variety of options available. Samples for these studies should not just be limited to those with ADHD, but should also include children with tics alone or in combination with other neurobehavioral disorders, as this may help to determine what treatments are best for tic disorders among all tic patients. Also, more research must be done on behavioral treatments such as CBT to treat ADHD, as it has success often with tics and other neurobehavioral disorders and has not been well researched for ADHD.

This study looked at the treatment of tic disorders comorbid to ADHD, and future clinical studies should do this as well. It is important to consider the severity of co-occurring disorders before constructing a specific treatment plan. Treating comorbid disorders before the perceived primary disorder may be beneficial to patients with neurobehavioral conditions, as they can be very severe and are often the root cause of excessive problems.

Limitations

Given that this study was conducted solely with data from a public survey, there are multiple limitations to the design. There is no way to entirely reject the other medications and non-pharmaceutical treatments as unsuccessful in treating tics, as the survey was limited in its sample for each treatment and its specific questioning on each treatment

effect. The questions related to treatments were general and did not address specific factors relating to treatments and their effects, like drug dosage and period of use, and there are additional treatments for tics that were not included in the ADHD-focused survey. In addition, the data collected during the survey was all parent-reported information not confirmed by a medical professional. This may have subjected the survey to response bias.

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