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The Developmental Course of ADHD in the Preschool Classroom: Toward a Prevention Treatment Framework

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THE DEVELOPMENTAL COURSE OF ADHD IN THE PRESCHOOL CLASSROOM: TOWARD A PREVENTION TREATMENT FRAMEWORK

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ABSTRACT

The objective of this study was to examine the developmental trajectories of inattention and hyperactivity/impulsivity symptom levels during preschool among a majority Head Start sample of 261 three- to five-year-old children (87% Head Start; 59% Caucasian; 53% boys; M_{age} = 3.97 years). Teacher ratings of ADHD symptom levels across four time points within the academic year demonstrated, on average, a course of increasing inattention that decelerated over time and a course of steadily increasing hyperactivity/impulsivity. When accounting for the clustering of children within classrooms, both inattention and hyperactivity/impulsivity showed an average increasing trajectory over the year with no deceleration. Group-based finite mixture modeling revealed three trajectories of inattention: stable low (57%), change (32%), and stable high (11%), as well as three trajectories of hyperactivity/impulsivity: stable low (63%), increasing (26%), and stable high (11%). In the inattention domain, analyses that accounted for clustering within classrooms revealed a stable moderate group instead of a change group. In the hyperactivity/impulsivity domain, findings held even when accounting for clustering. Group-based comparisons showed that as compared to girls, boys started the preschool year with higher levels of inattention and hyperactivity/impulsivity symptoms, had greater rates of increase in these symptoms over time, and were more likely to follow a high stable or increasing pattern of these symptoms over the year. Being younger was associated with higher inattention levels at the start of the preschool year but the rate of change in inattention was not associated with age. Children with stable high inattention were more likely to be younger than children with stable low inattention. Age was not associated with hyperactivity/impulsivity at the start of the preschool year but being older was linked with a steeper increase in these symptom levels over the course of the year. There were no differences in the mean age of children following different pathways of hyperactivity/impulsivity symptom levels through the year. Implications for assessment and intervention of ADHD during preschool are discussed.

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TABLE OF CONTENTS

Page

LIST OF TABLES

Table Page

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most prevalent and impairing childhood psychological disorders, impacting an estimated 8-10% of the population worldwide (Polanczyk, Willcutt, Salum, Kieling, & Rohde, 2014). Previously considered a disorder that remits in adolescence, research now illustrates that many children diagnosed with ADHD go on to experience continued symptom expression and corresponding impairment long into adulthood (Lahey et al., 2016; Willoughby, 2003). Consequently, ADHD is now primarily considered a *chronic* disorder with significant associated functional impairments and widespread economic cost to society (Chorozoglou et al., 2015).

The majority of the ADHD literature focuses on school-aged children, which is unsurprising given that ADHD is most often diagnosed upon school entry (Richters et al., 1995). However, over the past decade, increasing attention has been paid to the prevalence of ADHD symptoms in preschool children in an effort to consider new avenues for early intervention (Egger, Kondo, & Angold, 2006; Greenhill, Posner, Vaughan, & Kratochvil, 2008; Lavigne, LeBailly, Hopkins, Gouze, & Binns, 2009). Based on large epidemiological community samples, current prevalence estimates for ADHD in preschoolers range from 2 to 6 percent (Egger et al., 2006; Lavigne et al., 2009). Importantly, it is still not well understood how ADHD symptoms fluctuate within the preschool years, which may result in the misinterpretation of findings derived from cross-sectional data.

Extant longitudinal work has examined both the developmental course of ADHD symptoms that begin in preschool, as well as the developmental outcomes associated with early-emerging symptoms. The distinction between developmental course and outcome studies is key, as these studies provide different types of information. As outlined by Willoughby (2003), developmental *outcome* studies examine whether children who meet diagnostic criteria for ADHD at one time point continue to evidence functional impairment later in development. In contrast, developmental *course* studies examine the persistence of ADHD symptoms over time (i.e., trajectory studies) or whether children who meet diagnostic criteria for ADHD at one time point continue to meet criteria at a later time point (i.e., diagnostic retention studies). Both types of longitudinal studies are essential to advancing our understanding of the onset, course, and associated outcomes of early-emerging ADHD symptoms.

In addition to gaining an understanding of early-emerging ADHD symptoms, researchers are currently focused on identifying children who are most at risk for developing symptoms later in childhood (see Berger & Nevo, 2011). In order to accurately identify young children who are at risk for developing ADHD, it is critical to differentiate developmentally abnormal elevations of ADHD symptoms from more typical, time-limited, problem behaviors. This differentiation is particularly important for ADHD, since developmentally normative hyperactivity, inattention, and impulsivity are all to be expected at the preschool age. Yet, research to date has primarily focused on the continuity of parent-rated symptom expression from preschool through elementary school (e.g., Curchack-Lichtin, Chacko, & Halperin, 2014; Lahey et al., 2004), leading to a gap in our understanding of how ADHD symptoms may fluctuate *within* the preschool years, particularly from the perspective of teachers. To address this gap, the current study examined the developmental course of teacher-rated ADHD symptoms in an at-risk community sample across one academic preschool year. Given that very few studies have examined ADHD symptoms at multiple time points in preschool and, to our knowledge, no preschool studies have done so from the perspective of the teacher, the current study will use both variable-centered and person-centered approaches to examine the developmental course of symptoms across the school year. A variable-centered approach allows for the examination of average symptom trajectories across all participants, whereas a person-centered approach emphasizes individual variability by examining distinct groups of children with different trajectories of change in symptomatology across the year. By closely examining symptom expression, at the sample and subsample levels, across multiple time points in preschool, we aim to better understand the continuities and discontinuities of ADHD symptom presentation during this critical point of development.

1.1. Developmental Outcomes Associated with Preschool ADHD Symptoms

Longitudinal research examining preschool ADHD and associated functional impairment later in development has been critical in contributing to the current conceptualization of ADHD as a chronic condition that begins early in development. This body of work, along with diagnostic retention studies (reviewed below), also has validated the diagnosis of ADHD in young children by highlighting that both children with elevated behavior problems and those meeting full diagnostic criteria for ADHD in preschool frequently continue to evidence symptoms and impairment later in childhood, both at home and school (Lahey et al., 2016; Massetti et al., 2008; Smith et al., 2017). Indeed, in 2011, the American Academy of Pediatrics revised their clinical practice guidelines to emphasize the validity of ADHD diagnoses in children as young as four-years-old (Wolraich et al., 2011).

One of the first key developmental outcome studies was conducted in 1994 with preschool boys selected based on the presence of teacher- or parent-reported ADHD symptoms (Campbell, Pierce, March, Ewing, & Szumowski, 1994). In this study, 64 "ADHD-risk" boys and 43 age-matched control boys were evaluated at age four and again two years later. Results indicated that ADHD-risk boys were more likely at the two-year follow-up to show disruptive problems, high activity levels, and high-intensity behaviors (e.g., observed rough-and-tumble play, aggression with peers), as compared to control boys. Moreover, this pattern of findings held across multiple settings (i.e., home, preschool, laboratory). Findings from the Campbell et al. (1994) study were some of the first to suggest that preschool ADHD symptoms should not be dismissed as transient, age-appropriate behaviors.

Approximately a decade after the Campbell et al. (1994) study, Lahey et al. (2004) reported on their three-year follow-up of a sample of 125 boys and girls with either full (n = 96) or situational (n = 29) ADHD and 130 comparison children, first assessed at ages 4-6 (Lahey et al., 1998). Situational ADHD was defined by impairment present in only one setting. Findings indicated that children meeting full diagnostic criteria for ADHD at the first assessment (ages 4-6) showed significantly more global, social, and academic functional impairment compared to the control group, as rated by teachers, parents, interviewers and even children themselves, across the following three annual assessments. Importantly, even children meeting the situational ADHD criteria were more impaired three years later than control children, and they only differed from the full ADHD group on the global measure of functional impairment. These findings raise the possibility that the diagnostic requirement for cross-situational impairment may be too restrictive for young children who are just beginning school.

Additional follow-up studies using the Lahey et al. (1998) sample revealed that preschoolers with ADHD frequently go on to display academic challenges, social impairment, and comorbid conduct and internalizing problems into childhood and adolescence (Lahey et al., 2016; Lee, Lahey, Owens, & Hinshaw, 2008; Massetti et al., 2008). Of note, the most recent follow-up of the Lahey et al. cohort showed that despite overall declines in ADHD symptoms over time, children in the ADHD groups (full and situational criteria) at ages 4-6 continued to show more functional impairment at age 18 than youth in the control group. Indeed, only 10% of youth in the ADHD groups were functioning in the normative range during adolescence (i.e., few ADHD symptoms and no functional impairment; Lahey et al., 2016).

Additional research investigating children with ADHD diagnosed during early childhood supports initial findings from the Lahey et al. and Campbell et al. samples. For example, in a nationally representative sample of 590 kindergarten children diagnosed with ADHD (DuPaul, Morgan, Farkas, Hillemeier, & Maczuga, 2016), researchers examined the trajectories of children's academic and social functioning across the 1^{st}, 3^{rd}, and 5^{th} grades, and compared children's scores to the overall population mean. Although kindergarteners with ADHD demonstrated substantial heterogeneity in pathways of academic and social functioning, as evidenced by the numerous identified subgroups following different trajectories of functioning across time, many young children with ADHD appeared to be at risk for long-term academic underperformance and sustained deficits in interpersonal skills. Compared to math and interpersonal skill score trajectories, reading score trajectories remained highly stable over time, suggesting that children with ADHD who demonstrate below-average reading skills are at particular risk for continued challenges with reading later in elementary school. In addition, in a study of 3-year-old children with (n = 178) and without (n = 88) high levels of parent-reported hyperactivity, researchers assessed participants as adolescents or young adults and established hyperactivity at age 3 as a key predictor of later ADHD symptoms and comorbid problems (e.g., internalizing problems, conduct problems, autism spectrum disorder symptoms; Smith et al., 2017). Findings also documented an important sex difference, highlighting that the association between preschool hyperactivity and adolescent outcomes was stronger for boys than girls. Indeed, in a model that included additional preschool behavior problems, findings revealed that conduct and emotional problems during preschool, but not hyperactivity, were significant predictors of girls' later outcomes, whereas hyperactivity continued to predict boys' later outcomes. Together, the results from Smith et al. (2017) suggest that hyperactivity in preschool may not impact young boys and girls equally. Of note, these findings are not entirely consistent with other work that has suggested preschool girls with ADHD are at higher risk than boys for negative outcomes later in development (Lahey et al., 2016). More research is needed to disentangle the importance of child sex on the developmental outcomes of early emerging ADHD.

In sum, a number of empirical investigations of the developmental outcomes associated with early emerging ADHD have uniformly suggested that children meeting either full or situational ADHD at this early age are at substantial risk for later functional impairment across several domains (e.g., academic, social, comorbid mental health problems), though it remains unclear whether these associations might be different for boys and girls. Regardless, this body of work highlights that parents, teachers, and clinicians should pay close attention to ADHD symptoms in early childhood and should consider how best to intervene to prevent the onset of later functional impairment.

1.2. Developmental Course of ADHD Symptoms in Early Childhood

Along with the growing body of work documenting a clear pattern of negative outcomes associated with ADHD diagnoses made during early childhood, it is critical to also examine the developmental *course* of ADHD to fully understand how symptoms change across time and whether diagnoses made in preschool persist. There are two primary research questions that are key to developmental course studies: 1) how does the diagnostic status of children with early emerging ADHD change across time? and 2) how do early symptoms of inattention and hyperactivity/impulsivity, measured continuously, change over time? These two important research questions stem from two different theoretical frameworks, the former research question corresponding to a mental disorder (MD) framework, and the latter question corresponding to a developmental psychopathology (DP) framework. The MD perspective places an emphasis on categorizing children as “ADHD” or “non-ADHD” to make a clinical diagnosis and identify those most in need of services. This perspective is necessary to adhere to the current medical model used for the provision of psychological services. However, the MD perspective does not account for the fact that ADHD symptoms vary along a continuum of severity, with those categorized as “ADHD” falling at the most extreme end of the continuum. Indeed, as noted by Sonuga-Barke, Auerbach, Campbell, Daley, and Thompson (2005), the ADHD diagnostic category is not a “qualitatively distinct entity," which suggests that research using the MD framework may miss important information relating to the presentation of inattention, hyperactivity, and impulsivity in young children. Conversely, the DP perspective underscores the dynamic process of symptom development across time, leading to a greater emphasis on the continuum of ADHD symptoms that naturally occurs among typically and atypically developing children (Rutter, 2014). To fully understand the complex and dynamic development of ADHD symptoms in young children, it is necessary to integrate MD and DP research to broaden our understanding of the heterogeneous ways that ADHD symptoms develop and relate to impairment throughout the lifetime.

1.2.1. Diagnostic Retention Research

To receive an ADHD diagnosis, the current diagnostic system, based on the Diagnostic and Statistical Manual of Mental Disorders - Fifth Edition (DSM-V; American Psychiatric Association, 2013) requires either six of nine symptoms of hyperactivity/impulsivity and/or six of nine symptoms of inattention, with evidence of symptoms in multiple settings, as well as documented functional impairment. Research using the MD framework, which typically examines the prevalence and course of DSM-based ADHD diagnoses, is essential to informing best-practice clinical assessment and treatment. This body of work has helped to establish the relative stability of overall ADHD diagnoses made during preschool (Lahey et al., 2004) and the relative *instability* of ADHD presentations across time (Lahey, Pelham, Loney, Lee, & Willcutt, 2005). Indeed, in a sample of 118 clinic-referred children with ADHD diagnosed at ages 4-6 (full or situational criteria), a large portion of children (75%) continued to meet diagnostic criteria eight years later (Lahey et al., 2005). Importantly, this sample was also the first to document that children with ADHD commonly switched diagnostic subtypes across time, leading the authors to question the relevance of the ADHD subtypes. Of note, children diagnosed with the hyperactive/impulsive subtype at ages 4-6 often met the combined subtype criteria at a later time point, suggesting the hyperactive/impulsive presentation at this early age may be a precursor to the combined presentation.

As described earlier, one major limitation of research using the MD framework is the reliance on symptom cut points to designate children as ADHD or non-ADHD. The MD categorical approach often leads children who fall just below the six-symptom threshold to be categorized as “non-ADHD” regardless of whether functional impairment persists. In fact, Lahey et al. (2005) identified a large portion of children within their sample who regularly moved above and below the six-symptom threshold throughout their seven annual assessments. Thus, many children who were initially diagnosed with ADHD in early childhood continued to meet diagnostic criteria later in childhood but did not necessarily meet criteria at *every* follow-up assessment. These findings suggest that reliance on the MD framework at one time point may miss an important group of children who fall below the six-symptom threshold, but who may meet full diagnostic criteria at a later (or earlier) time point. Taken together, diagnostic retention studies have been important in establishing the validity of clinical ADHD diagnoses in young children but are limited by their emphasis on children with the most severe expressions of ADHD.

1.2.2. Developmental Trajectory Research

To address the limitations of the MD framework, a number of studies have used dimensional measures of ADHD, exploring the average trajectories of early-emerging ADHD symptoms over time (Harvey, Lugo-Candelas, & Breaux, 2015; Lahey et al., 2016), as well as group-based patterns of change (Galéra et al., 2011; Leblanc et al., 2008; Romano, Tremblay, Farhat, & Côté, 2006; Sasser, Beekman, & Bierman, 2015; Shaw, Lacourse, & Nagin, 2005; Willoughby, Pek, & Greenberg, 2012). Several studies examining symptoms of hyperactivity/impulsivity and inattention separately suggest a pattern whereby hyperactivity/impulsivity remained on a relatively flat or decreasing trajectory across time, whereas symptoms of inattention appeared to increase (Galéra et al., 2011; Harvey et al., 2015; Lahey et al., 2016). For example, Harvey et al. (2015) recruited a sample of 3-year-old children with elevated behavior problems that included a subsample of children who later met criteria for ADHD at age six (n = 75). Using parent ratings of all 18 ADHD symptoms, children in this subsample had trajectories of hyperactivity/impulsivity that remained flat across the four annual assessments, whereas symptoms of inattention were reported to increase. Of note, this study also examined trajectories of *individual* parent-reported inattention and hyperactivity/impulsivity symptoms over time, documenting substantial heterogeneity in patterns of change across each symptom; not every symptom of inattention increased over time and not every symptom of hyperactivity/impulsivity remained flat.

In a larger (n = 2,057) birth-cohort sample, Galéra et al. (2011) reported a similar pattern of results. Researchers examined 5-month-old children who were assessed by parent report at 1.5, 2.5, 3.5, 4.5, 5, 6, and 8 years of age. Children were grouped based on individual developmental trajectories of a 5-item measure of hyperactivity/impulsivity and 5-item measure of inattention using semiparametric mixture models, which revealed three statistically derived hyperactivity/impulsivity groups (low, moderate, high) and three inattention groups (low, moderate, high). Like the Harvey et al. (2015) sample, trajectories of inattention increased substantially over the preschool years, but were reported to then decline after age 6, reflecting time points not assessed by the Harvey group. Unlike in the Harvey et al. sample, Galéra and colleagues (2011) found hyperactivity/impulsivity symptoms to decrease slightly with age. Notably, the Harvey et al. and Galéra et al. studies used substantially different sampling techniques, as well as different measures of ADHD symptoms, which may account for the slight difference in reported results. When comparing developmental course studies, it is also important to consider the developmental time points assessed by each study. Research following children over long spans of time (e.g., 12-15 years) may report average trajectories of symptoms that differ from studies focused on shorter time frames (e.g., 2-3 years) simply by the nature of the length of time examined or time between assessments. For example, Lahey et al. (2016) followed preschool children through adolescence and reported overall decreases in *both* hyperactivity/impulsivity and inattention even though symptoms of inattention appeared to increase during early childhood. Thus, when drawing conclusions about the general course of ADHD symptoms during childhood, it is critical to account for study methodology, including measures used, informant perspective, length of time assessed, length of time between assessments, and study samples. Nonetheless, findings from existing longitudinal work assessing symptoms of ADHD among preschoolers generally appear to suggest a stable or declining course of hyperactivity/impulsivity and an increasing course of inattention during the preschool years.

In addition to examining the overall course of ADHD symptoms in young children, a growing body of work has studied the individual variability in change in ADHD symptoms over time. To accomplish this aim, a number of studies have used finite mixture modeling techniques to group children into probabilistic classes representing distinct groups with different patterns of change (Sasser et al., 2015; Shaw et al., 2005; Willoughby et al., 2012). For example, Shaw et al. (2005) examined the developmental trajectories of ADHD in a community sample of low-income boys (n = 284), assessing children from ages 2-10. Researchers grouped children based on a three-item parent report measure of hyperactivity and attention problems, which resulted in four separate trajectories: chronic, moderate stable, moderate desister, and low. Although past work has shown an overall *average* trend of decreasing hyperactivity/impulsivity and increasing inattention, there appears to be substantial individual variability in symptom trajectories that can provide important information to help distinguish children most in need of early intervention services. Although it is difficult to draw conclusions about ADHD symptoms as a whole from a study using a three-item scale, results from the Shaw et al. (2005) study suggest that young boys who evidence clinically elevated symptoms of hyperactivity/attention problems at the age of two are likely to continue to show symptom elevations throughout childhood. Interestingly, results from this study did not provide evidence for the existence of a group of children who had an increasing course of ADHD throughout early childhood, suggesting that children who demonstrate clinically elevated ADHD symptoms before the age of 10 can be identified early.

In a more recent study, Willoughby et al. (2012) examined the developmental course of parent-reported ADHD symptoms among boys and girls in a large, predominantly rural, community sample (n = 1,155). Unlike Shaw et al. (2005), the Willoughby et al. (2012) study used all 18 symptoms of ADHD and found seven distinct trajectories of change occurring across the preschool years (ages 3-5). The majority of children were grouped into three persistently low or mildly decreasing groups, with an additional two groups of children showing remitting symptoms across time, and two smaller groups that either increased over time, or were persistently high. The persistently high group consisted of about 8% of the sample, which is near the 2-6% range of preschool ADHD prevalence rates reported by other researchers (e.g., Lavigne et al., 2009). Of note, this study did not examine trajectories of inattention and hyperactivity/impulsivity separately, and thus, cannot speak to whether change groups would differ based on ADHD presentations. Nevertheless, findings support the overall notion that ADHD symptoms among preschoolers cannot all be dismissed as developmentally appropriate time-limited behavior, as a substantial portion of children follow a persistently elevated pathway across multiple assessment points in preschool.

In sum, these studies suggest a pattern whereby overall trajectories of hyperactivity/impulsivity remain flat or decrease while trajectories of inattention increase over the preschool years. Yet, there is substantial individual variability, as evidenced by the emergence of statistically derived groupings of children with distinct pathways of change in symptoms over time. Not all children with elevated ADHD symptoms in preschool show a course of decreasing hyperactivity/impulsivity and increasing inattention. Importantly, to our knowledge, nearly all extant longitudinal work examining the developmental course of ADHD symptoms has relied exclusively on parent reports. One exception to this comes from the work of Sasser et al. (2015) who examined teacher ratings of the nine DSM-based symptoms of inattention among 356 children previously enrolled in Head Start across four annual assessments from kindergarten to 3rd grade. Results yielded four unique developmental trajectories of inattention, including stable low, stable high, increasing, and decreasing symptom pathways. Although results do not provide information on the trajectories of inattention during preschool, results support the presence of symptom trajectory heterogeneity from the teacher perspective.

Despite the important work by Sasser et al. (2015), it generally remains unclear how findings on the course of ADHD symptoms during preschool using the parent perspective may change when using another informant's perspective, such as teachers. The gap in our understanding of ADHD symptom trajectories during preschool based on teacher report is noteworthy for several reasons. First, ADHD diagnoses require the presence of symptoms in multiple settings, and thus, the teacher perspective is often a critical component to assessment and diagnosis. Second, given that teachers interact with many children on a daily basis, it has been argued that teachers may be better equipped than parents to identify developmentally atypical behavior (Antrop, Roeyers, Oosterlaan, & Van Oost, 2002; Mannuzza, Klein, & Moulton, 2002). Third, schools and child care centers serve an important role in conducting developmental screenings and providing referrals for further assessment and intervention services. Consequently, gaining a better understanding of symptom continuity and discontinuity from a teacher perspective is essential. Given the above stated reasons, coupled with the fact that more than half of U.S. children ages 3-6 spend at least some time in an early childhood care or education setting before entry into kindergarten (Child Trends Databank, 2014), it is essential that this area of research begin to include the perspectives of early childhood educators. In addition, because available research varies in the measures used to assess ADHD symptoms, with many utilizing 3-5 item scales, more research is needed using all 18

DSM-based symptoms of ADHD to allow for further examination of the hyperactive/impulsive and inattentive presentations separately.

1.3. Early Identification of Risk

Longitudinal studies of ADHD symptoms in young children clearly point to the need for early intervention. Children showing clinically-elevated symptoms of ADHD during preschool appear to be more impaired later in childhood (Lahey et al., 2016), and a substantial portion of children follow a persistent course of symptomatology, providing evidence that children in need of services can be identified early (Lahey et al., 2004). Of note, it is not well understood whether children who meet diagnostic criteria for ADHD in preschool are qualitatively different than children who are diagnosed later in childhood. Taking into consideration research that broadly documents the association between mental disorder age of onset and symptom severity (Kessler et al., 2007), it is possible that early-onset ADHD marks a more severe or complex presentation than later-onset symptoms, warranting perhaps a different or more intensive method for intervention (Sonuga-Barke, Koerting, Smith, McCann, & Thompson, 2011). Regardless, it is without dispute that children with early-onset ADHD should be identified and provided with corresponding treatment. However, an essential question remains: is it possible to identify young children who will *later* develop ADHD, but who do not meet full diagnostic criteria in preschool? This question highlights another key group of children who may be missed in preschool due to subthreshold, or even nonexistent, ADHD symptoms but who nevertheless are a high-priority group for *preventative* early intervention efforts. To identify young children at risk for developing ADHD and associated impairment before the onset of disorder, we must first understand the early risk-factors predictive of ADHD onset. Further, because it is still not known whether the six-symptom diagnostic threshold is appropriate for very young children, future research should also seek to gain a better understanding of how ADHD symptoms in preschool children relate to impairment to help uncover the degree to which presence of subthreshold ADHD symptoms in preschool predicts impairment during childhood.

Despite substantial progress made over the past several decades informing our understanding of the genetic, biological, and environmental risk factors associated with ADHD as a whole (Barkley, 2015), there is no universally accepted method for systematically identifying young children at risk for developing ADHD and providing subsequent prevention-focused intervention. This gap is primarily because many well-established risk factors (e.g., maternal depression, low birth weight) are not exclusive to ADHD, and thus, their presence is often not sufficient to warrant ADHD-specific treatment. Nonetheless, the research reviewed herein helps to shed light on the key factors predicting the onset and course of ADHD that are essential to furthering a system of early identification and intervention.

Multiple recent review papers have summarized a number of "early appearing" factors associated with ADHD, including parenting and family characteristics (e.g., harsh parenting, low socioeconomic status (SES)), parental psychopathology (e.g., maternal depression), prematurity and low birth weight, early neuropsychological functioning, and early temperament traits and regulatory problems (Berger & Nevo, 2011; O'Neill, Rajendran, Mahbubani, & Halperin, 2017). For example, in a sample of 58 children with ADHD and 58 matched controls, Gurevitz, Geva, Varon, and Leitner (2014) retrospectively examined children's medical health records to identify early markers for the development of ADHD. Findings demonstrated eight unique factors during infancy that were associated with later ADHD, including advanced maternal age, lower maternal education, family history of ADHD, social problems, decreased head circumference percentile across time, delays in motor and language development, and difficult temperament. Such findings, along with the others reviewed by Berger and Nevo (2011), provide the groundwork for developing an early identification system that will be essential for most prevention-focused interventions.

A 2017 review by O'Neil and colleagues has helped to advance the discussion on early identification and intervention by summarizing the moderators and mediators of ADHD symptoms trajectories. This review article describes what is known about the differences between children who show persistent patterns of ADHD symptoms from those who show time-limited elevations, which is a key distinction for early intervention. Specifically, for prevention efforts to be successful, it is necessary to minimize the degree of false positives (i.e., children who are inaccurately identified as "at risk") and negatives (i.e., "at-risk" children who are not identified). This level of accuracy is especially important given that current evidence-based interventions for ADHD can be costly and resource intensive; thus, misidentification is an expensive error. Identifying which factors are most predictive of a child following a persistent course of ADHD versus a time-limited, and perhaps more age-appropriate course, will help inform how to best allocate resources. Overall, findings from this small body of work show that many of the psychosocial factors considered to be general risk factors for ADHD (e.g., SES, parental psychopathology) help distinguish young children who follow a persistently elevated course of ADHD from those with low levels of symptoms, but relatively few factors reliably distinguish children with persistent symptoms from those with decreasing trajectories (Sasser, Kalvin, & Bierman, 2016; Shaw et al., 2005; Willoughby et al., 2012). For example, Sasser et al. (2016) examined the developmental trajectories of parent-reported ADHD symptoms among a sample of 413 kindergarten children at risk for conduct problems, as measured by clinically-elevated externalizing problems on the Child Behavior Checklist (Achenbach, 1991). Children were assessed multiple times throughout childhood and adolescence. Findings revealed three patterns of co-occurring hyperactive/impulsive and inattention symptom trajectories: 1) low inattention and hyperactivity/impulsivity (Low), 2) initially high but declining hyperactivity/impulsivity and inattention (Declining); and 3) persistent high symptoms, with primarily hyperactive/impulsive symptoms in childhood and inattention symptoms in adolescence (High). Of note, both the High and Declining groups showed similar levels of parent-rated ADHD symptoms during early childhood but could be distinguished by levels of aggression, teacher-rated hyperactivity, and parent-rated emotion dysregulation. Family-factors (e.g., life stressors, discipline practices) distinguished the High and Declining groups from the Low group, but not from each other. Importantly, children in the High group were more impaired in adolescence (e.g., more arrests, higher school dropout rate) compared to either of the other two groups, but the Declining and Low groups did not differ. Results highlight the critical importance of identifying children most at risk for following a high persistent course of ADHD symptoms and suggest several behavioral markers that may help distinguish at-risk children from those showing time-limited symptom elevations.

Despite focusing on a younger age range (3-5 years), Willoughby et al. (2012) reported a similar pattern of results to Sasser et al. (2016). Specifically, these researchers collapsed the seven trajectory groups that originally emerged from their semi-parametric grouping analysis into four groups (stable low, increasers, remitters, persisters), and investigated 13 predictors of membership in these four groups. Consistent with previous research, a number of factors predicted membership in the persister group as compared to the stable low group, such as low birth weight, prenatal drug exposure, parental depression, and parental ADHD symptoms. However, only primary caregiver education and prenatal exposure to drugs and alcohol distinguished the persistent group from the decreasing group, with children in the decreasing group more likely to have a parent with a college degree and less likely to have been exposed to drugs and alcohol prenatally. Findings from the Willoughby et al. (2012) study also indicated that compared to children whose symptoms persisted over time, children in the increasing group were more likely to have a parent with a higher level of education and were less likely to have a parent with depression or childhood ADHD symptoms, suggesting these family factors may help delay the onset of symptoms. Of note, the authors reported that the increasing group was very small and therefore analyses including this group may have been underpowered to detect potentially important group differences. Although group comparisons with the persistent group as the reference are important and of interest, future research should also examine differences between children whose symptoms increase over time compared to children whose symptoms remain low in order to consider how to best identify at-risk children *before* they develop ADHD. This type of analysis would provide information about children who appear to have low levels of symptoms in early childhood but are likely to develop more symptoms at a later time point.

In sum, a variety of factors predict membership in the persistent ADHD group, but relatively few unique factors seem to differentiate children who either increase or decrease in ADHD symptom presentation over time. Some specific risk factors emerged as potentially important, including levels of aggression, hyperactivity, emotion dysregulation, parental education, parental psychopathology, and prenatal exposure to drugs and alcohol. Yet, it remains unclear how this information can be incorporated into a system for universal ADHD screening. Hence, more research is needed to explore risk factors that can differentially predict membership in the chronic (i.e., early-onset), increasing (i.e., at-risk), or decreasing (i.e., time-limited) groups in order to develop a system that accurately and reliably screens and identifies children most at risk for ADHD and associated functional impairment across the lifetime.

1.4. A Prevention Treatment Framework

Given the plethora of challenges faced by children and adults with ADHD, a question of great importance is how to most effectively intervene and provide treatment. Extant longitudinal research examining ADHD symptoms in preschool children has documented the validity of ADHD diagnoses made at this early age and has provided helpful information about the general course of parent-reported ADHD symptoms. Research investigating risk factors predicting the onset of ADHD also provides important information relevant to the creation of a systematic approach for identifying at-risk children. Yet, a system of early identification is insufficient without a corresponding system for intervention. To date, there is a large body of published literature examining the effectiveness of intervention strategies aimed to manage the symptoms of ADHD (Brown et al., 2005). This body of work emphasizes the positive impact of both psychopharmacological and psychosocial interventions, yet, these treatments have substantial drawbacks (e.g., costliness, adverse side effects); most importantly, they fail to address the underlying causes of the disorder. Given the limitations of current evidence-based treatments and the chronic impairment endured by those with ADHD, it is critical that research begin to advance treatments that address the underlying causes of the disorder and thereby prevent long-term impairments.

One avenue to accomplish the goal of effectively treating children with ADHD, including associated functional impairments, is through the use of a preventative intervention model that is implemented during the early childhood years. Importantly, prevailing etiological theory considers ADHD to have a strong biological basis, which is reflected in the disorder's current classification as a neurodevelopmental disorder in the most recent version of the *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 2013). The combination of biological and environmental causal factors, although complex, suggests that ADHD is a particularly good candidate for early intervention. In fact, several researchers have recently highlighted the role of early intervention in altering developmental trajectories of the disorder, citing the neural plasticity of young brains as an important developmental factor that may provide the opportunity for interventions that address more primary causal factors (Halperin, Bédard, & Curchack-Lichtin, 2012; Sonuga-Barke & Halperin, 2010). Similarly, intervening early may help address other environmental factors (e.g., parenting) linked with the exacerbation and maintenance of ADHD because intervention can occur before coercive parent-child interactions take place, or before difficult behavioral habits are formed (Sonuga-Barke & Halperin, 2010). Current early intervention programs (e.g., *Triple P*, *Incredible Years*) that target environmental factors associated with ADHD provide initial evidence that intervention implemented early in development has the potential for lasting benefits beyond the cessation of active treatment (see, Halperin et al., 2012). Thus, it may be possible to improve upon current best practices for the treatment of ADHD by moving toward a preventative model that targets intervention efforts toward young children at risk for developing ADHD.

1.5. Current Study

Although in theory ADHD is a prime candidate for a preventative intervention, there is substantially more research needed before it will truly be feasible for such an intervention to be developed and implemented on a wide-scale basis. More work is needed first to effectively identify young children most at risk for ADHD and associated functional impairments. To date, longitudinal studies of the developmental course of ADHD have focused almost exclusively on parent reports (for an exception see Sasser et al., 2015), and there are only a handful of studies that examine children at multiple time points in preschool (Galéra et al., 2011; Harvey et al., 2015; Leblanc et al., 2008; Romano et al., 2006; Shaw et al., 2005; Willoughby et al., 2012). Because preschool is a time of rapid development, when many forms of inattention, hyperactivity, and impulsivity are developmentally normative, it is necessary to gain a better understanding of the course of ADHD *within* the preschool years. It is of particular importance for research to address the currently insufficient understanding of how symptoms develop and change from the perspective of the teacher. Indeed, behavior that appears to be developmentally inappropriate, especially at the beginning of the school year, may in fact be a reaction to the transition to a school setting, which cannot be fully understood without examining teacher-rated symptoms at multiple time points throughout a school year.

Accordingly, the current study examined the continuities and discontinuities in teacher-rated ADHD symptoms measured at four time points during one preschool year. Given the identified gaps in the literature on this topic, it is necessary to first gain an understanding of overall average change in symptom trajectories before exploring individual differences in change. Thus, **Aim 1** of this study was to investigate a variable-centered approach to examine average change in symptoms of inattention and hyperactivity/impulsivity, separately, across the year. Based on longitudinal research documenting an overall trajectory of increasing inattention and decreasing or stable hyperactivity/impulsivity during early childhood (Galéra et al., 2011; Harvey et al., 2015), we expected our results to mirror those of the literature. Therefore, we hypothesized a slight increase in inattention and a slight decrease in hyperactivity/impulsivity symptom levels across the four study time points.

Aim 2 of the study was to conduct an exploratory person-centered analysis to investigate if there are meaningful groups with different trajectories of inattention or hyperactivity/impulsivity over the course of the school year. Person-centered approaches, such as Growth Mixture Modeling (GMM), have gained popularity over the past decade, but have not yet been applied to the preschool ADHD literature in this particular context. Although Aim 2 of the current study was exploratory due to the minimal amount of relevant literature, we hypothesized the emergence of at least three groups of symptom level change per outcome domain (i.e., inattention, hyperactivity/impulsivity), including a persistent high group, persistent low group, and a change group (increasing inattention, decreasing hyperactivity/impulsivity). These tentative hypotheses were based on person-centered work by Shaw et al. (2012) and Willoughby et al. (2012) who reported the presence of both stable and change groups in their samples using a combined measure of inattention and hyperactivity/impulsivity. These hypotheses were also informed by the broader longitudinal literature showing different patterns of change in symptom levels when examining inattention and hyperactivity/impulsivity separately (Galéra et al., 2011; Harvey et al., 2015).

Taking into consideration the sex differences commonly reported in ADHD symptom prevalence (Willcutt, 2012), in addition to the many developmental changes occurring between ages 3 and 5, the models for Aims 1 and 2 also included estimations of how age and sex are related to the developmental trajectories that emerged. Examination of these factors allow for a better understanding of the key demographic factors that may be linked to continuities versus discontinuities in symptom expression. Given the significant economic cost of ADHD and the far-reaching, long-term impairments for children, adults, and their families, it is critical that we move to develop a preventative intervention. The current study is an important first step that will help facilitate the identification of children who are most in need of these prevention efforts.

CHAPTER 2: METHOD

2.1. Participants and Procedures

Participants were recruited as part of two larger studies, both examining ADHD and disruptive behavior symptom levels among a community sample of preschool children. The first subset of children was drawn from a project conducted by researchers at the University of Vermont (n = 113), herein referred to as "subsample A". All participants drawn from the UVM study had documented parental consent. The second subset of children (n = 148) was drawn from a child information database collected and managed by Champlain Valley Head Start and was shared in a deidentified format (herein referred to as "subsample B"). The current study is in compliance with the University of Vermont's Institutional Review Board.

In total, 261 preschool students (M_{age} = 3.97, SD_{age} = 0.61) in Head Start-affiliated early education classrooms and their families participated in the study. 87% of participants were enrolled in Head Start highlighting that the majority of children came from families at or below 100% of the 2018 designated federal poverty threshold. Approximately half (53%) of the sample was male. The sample was racially and ethnically diverse (59% Caucasian, 18% African American, 12% Asian, 1% Pacific Islander, 8% other including multiracial/biracial and American Indian, and 2% unspecified). There were no exclusion criteria for the study.

Teachers from 18 classrooms completed a measure of attention and behavior for participating children in their classrooms at four time points over the course of the 2018-2019 academic year. Measures were administered to teachers in late September (Time

1/Baseline), early December (Time 2), late January (Time 3), and early May (Time 4). The current study uses a subset of variables from the collected teacher ratings.

2.2. Measures

2.2.1. Demographic Information

Demographic information, including child sex, race/ethnicity, and birth date was collected from each child's school record.

2.2.2. ADHD Symptoms

Symptoms of ADHD were assessed with the ADHD Rating Scale – IV Preschool Version (McGoey, DuPaul, Haley, & Shelton, 2007), an 18-item questionnaire administered to classroom teachers. Items were rated on a 4-point Likert scale indicating the frequency of each DSM-IV ADHD symptom (0 = not at all; 3 = very often). The McGoey et al. (2007) preschool measure was modified from the original ADHD Rating Scale – IV (DuPaul et al., 1998) to include items with developmentally appropriate examples applicable to preschool children. For example, the DSM-IV symptom "Often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (e.g., schoolwork or homework)" is described by the ADHD Rating Scale-IV Preschool Version as "Avoids tasks that require sustained mental effort (e.g., puzzles, learning ABC's, writing name)." Notably, although current ADHD diagnoses are based on the DSM-V (American Psychiatric Association, 2013), ADHD symptom definitions did not change from the prior DSM-IV version (American Psychiatric Association, 2000), indicating that the ADHD Rating Scale – IV Preschool Version is applicable to the most current diagnostic system. In the current study, items were averaged to obtain two subscale scores (inattention and hyperactivity/impulsivity), with higher scores indicating higher ADHD symptom levels. Past research has demonstrated high reliability for teacher reports on the ADHD Rating Scale – IV Preschool Version (McGoey et al., 2007), and in the current study coefficient alphas ranged from .93 to .95 across all IA assessments and .92 and .93 across all HI assessments.

2.3. Data Analytic Plan

2.3.1. Overview of Aim 1 Data Analytic Plan

Aim 1 consists of a variable-centered approach to examine the average trajectory of change in preschool ADHD symptom levels across one academic year. To accomplish this aim, unconditional and conditional Latent Growth Curve Models (LGCMs) were fit to the data, separately for both the inattention (IA) and hyperactivity/impulsivity (HI) subscales of ADHD symptomatology. To determine the best-fitting unconditional model, both linear and quadratic polynomial change models were compared on a series of model fit indices, including Akaike's Information Criteria (AIC; Akaike, 1973), Bayesian Information Criteria (BIC; Schwarz, 1978), weight of evidence estimates (e.g., chi-square test), standardized root mean residual (SRMR), root mean square error of approximation (RMSEA), the comparative fit index (CFI) and the Tucker-Lewis Index (TLI). Models with the smallest AIC and BIC values are considered to be the best fit. Moreover, based on the guidelines of Wickrama et al. (2016), strong model fit is indicated by SRMR values less than or equal to 0.08, RMSEA values less than or equal to 0.06, and CFI and TLI values of 0.95 or greater.

After the overall polynomial change structure was selected for the unconditional models, further analyses were conducted to examine change in IA and HI symptom levels across the year when accounting for a set of covariates, specifically, age and sex. In addition, a variable accounting for whether the preschool classroom participated in a year-long structured physical activity intervention (i.e., “subsample”) was included as a covariate given that students from subsample A participated in the intervention, whereas those from subsample B did not. Finally, because students are nested within classrooms, whenever possible, models were estimated in Mplus to account for non-independence of observations due to clustered sampling, which adjusts standard errors to account for variance due to specific classroom factors (e.g., teacher, specific classroom interventions).

2.3.2. Overview of Aim 2 Data Analytic Plan

Aim 2 consists of a person-centered approach to examine continuities and discontinuities in preschool ADHD symptoms across one academic year. To accomplish this aim, GMM analyses were conducted using Mplus version 8 (Muthen & Muthen, 2017). GMM is a multivariate analytic approach that estimates an underlying grouping variable (latent class) based on a continuous dependent variable measured longitudinally. Results from GMM analyses provide statistically derived groups with distinct trajectories of change across time for the inputted continuous variable. Model trajectories were estimated separately for IA and HI across four time points to determine whether there are meaningful groups that emerge within each domain (“ADHD-change groups”).

Following the procedures outlined by Wickrama et al. (2016), a series of models were fit to the data, with number of classes per model added iteratively (e.g., 1, 2, 3, 4). First, a series of Latent Class Growth Analysis (LCGA) models were examined in which all variance and covariance growth parameters within each class were fixed to zero. Next, a series of full GMMs were fit to the data, which allowed all growth parameters, including means, covariances, and residual variances, to vary across classes. All estimated models were compared using AIC, BIC, adjusted BIC (aBIC), entropy, and the Lo-Mendell-Rubin likelihood ratio test (LMR-LRT). Higher entropy values indicate improved enumeration accuracy and class separation. The LMR-LRT compares the indicated model to a model with one fewer classes to determine the best-fitting model. Each model was also evaluated on its interpretability and parsimony to determine whether each estimated grouping had sufficient theoretical grounding necessary to make valid interpretations. Finally, LCGA and GMM model specification were repeated with the addition of the cluster feature in Mplus to account for the non-independence of observations (i.e., children nested within classrooms). All modeling procedures were conducted separately for IA and HI symptoms.

2.3.3. Overview of Aim 2a Data Analytic Plan

In order to understand key factors associated with the continuities and discontinuities of ADHD symptom trajectories during the preschool years, an additional sub-aim was to examine both age and sex as outcomes to explore if there are differences in latent class groups based on age and sex. As part of this analysis, the latent class groups that emerged from the unconditional GMM were considered as different levels of a categorical variable representing distinct trajectories of ADHD symptoms across the schoolyear. One-way analyses of variance (ANOVAs; when age was the outcome) or logistic regression (when sex was the outcome) were utilized to determine whether ADHD latent class groups varied based on age or sex. All models were estimated separately for IA and HI symptoms.

CHAPTER 3: RESULTS

3.1. Missing Data

Approximately 66% of participants had complete data across each of the four study time points. Almost 17% of the sample was missing one time point of data, 8% was missing 2 time points of data, and 9% was missing 3 time points of data. Amount of missing data (i.e., number of time points with missingness) was significantly associated with subsample ($r = .22$, $p < .001$), age ($r = -.20$, $p < .001$), and IA symptom levels at time 2 ($r = .17$, $p = .02$), but was not associated with children's sex or any other ADHD symptom level outcomes. Specifically, children from subsample B had more time points of missingness than children from subsample A. Further, younger ages were associated with more time points of missingness. Finally, more time points with missingness was associated with higher IA symptom levels at time 2.

Because subsample B involved data collection from an administrative database at Head Start, reasons for missingness are unknown. In subsample A, missing data were primarily due to the child's absence from school at the given time point (e.g., child did not enroll in preschool until after baseline data collection; child left the school prior to the final data collection wave). Importantly, from what is known about subsample A, one possible reason age was significantly associated with missingness was because children were unable to enroll in preschool until they were three years old, and thus younger children who enrolled in preschool later in the year had fewer time points of data.

All models for Aims 1 and 2 were examined using maximum likelihood estimation (ML) to reduce bias in parameter estimates and standard errors that stem from missing data.

3.2. Study Descriptive Statistics

Sample means, standard deviations, and correlations among study variables are presented in Table 1. There were significant positive correlations between subsample and all ADHD outcome variables, indicating that children coming from subsample B began the year with higher symptom levels than children from subsample A, and they continued with higher levels across the school year. There were also significant negative correlations between sex and all ADHD outcome variables, indicating higher IA and HI symptom levels for boys compared to girls at each study time point. Finally, there were significant negative correlations between age and all IA outcome variables, revealing that being older was associated with lower levels of IA symptom levels. For HI symptoms, age was only significantly associated with baseline symptom levels. Specifically, being older was associated with lower levels of HI symptom levels only at baseline.

3.3. Aim 1 Results

3.3.1. Unconditional Latent Growth Curve Models

A series of unconditional LGCMs with varying structures of polynomial change (i.e., linear, quadratic) were fit to the data for IA and HI symptomatology. Corresponding model fit indices are reported in Table 2. For IA symptom levels, the quadratic model demonstrated an overall better fit to the data across all model fit indices. Specifically, the quadratic model revealed lower AIC, BIC, aBIC, RMSEA, and SRMR values and higher TLI and CFI values, as compared to the linear model. For HI symptoms, the quadratic model revealed slightly lower AIC, BIC, and aBIC values, a lower RMSEA, and a slightly higher TLI value compared to the linear model. Both the CFI and SRMR values were equal across the linear and quadratic models. Although the quadratic model was slightly favored based on model fit indices, model results indicated no significant quadratic parameter. Given there were no substantive differences between the quadratic and linear models along with a preference for parsimony, the linear model was selected to represent change in HI symptom levels across the four study time points. The final IA and HI model parameters, including the intercept, linear slope, and quadratic term where applicable, are reported in Table 3. The final models revealed an average increase in IA symptom levels over time with a deceleration in the rate of change in IA symptom levels over time. Further, results indicated an average increase in HI symptom levels over time. IA and HI symptom means and standard errors across the four time points are reported in Table 4 and depicted in Figure 1.

Follow-up unconditional IA and HI LCGM models were examined to account for the non-independence of observations due to clustered sampling (i.e., students nested within classrooms). For IA symptomatology, the quadratic model demonstrated adequate fit for the data, however model results only yielded significant intercept and linear slope effects. The quadratic term was no longer significant in the model that accounted for clustering, suggesting there is not a significant deceleration of IA symptom levels after accounting for variance due to shared classroom experiences. For HI symptomatology, the linear model again demonstrated adequate fit for the data when accounting for clustering, and the pattern of model results remained the same as compared to the model that did not account for clustering. See Table 5 for model fit results when accounting for clustering.

3.3.2. Conditional Latent Growth Curve Models

Using the best fitting unconditional LGCM from above, the next step was to conduct a conditional LGCM to model average symptom level trajectories over time accounting for a set of relevant covariates. Specifically, each model controlled for participation in a physical activity intervention as described above in the analysis plan (i.e., “subsample”) and accounted for children’s age and sex. Table 6 provides an overview of model fit indices for the conditional LGCMs, reported separately by IA and HI models. For both IA and HI models, model fit was deemed adequate.

Overall model results for IA symptoms, including intercepts, linear slopes, and quadratic terms are reported in Table 7. Results revealed a significant difference between subsample A and B in the intercept of the IA model, when controlling for sex and age, such that children from subsample B began the year with higher IA symptom levels than children from subsample A (intercept effect for subsample = 0.24, $p = .007$). However, there was no difference in the rate of change in IA symptom levels across the year between subsamples A and B. Additionally, results revealed a significant difference between boys and girls in the intercept of the IA model when controlling for child age and subsample, such that boys began the year with higher IA symptom levels than girls (intercept effect for sex = -0.25, $p = .005$). There was also a significant sex difference in the linear slope factor, indicating that boys demonstrated a larger rate of increase in IA symptom levels over the year as compared to girls (slope effect for sex = -0.06, $p = .025$). There was no sex effect for the quadratic term, suggesting that the rate of deceleration in IA symptom levels across time did not differ between boys and girls. IA symptom level means for boys and girls across the year are reported in Table 8. IA symptom level trajectories by sex are illustrated in Figure 2. In terms of age effects, results indicated that when controlling for child sex and subsample, being younger was linked with higher IA symptom levels at the beginning of the year (intercept effect for age = -0.28, $p < .001$), though the pattern of change in IA symptom levels over time did not vary by age.

Results from the conditional LCGM for HI symptom levels indicated that when controlling for children's age and sex, subsample B began the year with higher HI symptom levels than subsample A (intercept effect for subsample = 0.27, $p = .002$), but did not differ from subsample A in their rate of change in HI symptom levels across the year. Further, when controlling for children's age and subsample, boys began the year with higher HI symptom levels than girls (intercept effect for sex = -0.27, $p = .002$) and had a marginally significant larger rate of increase in HI symptom levels across the year (slope effect for sex = -0.02 $p = .066$; see Table 7 for overall HI model results). HI symptom level means for boys and girls across the year are reported in Table 8. HI symptom level trajectories by sex are depicted in Figure 3. Unlike the IA model, results indicated that when accounting for children's sex and subsample, age was not associated with baseline HI symptom levels. However, being older was linked with a steeper increase in symptom levels across the year (slope effect for age = 0.02, $p = .026$).

Importantly, the conditional LCGM model for IA could not be examined when accounting for the clustering of data (i.e., students within classrooms) due to model complexity. For HI, the conditional LCGM that accounted for clustering of data demonstrated the same pattern of significance as compared to the model that did not account for nesting.

3.4. Aim 2 Results

3.4.1. Model Selection

Using the best-fitting model structure from the unconditional LGCM, a series of LCGA models were fit to the data, with number of classes per model added iteratively. See Table 9 for LCGA model fit indices for both IA and HI symptoms. For the IA model (quadratic change), the 4-class solution revealed slightly lower AIC, BIC, and aBIC values. However, the LMR-LRT test indicated that the 4-class solution was not a better fit to the data compared to the 3-class solution. Further, the 3-class solution had the highest entropy value as compared to either the 2-class or 4-class solutions. Based on this information along with a preference for parsimony, the 3-class solution was selected as the best-fitting IA LCGA model. A series of full GMM models were attempted but due to model complexity there were a number of model specification errors that could not be resolved. As such, the 3-class quadratic LCGA model with restricted within-class intercept and slope parameters was selected as the overall final model for IA.

For the HI model (linear change), LCGA class enumeration revealed slightly lower AIC, BIC, and aBIC values for the 4-class model, but the 4-class model was not a superior fit to the data as compared to the 3-class model as indicated by the LMR-LRT value. Moreover, the entropy value for the 3-class model was higher than for the 4-class model. Based on model fit indices and the parsimony of the 3-class model over the 4-class model, the 3-class linear LCGA was selected as the best-fitting model. A series of full GMM models were attempted to model HI symptoms, but similar to IA symptoms, model complexity contributed to a number of specification errors that decreased the acceptability of model results. As such, the 3-class linear LCGA was selected as the final model for HI.

3.4.2. Model Results

Final model results, including intercepts, slopes, and quadratic terms when applicable, are presented in Table 10. For the 3-class IA model, class 1 was assigned the descriptive label “IA Stable High” given that this group began the year with high symptom levels (baseline intercept =2.03, $p < .001$) that remained stable over time (i.e., nonsignificant linear and quadratic terms). Class 2 was given the descriptive label “IA Change” given this group began the year with moderate symptom levels (baseline intercept = 0.97, $p < .001$) and showed a pattern of increasing symptom levels that decelerated over time (linear slope = 0.08, $p = .02$; quadratic term = -.008, $p = .04$). Finally, class 3 was given the descriptive label “IA Stable Low” given this group began the year with low IA symptom levels (baseline intercept = 0.21, $p < .001$), that remained stable over time (i.e., nonsignificant linear and quadratic terms). The High Stable group contained approximately 11% of the sample, the Change group contained 32% of the sample, and the Low Stable group consisted of 57% of the sample.

For the 3-class HI symptom model, similar groupings emerged. Class 1 began the year with high HI symptom levels (baseline intercept = 2.15, $p < .001$), which remained stable across the year (i.e., nonsignificant linear slope). This class was therefore given the descriptive label “HI Stable High.” Class 2 was given the descriptive label “HI Increasing” given that this group began the year with moderate HI symptom levels (baseline intercept = 0.91, $p < .001$) and demonstrated an increase in symptoms over time (linear slope = 0.06, $p < .001$). Finally, class 3 was given the descriptive label “HI Stable Low” given that this group started the year with relatively low symptom levels (baseline intercept = 0.26, $p < .001$) and symptom levels did not change across the year (i.e., nonsignificant linear slope). The Stable High group consisted of 11% of the sample, the

Increasing group contained about 26% of the sample, and the Stable Low group consisted of 63% of the sample. Latent class group means for IA and HI at each of the four study time points are reported in Table 11. IA symptom level trajectories for each latent class are depicted in Figure 4. HI symptom level trajectories for each latent class are depicted in Figure 5.

3.4.3. Model Results with Clustering by Classroom

Follow-up LCGA model iterations were examined to account for the clustering of children within classrooms. The 3-class IA quadratic LCGA and the 3-class HI linear LCGA both demonstrated adequate fit and were a better fit than the 2- or 4-class solutions (See Table 12 for model fit indices when accounting for clustering). When taking into account the shared variability of children within the same classrooms, the 3-class solution for IA symptoms again revealed a group with high stable symptoms ("IA Stable High") and a group with low stable symptoms ("IA Stable Low"). Instead of a group that demonstrated a change in IA symptoms across the year, model results that accounted for clustering yielded a group with moderate symptoms that remained stable across the year ("IA Stable Moderate"). Although accounting for the clustering of data resulted in a change in the significance level of the slope effect, which has implications for interpretation, both groups (i.e., "IA Change" and "IA Stable Moderate") include the same individuals. Thus, follow-up group-based analyses will herein refer to this group as "IA Change/IA Stable Moderate." For HI symptoms, the 3-class linear LCGA that accounted for clustering revealed a similar pattern of findings as compared to the original LCGA without clustering. Namely, results yielded "HI Stable High," "HI Increasing," and "HI Stable Low" groups.

3.5. Aim 2a Results

3.5.1. Variation in Latent Class Group Membership by Age

Using the final model results and corresponding IA and HI latent class groups reported above, the next step was to examine whether children's latent class group membership varied by age. In the IA symptom domain, results from the one-way ANOVA yielded a significant omnibus test, indicating there was mean-level variability in children's ages across IA latent class groups, F (2, 258) = 3.27, p = .04. Follow-up pairwise comparisons revealed that children in the IA Stable High group were significantly younger than children in the IA Stable Low group (p = .03, Cohen's d = 1.10). Neither the IA Stable High nor the IA Stable Low groups differed significantly from the IA Change/IA Stable Moderate group. In the HI symptom domain, there was no mean-level variation in children's ages across HI latent class groups. See Table 13 for means and standard deviations for children's ages by ADHD latent class groups.

3.5.2. Variation in Latent Class Group Membership by Sex

Next, a series of binary logistic regressions were conducted to examine variation in IA and HI latent class groups based on sex. See Table 14 for logistic regression model results for each symptom domain. For IA symptomatology, results indicated that membership in the IA Stable Low group was significantly associated with child sex when compared to membership in the IA Change/IA Stable Moderate group, b = 0.814, Wald $\chi_2(1)$ = 8.31, p = .004. Specifically, children in the IA Stable Low group were 2.26 times as likely to be female than children in the IA Change/IA Stable Moderate group. Moreover, membership in the in the IA Stable High group was significantly associated with child sex when compared to the IA Stable Low group, b = -.938, Wald $\chi_2(1)$ = 4.95,

p = .026. Children in the IA Stable High group were 2.56 times as likely to be male than children in the IA Stable Low group (odds ratio for males = the inverse of odds ratio for females: 1.0/0.39 = 2.56). The ratio of boys to girls did not vary between the IA Stable High and IA Change/IA Stable Moderate groups.

For HI symptomatology, results indicated that membership in the HI Stable Low group was significantly associated with child sex when compared to membership in the HI Increasing group, b = .863, Wald $\chi^2(1) = 8.39$, p = .004. Specifically, children in the HI Stable Low group were 2.37 times as likely to be female than children in the HI Increasing group. Moreover, membership in the in the HI Stable High group was significantly associated with child sex when compared to the HI Stable Low group, b = -1.20, Wald $\chi^2(1) = 7.28$, p = .007. Specifically, there was a 3.33 times greater likelihood of being male in the HI Stable High group as compared to the HI Stable Low group (odds ratio for males = the inverse of odds ratio for females: 1.0/0.30 = 3.33). The ratio of boys to girls did not vary between the HI Stable High and Increasing groups.

CHAPTER 4: DISCUSSION

The current study examined the developmental course of teacher-rated ADHD symptom levels among a sample of at-risk preschoolers using both variable- and person-centered approaches. Past research documenting the developmental outcomes associated with preschool ADHD symptoms (e.g., Lahey et al., 2016) and persistence of symptoms across time (e.g., Galéra et al., 2011; Harvey et al., 2015) has highlighted the importance of identifying ADHD early in development. Our primary goal was to build on existing research to better understand the continuities and discontinuities of ADHD symptom trajectories over the course of an academic year from the perspective of early childhood educators, and to consider a full range of IA and HI symptomatology (i.e., all 18 ADHD symptoms).

4.1. Average Trajectories of ADHD Symptoms Over Time

Results from Aim 1 of the study, which examined the average pattern of change in IA and HI symptom levels across the preschool year, demonstrated a pattern whereby: 1) IA symptom levels increased with deceleration over time; and 2) HI symptom levels steadily increased across the year. These findings stand in slight contrast to prior research and the study's a priori hypotheses, which posited a pattern of increasing IA and decreasing or stable HI symptoms. Notably, there are important methodological differences between the present study and past research on the topic, which may account for the divergence from prior findings. First, past longitudinal research has focused almost exclusively on parent ratings of ADHD symptoms, and given the well-documented discordance between parent and teacher ratings in school- and preschool-aged populations (Narad et al., 2015; O'Neill, Schneiderman, Rajendran, Marks, &

Halperin, 2014; Schmiedeler & Schneider, 2014), differences between parent- and teacher-rated symptom trajectories are, perhaps, not surprising. In particular, given that children's attention and behavior are generally considered highly context dependent (Chacko, Wakschlag, Hill, Danis, & Espy, 2009), it is not unreasonable to expect that symptoms may increase in one setting and remain stable in another. However, future research that examines how parent and teacher ratings of ADHD symptoms correspond across the preschool years is needed to further our understanding of the emergence and course of ADHD symptoms across multiple contexts during early childhood.

Additionally, very few studies have included more than one assessment of symptoms during the preschool years, and none to our knowledge have focused entirely on one academic preschool year. This gap in the literature is noteworthy for two reasons. First, most studies examining teacher ratings across time are limited by changing classroom environments each year (e.g., different teachers, peers, daily schedules, and other contextual factors). Second, children ages three to five experience rapid brain development and corresponding behavioral changes which raises the possibility that some attention and/or behavioral challenges may be time limited. As noted by Leblanc et al. (2008), the significant developmental changes occurring during early childhood may "limit the reliability and validity of parental assessment when taken at a single point in time, and for this reason, it is advisable to examine the behavior over a longer period of time" (p. 984). The same logic applies to teacher assessments and hence supports the study of the course of ADHD symptoms across shorter periods of time during early childhood (i.e., within one year). Despite the clear importance of improving our understanding of symptom fluctuations during preschool, results are difficult to compare to research that examines symptoms over longer spans of time.

Although these key methodological differences may help explain why our findings partially diverged from past research, it is also important to consider conceptual reasons why results varied across the IA and HI symptom domains. Given the conceptualization of ADHD as a neurodevelopmental disorder, there are likely biological, genetic, and neuropsychological contributors to the unique pathways of IA and HI symptom level progressions over time. However, it is also likely that environmental factors influence the variation in symptom pathways across domains. For example, it is possible that there are more opportunities for preschool children to receive effective feedback and training regarding their attention in the preschool setting (e.g., attention tactics such as “1, 2, 3, eyes on me”), as compared to hyperactive or impulsive behaviors, which could contribute to the deceleration of inattention symptom levels across the year. Indeed, this deceleration may reflect children’s learning in the area of attention, whereas, the steady increase in HI behaviors may reflect a lack of learning or adjustment to the demands of the environment. Moreover, it is possible that teachers are simply more likely to notice HI behaviors given their disruptive nature in the classroom and therefore, the steadier increase in HI symptoms over the year may reflect teachers’ attention and sensitivity to disruptive behaviors as opposed to inattentive behaviors. More research is needed to explore these potential environmental factors, among others, to better understand what factors contribute to the differences between IA and HI symptom trajectories. Nonetheless, results from the present study help shed light on some of the nuances in symptom change during a key developmental period.

Of note, our findings suggest that, on average, both IA and HI symptom levels are at their lowest at the start of the school year. It is possible that this finding represents a "honeymoon period," which is a phenomenon characterized by more positive behavior at the start of a program or school year and increased misbehavior as children become more comfortable with teachers/staff (Alberto & Troutman, 2009). This phenomenon may be particularly useful in explaining results in the IA symptom domain, given the average trajectory of increasing symptoms that appears to flatten out over time. However, given that HI symptoms demonstrate a steadier course of increase across each of the four assessments, a honeymoon effect may be less helpful in explaining findings for this symptom domain. Importantly, both IA and HI baseline symptoms were measured approximately one month into the school year to allow teachers sufficient time to get to know the children and to avoid a potential honeymoon effect as much as possible. Thus, it is conceivable that average symptom level trajectories simply represent a natural progression of symptoms, rather than the effects of a honeymoon period.

The discussion of average ADHD symptom level trajectories would be incomplete without highlighting the makeup of our sample. Specifically, this study drew from a predominantly at-risk community population and therefore findings are not generalizable to a clinical sample of children diagnosed with ADHD. Across both subsamples A and B, mean ADHD symptoms for both IA and HI were relatively low and far below what would be considered the clinical range. However, it is noteworthy that even in a community sample, there was significant variability in scores. Thus, although the results of this study cannot speak to the symptom trajectories of children diagnosed with ADHD, findings do shed light on the trajectory of attention and behavior in a predominantly normative, but at-risk sample. Research involving community populations is ideal when adopting a prevention treatment framework for two reasons: 1) targeted preventative interventions rely on the identification of children at risk for a disorder among the general population; and 2) whole population preventative interventions also rely on an understanding of the variability and progression of symptoms across all children, both typically and atypically developing. Hence, use of an at-risk community sample to explore the trajectories of ADHD symptom levels in preschoolers was well suited to the aims of the present study.

4.2. Continuities and Discontinuities in ADHD Symptoms Over Time

In addition to examining the average trajectories of IA and HI symptom levels across the four study time points, a second aim of this study was to explore the heterogeneity in symptom trajectories with a person-centered analysis. Results from Aim 2 showed three distinct groups within the IA and HI symptom domains, each with unique trajectories of ADHD symptoms across the year. In line with the a priori hypotheses, in both the IA and HI symptom domains, results demonstrated a small group of children who started the year with high ADHD symptom levels that remained stable over time (i.e., IA and HI Stable High groups), and a large group of children who started the year with low ADHD symptom levels that remained stable over time (i.e., IA and HI Stable Low groups). Based on past work we also hypothesized a group with increasing IA and a group with decreasing HI symptom levels. However, contrary to these expectations, findings showed a group with steadily increasing HI (i.e., HI Increasing) and a group with increasing IA symptoms that decelerated over time (i.e., IA Change). Yet, given the methodological differences of this study compared to past research as described above, as well as the exploratory nature of Aim 2, the lack of full support for our initial hypotheses is again, not surprising.

Interestingly, the IA Stable High and HI Stable High groups represented approximately 11% of the sample for each symptom domain, which falls within the range of other "stable high," "chronic," and "persistent" groups reported using community or population-based samples (Galéra et al., 2011; Leblanc et al., 2008; Romano et al., 2006; Sasser et al., 2015; Shaw et al., 2005; Willoughby et al., 2012). Although caution should be used in comparing across studies given the varying methodological approaches, findings seem generally consistent regarding this particular group. In addition, the sample examined by Sasser et al. (2015), which included children previously enrolled in Head Start, also reported 11% of participants categorized into the stable high inattentive group using teacher ratings, despite symptom measurements that occurred during elementary school. Another study utilizing a low-income sample of boys reported an even higher proportion of their participants falling in the chronic group (i.e., 20%; Shaw et al., 2005), but differed substantially from the current study and Sasser et al. (2015) given their use of a three-item parent report measure of hyperactivity/attention problems. In contrast, most studies with population-based cohorts that did not specifically sample at-risk children reported 7 - 8% of participants belonging to the high stable/persistent groups (Leblanc et al., 2008; Romano et al., 2006; Willoughby et al., 2012), which aligns more closely to estimated ADHD diagnostic rates in preschool (Lavigne et al., 2009). Although it is unknown whether any children in our High Stable groups had an official ADHD diagnosis, and we are cautious not to speculate on diagnostic status without parent or impairment data, an ADHD prevalence rate of 11% would not be unrealistic given the at-risk status of the majority of our sample. Regardless of diagnostic category, the stable nature of IA and HI symptom elevations for some in the present study suggests the potential utility of directing early intervention services to children with elevated symptoms.

Importantly, the lack of any decreasing symptom trajectory group in either the IA or HI symptom domains is notable. Although many teachers, clinicians, and other providers might adopt a "wait and see" approach in order to avoid over pathologizing normative behaviors, results from the current study suggest that, on average, symptom elevations either remain stable or increase over the course of the year. Though certainly in need of replication, our findings do not support the argument that the diagnostic assessment of ADHD during early childhood necessitates multiple time points of data to account for age-typical change in attention and behavior. Instead, an alternative approach is needed to ensure we do not over pathologize normative behaviors among young children but, at the same time, do not miss an important opportunity for early intervention/prevention. For example, as suggested by Harvey et al. (2009), the use of provisional diagnoses may be helpful by ensuring access to interventions while conveying a cautious and tentative approach to diagnosis in young children. Similarly, prioritizing the use of low-risk interventions may be helpful to addressing symptom elevations in the preschool population. In sum, results from this study, along with the broader literature, support the adoption of proactive screening and intervention approaches for preschool children.

4.3. Consideration of Classroom Factors

Whenever possible, follow-up analyses examined models that accounted for the nesting of children within classrooms and were compared to the original models that did not account for nesting. This approach was utilized because children in the same classrooms have many shared experiences, such as classroom organization, teacher attitudes toward ADHD/behavior problems, and teacher behavior management practices, and as a result, may have shared variability in their ADHD symptom scores. However, it is typically recommended that a study contain a minimum of 30 to 50 classrooms to sufficiently account for the clustering of data (Kreft & De Leeuw, 1998; Maas & Hox, 2005). Given our sample contained 18 classrooms, some models were deemed too complex to examine when accounting for clustered data.

For the models that were viable, the vast majority of results (i.e., pattern of significance) remained the same as the models that did not account for nesting. Two notable exceptions to this pattern occurred. First, the quadratic term for the average IA trajectory model (i.e., variable-centered model) was no longer significant when accounting for nesting, suggesting that *both* IA and HI symptom levels follow a steady course of increase over the year without any deceleration. Second, the "IA Change" group that emerged from the person-centered model no longer demonstrated a significant pattern of change and was therefore renamed "IA Moderate Stable." This finding suggests that when accounting for the shared variability in scores stemming from classroom factors, IA symptoms demonstrate a severity effect such that children follow a stable course of low, moderate, or high symptom trajectories.

Importantly, the results in the IA domain across model types (i.e., variable- versus person-centered) are somewhat contradictory when accounting for the nesting of data. Specifically, the variable-centered model suggests an average linear increase in IA over the year, whereas the person-centered model yields no groups with significant change. Given these seemingly contradictory findings across model types, it is recommended that future work in this area include a larger sample with at least 30 classrooms.

4.4. Examination of Sex Effects

In addition to understanding the average trajectories and continuities/discontinuities in symptom change across time, we sought to examine the relation of children's sex to the developmental course of symptoms through the year. Across both symptom domains, boys started the preschool year with higher levels of symptoms than girls and increased in their symptom levels at a faster rate. Of note, the difference in rates of HI symptom increases between boys and girls was only marginally significant, and therefore warrants replication. Moreover, children with the least risk for ADHD (i.e., the HI and IA Stable Low groups) were more likely to be female than the groups that displayed any change (i.e., IA Change/Stable Moderate and HI Increasing) or the stable high groups (i.e., IA Stable High/HI Stable High), suggesting males may be more likely than females to have either an increasing or stable high course of symptomatology through the year. These results are consistent with research documenting an association between being male and high/persistent IA and HI using parent-reported symptoms (Leblanc et al., 2008; Romano et al., 2006), as well as the broader literature showing a higher preschool ADHD diagnostic rate among boys as compared to girls (Egger et al., 2006). Although this study supports the finding that boys are at a greater risk for elevated ADHD symptom levels and persistence of symptoms over time compared to girls, other work has shown that when comparing girls with ADHD to typically developing girls, the magnitude of the difference in symptom severity is *larger* than when comparing ADHD boys to typically developing boys (Riddle et al., 2013). Further, some research suggests girls with ADHD may be at greater risk than boys for negative developmental outcomes (Lahey et al., 2016). Hence, future research should continue to focus on sex differences in symptom onset, symptom progression, and related impairment outcomes to aid in our understanding of how to best identify and treat ADHD in both boys and girls.

4.5. Examination of Age Effects

Given the many developmental changes that occur between the ages of three and five, age was an important factor to consider in this study. For IA symptoms, variable-centered modeling revealed that being younger was associated with higher symptom levels at the start of the school year but the rate of change in IA symptoms across the year was not associated with age when accounting for relevant covariates (i.e., sex and subsample). Further, person-centered modeling revealed that children who followed a stable course of high IA symptoms across the year (i.e., “Stable High” group) were significantly younger than children following a stable low course of IA (i.e., “Stable Low” group), though neither group differed in their average age from the IA Change/IA Stable Moderate group. These findings raise the question as to whether being younger is a risk factor for elevated IA symptom levels or simply reflective of a normative difference between older and younger children in their innate attentional capacities.

Particularly given that many classrooms contained children ranging in age from three to five, it is possible that age-typical inattention of younger children stood out in contrast to their older peers, an effect that may not happen in a classroom with one age group (e.g., a three-year-old classroom). Yet, assuming these results are in part due to normative age differences in attention, one might also expect to see a group of children with decreasing IA symptoms over the year who are younger, on average, than groups with more stable symptoms, but such a group did not emerge.

In contrast to the IA symptom domain, variable-centered model results showed that age was not associated with HI symptoms at the start of the year but being older was linked with a steeper increase in HI symptoms across the year when accounting for relevant covariates. Person-centered modeling demonstrated that average age did not vary across children following different pathways of HI symptom progression throughout the year (i.e., Stable High, Increasing, or Stable Low). Differences in the results by age for the HI domain might reflect variations in teacher expectations for behavior across older and younger children. Specifically, it is possible that being older was associated with a steeper increase in HI symptoms because teachers increased their expectations for behavior for the older children in the class as they approached entry to kindergarten. More research is clearly needed to understand the role of teacher expectations for behavior across preschool children of varying ages, and the potential impact of these expectations on ADHD symptomatology. However, if teachers do have stricter behavioral expectations for children right before kindergarten entry, it is possible that this period could be an optimal time to identify HI symptoms in young children.

This study was unique in its ability to examine the effect of age on symptom trajectories given that most developmental course studies have had more restricted age ranges at each assessment time point (Leblanc et al., 2008; Shaw et al., 2005; Willoughby et al., 2012). Past research has shown that older preschoolers are more likely to meet diagnostic criteria for ADHD than younger preschoolers (Egger et al., 2006) but the ability to predict ADHD diagnosis in kindergarten from preschool behavior problems does not differ for preschool ratings collected at ages 3, 4, or 5 (Harvey, Youngwirth, Thakar, & Errazuriz, 2009). Further consideration of how symptom onset and progression differ across children at different ages in preschool is needed and should be prioritized in future work.

4.6. Implications for Preventative and Early Interventions

One aspect of a prevention treatment framework that warrants attention is our ability to identify young children at-risk for ADHD *prior* to full disorder onset. Consequently, we were particularly interested in the groups with any type of increasing symptom level pattern that emerged from our person-centered models. Although in both the IA and HI symptom domains children's sex distinguished high from low symptom trajectories, it did not help distinguish children who followed a stable course of symptom elevation from those with changing or increasing symptom trajectories. Similarly, age did not distinguish the changing or increasing IA/HI trajectory groups from those with stable trajectories. Importantly, in the IA domain, the IA Change group became a stable moderate group after accounting for nesting of data, which may partially explain why this group could not be distinguished from the other groups on the basis of child age or sex. Regardless, more research is needed to identify factors that can differentiate the increasing versus stable symptom groups and aid in the identification of children at risk for developing ADHD. For example, examination of family/parenting factors, classroom/environmental factors, neuropsychological profiles, temperament, and genetic traits are all prime variables to include in future research studies on the topic.

With a growing call for public funding of universal pre-kindergarten education (UPK) and some cities and states already beginning to adopt UPK laws that provide wider access to pre-kindergarten education services (Friedman-Krauss et al., 2019), it is an ideal time to consider models of ADHD prevention in the school setting. In other contexts with wide access to children and families, such as pediatric primary care, programs are currently being disseminated that help improve the ability of providers to universally screen and effectively treat ADHD in young children (Epstein et al., 2016; Epstein et al., 2008). As the early education setting increasingly becomes one of universal access, efforts to develop similar programs that help teachers/staff systematically identify ADHD or ADHD-risk without undue levels of burden should be a high-priority. Low-cost, low-burden interventions that can be implemented in the classroom and that have the potential to alter the developmental course of ADHD symptom levels will be crucial in moving the field toward a prevention framework for ADHD.

4.7. Strengths and Limitations

There were several limitations to this study that should be taken into account when interpreting the results. First, a larger sample across more classrooms is needed for future replication to ensure adequate power to detect latent groups, particularly when accounting for the clustering of data. Second, this study did not include any impairment data, which limits our ability to know whether symptom elevations corresponded with daily challenges and disruptions in the classroom. Indeed, symptoms only tell one part of the story and it also remains unclear whether the DSM-based symptoms developed for older children are adequate to capture the disorder in preschoolers. Thus, future research that includes impairment data and further considers developmentally appropriate manifestations of symptoms in preschoolers is needed. Additionally, although the use of teacher data was a significant strength in this study, a lack of parent data is a limitation. More research is needed to understand how symptom development across contexts/raters occurs over time. Finally, our person-centered analysis was limited by model complexity which resulted in the use of latent class growth analysis instead of full growth mixture models. Future research with larger samples, including a larger number of classrooms, should allow for the examination of models that more accurately represent the population (e.g., modeling all parameters to vary within and across latent classes).

Despite these limitations, this study also had a number of important strengths. First, the sample was diverse, including a high proportion of racial/ethnic minority children and socioeconomically disadvantaged youth. This is a notable strength given this area of the literature has been criticized for a lack of diversity (Lee, Sibley, & Epstein, 2016) and the use of an at-risk community sample allows for the examination of a full range of naturally occurring symptom variability, which is key to exploring questions of prevention. Moreover, this study was unique in its ability to examine four assessments of ADHD symptoms within nine months, thus yielding important information regarding symptom trajectories during a time of rapid developmental change. Given all of the limitations of past research in this area, as has been discussed, additional study strengths included the use of teacher ratings, examination of IA and HI trajectories separately, and inclusion of all 18 DSM-based ADHD symptoms.

4.8. Conclusions

Results from this study are an essential first step toward refining our system of early identification of ADHD. Teacher-rated symptoms of ADHD across a single preschool year demonstrated, on average, a course of increasing inattention that decelerated over time and a course of steadily increasing hyperactivity/impulsivity across the year. Within symptom domains, the vast majority of children demonstrated low IA and HI symptom levels that remained stable across the year (57% and 63%, respectively), while a small minority of children followed a chronic pattern of symptom elevations that remained stable across the year (11% in each domain). In the IA symptom domain, some children (32%) demonstrated moderate symptom levels that changed slightly (increased with deceleration) but after accounting for the clustering of children within their classrooms, this group appeared to remain stable overall. In contrast, in addition to the high stable and low stable HI trajectories, about 26% of children followed an increasing course of HI symptom levels. Boys started the year with higher levels of symptoms, increased in symptom levels at a faster rate, and were more likely to follow a high stable or increasing pattern of symptoms through the year as compared to girls. Finally, being younger was associated with higher levels of inattention at the start of the year, as well as with following a course of stable high IA symptoms; whereas, being older was associated with steeper increases in hyperactivity/impulsivity over the year. Results suggest a “wait and see” approach to intervention may miss an important opportunity for early intervention given most children follow stable or increasing symptom trajectories.

Consideration of low-risk, low-burden interventions that can be applied preventatively should be high-priority for this population. Further replication of results along with research that incorporates impairment and parent data is needed.

Table 1. Means, standard deviations, and correlations among study variables

Variable	1	2	3	4	5	6	7	8	9	10	11	M	SD
1. Subsample[a]	--											1.57	.50
2. Sex[b]	.02	--										1.47	.50
3. Age	-.08	.04	--									3.97	.61
4. IA T_1	.15*	-.19**	-.24**	--								0.63	.71
5. IA T_2	.20**	-.25**	-.17*	.77**	--							0.75	.75
6. IA T_3	.20**	-.21**	-.18**	.71**	.81**	--						0.74	.79
7. IA T_4	.31**	-.20**	-.17*	.73**	.76**	.83**	--					0.73	.79
8. HI T_1	.19**	-.17*	-.15*	.83**	.71**	.62**	.70**	--				0.63	.74
9. HI T_2	.15**	-.26**	-.04	.67**	.84**	.68**	.67**	.78**	--			0.70	.74
10. HI T_3	.18**	-.21**	-.05	.62**	.74**	.82**	.77**	.72**	.85**	--		0.75	.80
11. HI T_4	.20**	-.21**	-.02	.61**	.70**	.71**	.82**	.74**	.82**	.90**	--	0.76	.79

Note. [a] 1 = Subsample A, 2 = Subsample B [b] 1 = boys, 2 = girls; IA = Inattention; HI = Hyperactivity/Impulsivity; T_1 = Time 1 (Baseline); T_2 = Time 2 (3 months); T_3 = Time 3 (5 months); T_4 = Time 4 (8 months)
*$p \leq .05$, **$p \leq .01$

Table 2: Model fit indices for unconditional LGCMs

Fit Indices	Linear Model	Quadratic Model
Inattention Symptoms		
AIC	1351.54	**1337.32**
BIC	1383.62	**1380.09**
ABIC	1355.09	**1342.05**
Chi-Square Test of Model Fit	21.93*	**1.70**
RMSEA	0.11	**0.0**
CFI	0.98	**1.0**
TLI	0.97	**1.0**
SRMR	0.04	**0.02**
Hyperactivity/Impulsivity Symptoms		
AIC	**1251.06**	1238.01
BIC	**1283.14**	1280.78
ABIC	**1254.61**	1242.73
Chi-Square Test of Model Fit	**23.39***	4.43
RMSEA	**0.12**	0.07
CFI	**0.98**	0.98
TLI	**0.97**	0.99
SRMR	**0.03**	0.03

Note. AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; ABIC = Adjusted BIC; RMSEA = Root Mean Square of Approximation; CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; SRMR = Standardized Root Mean Residual; Bold = selected model; * $p \leq .05$

Table 3: Best-fitting unconditional LGCM results for inattention and hyperactivity/impulsivity symptoms

	Inattention Symptoms		Hyperactivity/Impulsivity Symptoms	
	Estimate	Standard Error	Estimate	Standard Error
Intercept	0.65***	0.05	0.66***	0.05
Linear Slope	0.05***	0.02	0.02***	0.01
Quadratic Term	-.004**	0.002	---	---

Note. *** $p \leq .001$; ** $p \leq .01$; * $p \leq .05$; Only the inattention model included a quadratic term

Table 4. Inattention and hyperactivity/impulsivity symptom means across study time points

	Time 1 (*n* = 214)	Time 2 (*n* = 209)	Time 3 (*n* = 228)	Time 4 (*n* = 231)
Inattention Symptoms				
Mean	0.63	0.76	0.74	0.73
Standard Error	0.51	0.56	0.62	0.55
Hyperactivity/Impulsivity Symptoms				
Mean	0.63	0.70	0.75	0.76
Standard Error	0.54	0.55	0.65	0.62

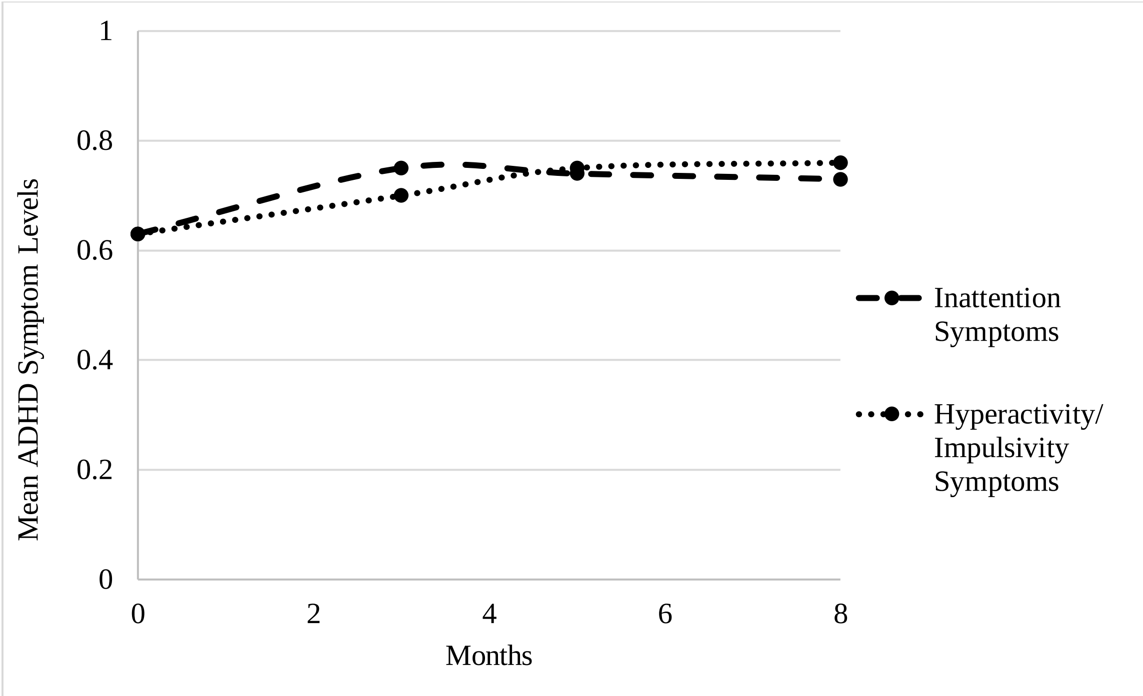

Figure 1. Average trajectories for inattention and hyperactivity/impulsivity symptom levels

Note. This figure utilizes a restricted y-axis range to depict mean ADHD symptom levels. Mean ADHD symptom level scores can theoretically fall between the values of zero and three. A restricted range of zero to one was utilized to improve visualization and subsequent interpretation.

Table 5. Model fit indices for unconditional LGCMs accounting for nesting by classroom

Fit Indices	Inattention Symptoms	Hyperactivity/Impulsivity Symptoms
AIC	1337.33	1251.06
BIC	1380.11	1283.14
ABIC	1342.06	1254.61
Chi-Square Test of Model Fit	1.08	11.73*
RMSEA	0	0.07
CFI	1	0.98
TLI	1.01	0.98
SRMR	0.02	0.03

Note. AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; ABIC = Adjusted BIC; RMSEA = Root Mean Square of Approximation; CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; SRMR = Standardized Root Mean Residual; * $p \leq .05$

Table 6. Model fit indices for conditional LGCMs

Fit Indices	Inattention Symptoms	Hyperactivity/Impulsivity Symptoms
AIC	1301.28	1229.94
BIC	1376.13	1283.41
ABIC	1309.55	1235.85
Chi-Square Test	5.28	31.14*
RMSEA	0.02	0.08
CFI	1.0	0.98
TLI	0.99	0.96
SRMR	0.013	0.03

Note. AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; ABIC = Adjusted BIC; RMSEA = Root Mean Square of Approximation; CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; SRMR = Standardized Root Mean Residual; * $p \leq .05$

Table 7. Best-fitting conditional LGCM results for inattention and hyperactivity/impulsivity symptoms

	Inattention Symptoms		Hyperactivity/Impulsivity Symptoms	
	Estimate	Standard Error	Estimate	Standard Error
Intercept				
Subsample[a]	0.24**	0.09	0.27**	0.09
Sex[b]	-0.25**	0.09	-0.27**	0.09
Age	-0.28***	0.08	-0.12	0.08
Linear Slope				
Subsample[a]	-.002	0.03	.002	0.03
Sex[b]	-0.06*	0.03	-0.02†	0.03
Age	0.02	0.03	0.02*	0.002
Quadratic Term				
Subsample[a]	0.003	0.003	---	---
Sex[b]	0.01	0.003	---	---
Age	-0.001	0.003	---	---

Note. *** $p \leq .001$; ** $p \leq .01$; * $p \leq .05$; †marginal significance; [a] 1 = Subsample A, 2 = Subsample B; [b] 1 = boys, 2 = girls; Only the inattention model included a quadratic term.

Table 8. Inattention and hyperactivity/impulsivity symptoms means across time for boys and girls

	Time 1 (Baseline)			Time 2 (3 months)			Time 3 (5 months)			Time 4 (8 months)		
	n	*M*	*SE*	*n*	*M*	*SE*	*n*	*M*	*SE*	*n*	*M*	*SE*
IA Symptoms												
Boys	112	0.76	.49	114	0.93	.55	119	0.89	.65	118	0.87	.65
Girls	102	0.49	.48	95	0.55	.49	109	0.56	.52	113	0.58	.49
HI Symptoms												
Boys	112	0.75	.55	114	0.87	.59	119	0.91	.69	118	0.92	.66
Girls	102	0.50	.49	95	0.49	.41	109	0.58	.54	113	0.59	.52

Note. IA = Inattention; HI = Hyperactivity/Impulsivity

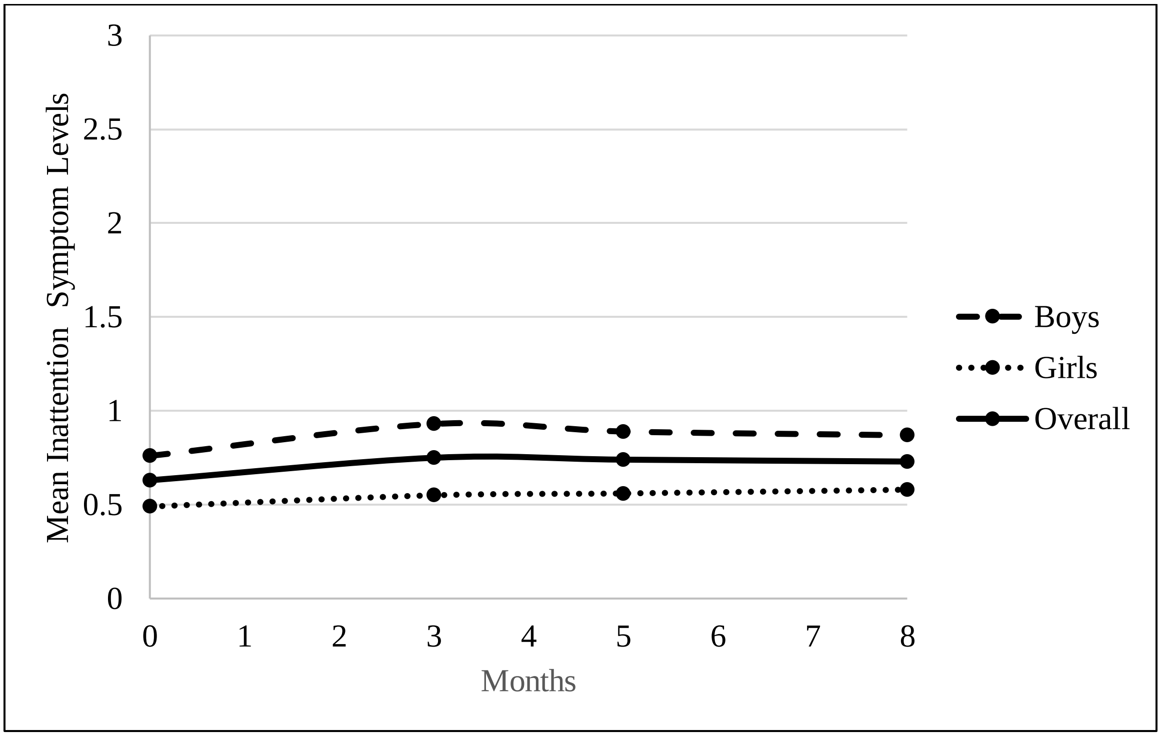

Figure 2. Inattention average symptom level trajectories across time for boys and girls

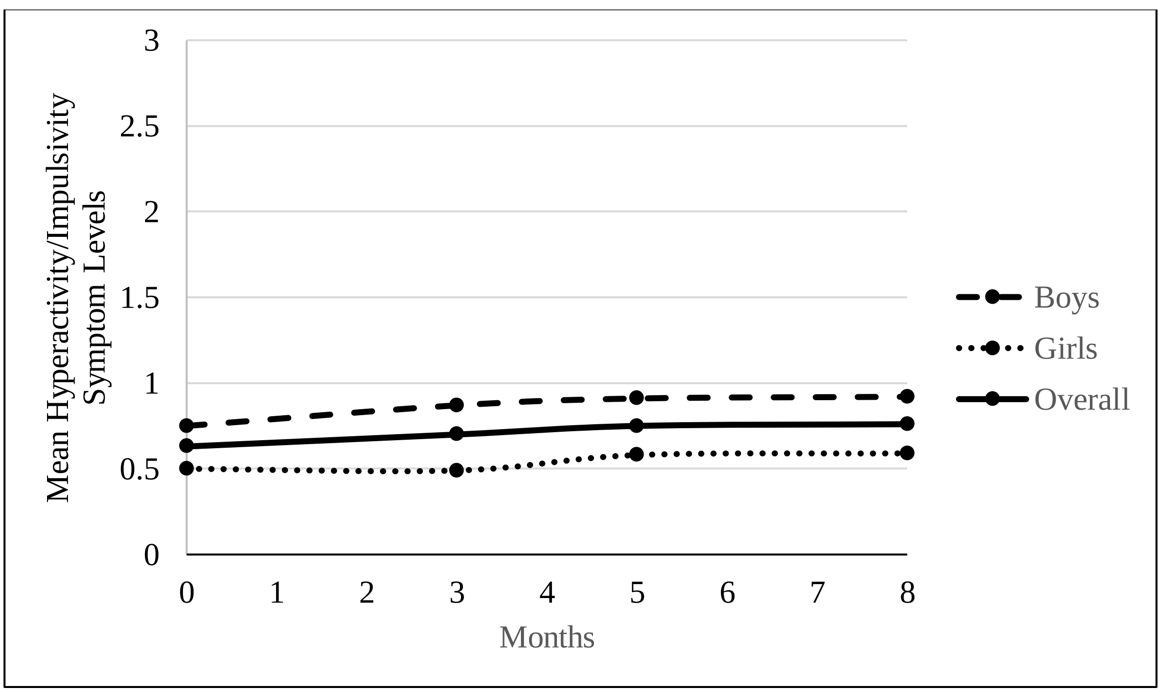

Figure 3. Hyperactivity/Impulsivity average symptom level trajectories across time for boys and girls

Table 9. Latent class growth analysis model fit indices for inattention and hyperactivity/impulsivity symptoms

Fit Indices	2	3	4
IA Symptoms			
AIC	1520.4	**1317.7**	1268.6
BIC	1559.6	**1371.2**	1336.3
ABIC	1524.7	**1323.6**	1276.1
Entropy	0.89	**0.89**	0.84
LMR-LRT	469.60**	**201.60***	52.20
HI Symptoms			
AIC	1443.3	**1233.1**	1150.0
BIC	1475.3	**1275.9**	1203.5
ABIC	1446.8	**1237.9**	1155.9
Entropy	0.94	**0.91**	0.88
LMR-LRT	574.82***	**203.91**	84.12

Note. IA = Inattention; HI = Hyperactivity/Impulsivity; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; ABIC = Adjusted BIC; LMR-LRT = Lo-Mendell-Rubin likelihood ratio test; Only the inattention model included a quadratic term; Bold = selected model; ***$p \leq .001$; **$p \leq .01$; * $p \leq .05$

Table 10. Latent class growth analysis model results for inattention and hyperactivity/impulsivity symptomatology across time

	Assigned Label	**Intercept**	**Linear Slope**	**Quadratic Term**
IA Symptoms				
Class 1 (*n* = 30)	IA Stable High	2.03***	0.06	-.004
Class 2 (*n* = 83)	IA Change	0.97***	0.08*	-.008*
Class 3 (*n* = 148)	IA Stable Low	0.21***	0.02	-.001
HI Symptoms				
Class 1 (*n* = 29)	HI Stable High	2.15***	0.02	---
Class 2 (*n* = 69)	HI Increasing	0.91***	0.06***	---
Class 3 (*n* = 163)	HI Stable Low	0.26***	0.001	---

Note. IA = Inattention; HI = Hyperactivity/Impulsivity; ***$p \leq .001$; **$p \leq .01$; * $p \leq .05$

Table 11. Latent class growth analysis group means across time, separately reported by inattention and hyperactivity/impulsivity symptoms

	Time 1 (Baseline)		**Time 2** (3 months)		**Time 3** (5 months)		**Time 4** (8 months)	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
IA Symptom Groups								
IA Stable High (*n* = 30)	2.03	.47	2.19	.30	2.19	.29	2.25	.17
IA Change (*n* = 83)	0.99	.25	1.12	.24	1.17	.26	1.06	.16
IA Stable Low (*n* = 148)	0.19	.06	0.27	.09	0.22	.09	0.26	.09
HI Symptom Groups								
HI Stable High (*n* = 29)	2.09	.38	2.29	.25	2.35	.25	2.25	.24
HI Increasing (*n* = 69)	0.92	.33	1.09	.22	1.32	.22	1.36	.19
HI Stable Low (*n* = 163)	0.25	.09	0.27	.06	0.25	.07	0.27	.09

Note. IA = Inattention; HI = Hyperactivity/Impulsivity

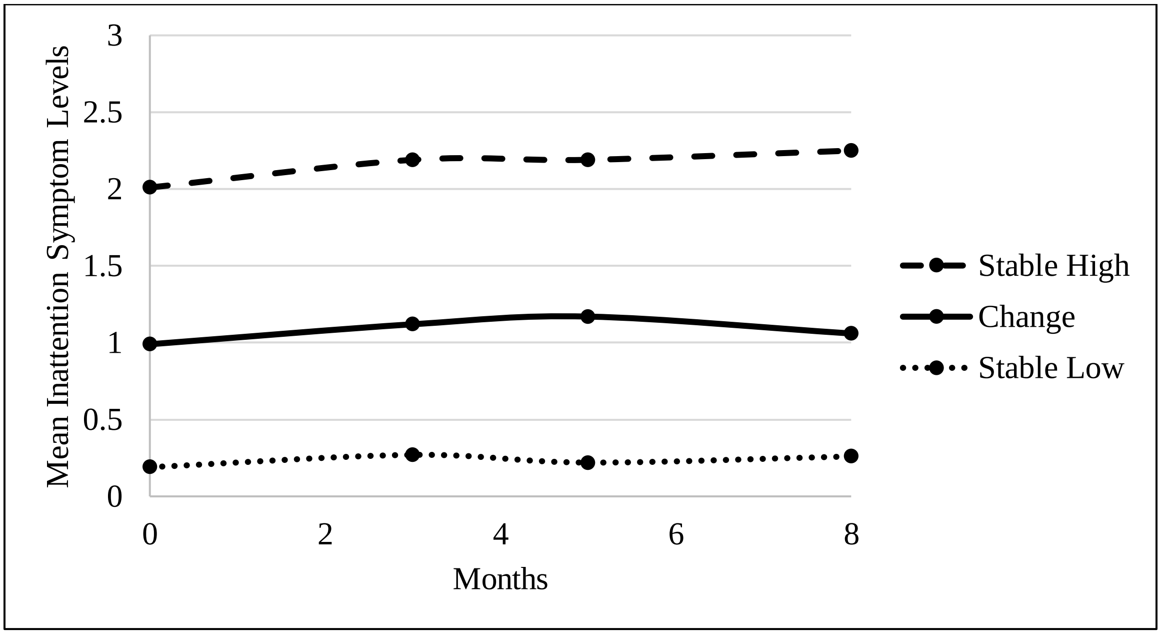

Figure 4. Trajectories of inattention symptom levels by latent class group

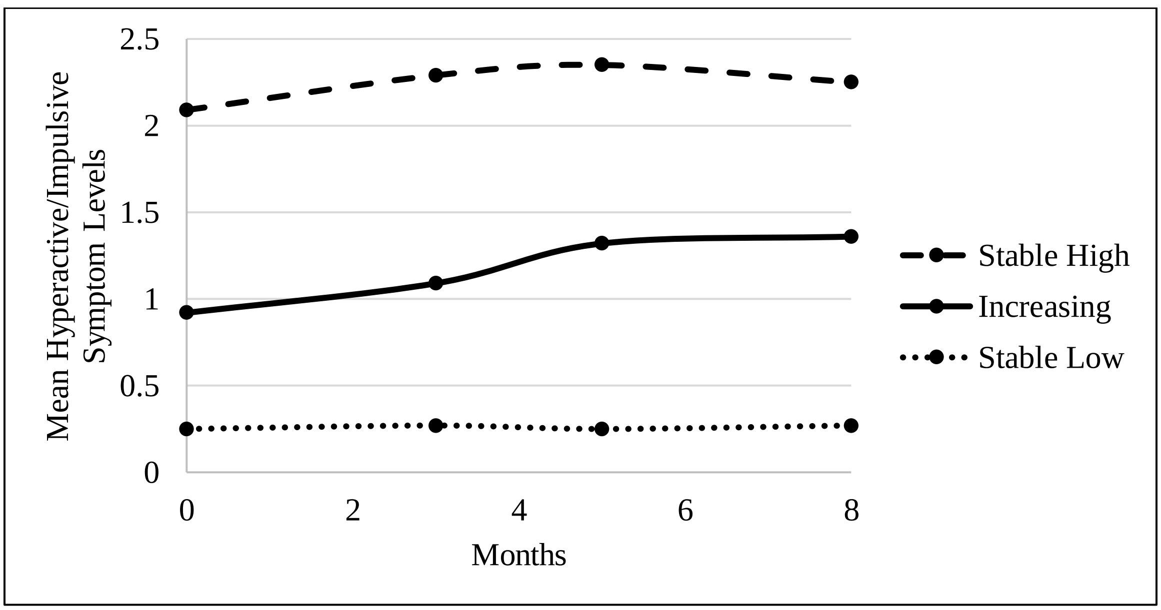

Figure 5. Trajectories of hyperactivity/impulsivity symptom levels by latent class group

Table 12. Model fit indices for latent class growth analysis accounting for nesting by classroom

Fit Indices	Inattentive Symptoms	Hyperactivity/Impulsivity Symptoms
AIC	1317.7	1233.1
BIC	1371.2	1275.9
ABIC	1323.6	1237.9
Entropy	0.89	0.91
LMR-LRT	201.60	203.91

Note. AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; ABIC = Adjusted BIC; LMR-LRT = Lo-Mendell-Rubin likelihood ratio test; $^{***}p \leq .001$; $^{**}p \leq .01$; $^{*}p \leq .05$

Table 13. Means and standard deviations for children's age by ADHD latent class group

	Age	
	M	*SD*
IA Symptoms		
IA Stable High (*n* = 30)	3.73_{a}	.60
IA Change/IA Stable Moderate (*n* = 83)	$3.95_{a,b}$	.59
IA Stable Low (*n* = 148)	4.04_{b}	.62
HI Symptoms		
HI Stable High (*n* = 29)	3.95	.64
HI Increasing (*n* = 69)	3.95	.58
HI Stable Low (*n* = 163)	3.99	.63

Note. Results from post hoc comparisons are identified by superscripts a and b. Means that differ significantly within each domain of competence are identified by different superscripts, means that do not differ between groups are identified by the same superscript.

Table 14. Binary logistic regression model results for inattention and hyperactivity/impulsivity symptom domains

	Model predicting child sex				
	Reference Group	ß	SE	Odds Ratio (female)	*p*-Value
IA Symptoms					
IA Stable Low	IA Change/IA Stable Moderate	0.81	.28	2.26	.004
IA Stable High	IA Stable Low	-0.94	.42	0.39	.026
IA Stable High	IA Change/IA Stable Moderate	-0.12	.45	0.88	.780
HI Symptoms					
HI Stable Low	HI Increasing	0.86	.30	2.37	.004
HI Stable High	HI Stable Low	-1.20	.44	0.30	.007
HI Stable High	HI Increasing	-0.34	.49	0.71	.489

Note. Sex variable coding: 1 = males, 2 = females; SE = Standard Error

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