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Investigating Developmental Patterns of Symptom and Impairment Change Among Youth With ADHD, Subthreshold ADHD and Youth Without ADHD

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INVESTIGATING DEVELOPMENTAL PATTERNS OF SYMPTOM AND IMPAIRMENT CHANGE AMONG YOUTH WITH ADHD, SUBTHRESHOLD ADHD AND YOUTH WITHOUT ADHD

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ABSTRACT

Introduction. Despite a substantial prevalence of subthreshold Attention-Deficit/Hyperactivity Disorder (ADHD) and research indicating that many youth with this disorder have impaired functioning and negative outcomes, few studies have considered patterns of symptom and functioning change for youth with probable ADHD, subthreshold ADHD and youth without ADHD transitioning from childhood to adolescence. Additionally, we are not aware of any studies examining predictors of impairment severity among youth with subthreshold ADHD, and few studies have examined predictors of treatment utilization and patterns of symptom and functioning change based on medication status for youth with subthreshold ADHD compared to youth with ADHD. Methods. This study utilized data from the South Carolina Project to Learn about ADHD in Youth (SCPLAY). After a two-phase screening, a sample of children at high and low risk (frequency-matched on gender) of ADHD and parents/caregivers were invited for interviews. The Jacobson & Traux reliable change index (RCI) and chi-square tests were used to examine patterns of (ADHD) symptom and functional impairment change and logistic regression methods were used to identify predictors of impairment severity and medication use. Results. At baseline interview, children were identified who met symptom criteria for subthreshold ADHD (N=84), probable ADHD (186), and probable non-ADHD (n=211) and patterns of change in symptoms and functioning were examined at follow-up (starting three years later) (n=292). Subthreshold ADHD symptoms were seen in as many as 17% (N = 84) of the
youth studied at baseline. Youth (both non-ADHD and subthreshold ADHD at baseline) who achieved probable ADHD status at follow-up are more likely to show impaired functioning than individuals achieving subthreshold ADHD or non-ADHD status. Thirty three percent of youth who were subthreshold at baseline remained in that category at follow-up and 12%-21% showed significant decline in at least one domain of functioning. Youth who were subthreshold ADHD at baseline who were subthreshold at follow-up and taking medication (year prior to follow-up) declined in four of the five domains of functioning and youth who were subthreshold ADHD at baseline and probable ADHD at follow-up (and medicated the year prior to follow-up) declined in three out of five domains of functioning. Change in functioning, both improved functioning and worsened functioning, often occurred when there was no reliable or significant change in symptoms. In multivariable analyses, severe impairment was significantly predicted by psychiatric comorbidity among probable ADHD cases, being male among subthreshold ADHD, and primary parent psychiatric history and medication use among individuals without ADHD at follow-up. Use of ADHD medication the year prior to follow-up was significantly predicted by parent perceived burden in the subthreshold ADHD model and female gender in the probable ADHD model.

**Conclusions.** The findings show the importance of examining both symptom and functioning constructs in the consideration of their unique contributions to ADHD and subthreshold ADHD diagnoses and of acknowledging the need to examine nuanced changes in diagnostic status during development. These findings may be relevant to efforts to intervene earlier in childhood and to help identify high-risk individuals who may be good candidates for targeted interventions.
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Chapter 1

INTRODUCTION

BACKGROUND

Attention-Deficit/Hyperactivity Disorder (ADHD) is a highly prevalent, persistent, heterogeneous, costly, and impairing disorder. In 2006, 7% (1.5 million) of American children aged 3-17 had ADHD (Bloom & Cohen, 2007). Using a strict diagnostic case definition, a recent longitudinal community-based study in South Carolina (SCPLAY) reported an 8.7% ADHD prevalence rate among children 5-13 years of age (M. L. Wolraich et al., 2012). Rates of parent-reported ADHD diagnosis increased 3% annually from 1997 to 2006 (Pastor & Reuben, 2008), and by 2007, parents reported nearly one in ten American school-aged children had received a diagnosis (CDC, 2010).

While diagnostic retention (maintaining full ADHD diagnostic status over time) rates vary, both clinical and community-based studies show that a considerable proportion of childhood ADHD cases persist into adolescence (Bussing, Mason, Bell, Porter, & Garvan, 2010; Polanczyk & Jensen, 2008). Symptom trajectory studies, those that determine the number of ADHD symptoms exhibited across recurring assessments, show a decrease in ADHD symptoms with increasing age; however, there is clear evidence of variable symptom persistence for many (Holbrook, 2012; Willoughby, 2003). The 1980’s marked the turning point when researchers began to refute the assumption that ADHD remitted by adolescence (Willoughby, 2003). Since that time, the perception
of ADHD has changed from characterization as a childhood disorder to that of a lifespan disorder (McGough & Barkley, 2004).

ADHD is heterogeneous in terms of symptom and functional impairment expression and course. ADHD is characterized by hyperactive-impulsive and/or inattentive symptoms (present before age 7) that continue over time and cause associated social, academic, and/or occupational impairment in functioning in at least two settings (e.g., home and school) (American Psychiatric Association, 2000). ADHD expression reflects a dynamic interplay of individual characteristics and the circumstances of each child (Johnston & Mash, 2001). The clinical complexity of ADHD is also marked by frequent co-morbid disorders such as Oppositional Defiant Disorder (ODD), Depression, and Conduct Disorder (CD) (Steinhausen, 2009).

The public health cost of ADHD is high both in fiscal and human terms. In the US, the annual societal cost of ADHD in childhood and adolescence is approximately $42.5 billion; an estimated yearly cost (health care, education, parental work loss, and juvenile justice cost data from 13 studies in 2005) of $14,576 for individuals with ADHD (W. E. Pelham, Foster, & Robb, 2007). In terms of the human toll, children with ADHD have marked impairments which impact many aspects of the individual’s life (Health, 1998 Nov 16-18). Children with ADHD can experience adverse educational, vocational, economic and social-emotional outcomes which, in turn, have a profound impact on affected youth’s development, their families, schools, and society (Health, 1998 Nov 16-18). Functional impairments, not symptom count or symptom severity drives these large fiscal and societal costs (Goldstein & Naglieri, 2009).
The developmental course of ADHD functioning from childhood to middle adolescence has been described by one researcher as “a bumpy road for many” (Mannuzza & Klein, 2000). Those who encounter prolonged underachievement and failure, associated with ADHD, may fare more poorly throughout life (Young & Gudjonsson, 2008) and childhood impairment is the best predictor of short- and long-term outcomes for children and adolescents (Fabiano & Pelham, 2009). As a result of the significant ADHD-associated impairment experienced by youth, frequent utilization of health services, and the large personal, economic, and societal impact, ADHD is recognized as a major public health concern (W. E. Pelham, et al., 2007; Scahill et al., 1999).

STATEMENT OF THE PROBLEM

Symptoms: Only Part of the ADHD Developmental Course Picture

Diagnostic retention and symptom trajectory studies, while valuable in helping to shape our understanding of the persistence of ADHD and ADHD symptomatology, only provide part of the ADHD developmental course picture. ADHD is a chronic condition for many, and although symptoms tend to decline over time, this does not necessarily mean that normalized functioning follows (Willoughby, 2003). Distress is caused more by impairment than symptoms, and impairment is the main reason for treatment referrals (J. S. Owens, Johannes, & Karpenko, 2009). Impairment in daily function, rather than the number of symptoms, determines one’s quality of life (Goldstein & Naglieri, 2009) and allows for an understanding of service needs (Gordon et al., 2006). Measures of impairment are as important as measures of symptoms in determining diagnosis (Lahey et
al., 2004); and, measuring functional impairment is even more important in treatment planning than measuring symptoms (Lahey, et al., 2004).

**Functional Impairment: An Understudied Area**

With regard to ADHD, much less research attention has been devoted to the study of impairment than the study of symptoms (Fabiano & Pelham, 2009). Relatively few studies have examined adolescents compared to children (Seidman, 2006), and more prospective studies of children transitioning to adolescence are needed (Willoughby, 2003). The functional forms that developmental changes take are unclear, and potential heterogeneity in patterns of change is an understudied area (Willoughby, 2003).

Assessing ADHD function is a weighty undertaking for clinicians and researchers from both legislative and insurance standpoints because assessment results have implications for youth obtaining treatment access (Canino, Costello, & Angold, 1999). Many federal and state agencies and insurance company policies include the presence of impairment as a requirement for service provision approval for ADHD (Canino, et al., 1999). Decisions about the presence or absence or degree of impairment can affect treatment, referrals, estimates of geographical service area needs, income support awards, and eligibility of school services which in turn impacts youths' lives (Canino, et al., 1999). Policies for assessment of impairment require that ADHD be evaluated using the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR; a guidebook used by professionals to make psychiatric diagnoses) criteria (American Psychiatric Association, 2000), but do not contain recommendations or guidance on measuring impairment (Canino, et al., 1999). The DSM-IV-TR, too, offers little guidance on how to measure impairment (Gordon, et al., 2006).
Youth with Subclinical ADHD: Need for Further Research

Research indicates that a sizable number of youth, not meeting symptom criteria for a diagnosis of ADHD, experience significant functional impairment that may require intervention (Angold, Costello, Farmer, Burns, & Erkanli, 1999; Steinhausen, 2009). This subclinical group may have just as much impairment as youth who meet ADHD diagnostic criteria (Goldstein & Naglieri, 2009). Researchers considering subclinical ADHD have employed various terminologies (e.g., functional persistence, subsyndromal, subthreshold, symptomatic persistence, ADHD Not Otherwise Specified (NOS), ADHD residual type, and ADHD in partial remission). The term subclinical is used broadly in this study to include any of these diminished forms of ADHD. Definitions of subclinical ADHD often differ on the number of inclusionary symptoms, inclusion or exclusion and degree of impairment, and inclusion or exclusion of other ADHD diagnostic criteria. Chapter 1 provides a more in depth discussion of the nosological inconsistencies in the ADHD literature. This study uses subthreshold ADHD, a term proposed by the American Academy of Pediatrics in 1997, defined as three to five ADHD-HI or ADHD-IA symptoms (using the DSM-IV diagnostic criteria (S. Faraone et al., 2006). When referring to other studies or papers in which the authors use a different term for a subthreshold form of ADHD that term will be used.

To date, there have been relatively few prospective longitudinal studies following subthreshold cohorts of youth. We are not aware of any studies examining predictors of impairment severity (e.g. socio-economic status, comorbidity, severity of symptoms, etc.) among youth with subthreshold ADHD and few studies have examined predictors of treatment utilization for youth with subthreshold ADHD compared to youth with ADHD
(Bauermeister et al., 2003; Leslie et al., 2005). This is an area in need of study because subthreshold ADHD (as with full ADHD diagnosis) is not a short-lasting problem and may not be outgrown.

Youth who do not meet symptom count criteria, but demonstrate sufficiently impairing symptoms, are a group who may be denied services based on current policies (Canino, et al., 1999). For example, though children with subthreshold ADHD (meeting fewer than the required symptoms for a diagnosis) are more likely to have poor outcomes, they generally do not qualify for school or treatment services (Bussing, 2010). Children and adolescents who fail to achieve full diagnosis or full remission but continue to struggle with functional burden are a group in need of research and clinical attention (Karpenko, Owens, Evangelista, & Dodds, 2009).

**Symptom and Functional Impairment Trajectories: Patterns of Change**

Recently in the ADHD literature, two studies have emerged focusing on the poorly understood connection between reliable change in symptoms relative to functioning (E. B. Owens, Hinshaw, Lee, & Lahey, 2009; Rosenblatt & Rosenblatt, 2002). “Reliable change” (RC) is a statistical approach to measuring an individual’s change in performance on a standardized outcome measure (e.g., symptomatology or impairment) (Jacobson & Truax, 1991).

Clinically significant (CS) change involves calculating the Reliable Change Index (RCI) to determine if “the magnitude of change for a given client is statistically reliable” (Jacobson & Truax, 1991) and evaluating if scores move from a clinical to a normative distribution (Karpenko, et al., 2009). CS is often defined as return to normal functioning, or when the level of functioning at the follow-up time point is closer to the mean of an
individual (assesses change at the individual level) without ADHD than an individual with ADHD (Jacobson & Truax, 1991).

Studies using CS change (Karpenko, et al., 2009) and RCI (Karpenko, et al., 2009; E. B. Owens, et al., 2009; Rosenblatt & Rosenblatt, 2002) methodology confirm that change in functioning, both improved functioning and worsened functioning, often occurs when there is no reliable or significant change in symptoms. CS change may be overly conservative compared to the RCI method alone for certain disorders, especially ones in which a complete return to normal functioning is not expected (e.g. schizophrenia and ADHD) because, while declines in symptoms and improvement in functioning may occur, normative scores may only be achievable for a small number of individuals (J. S. Owens, et al., 2009). Even if someone does not return to the normal range of functioning, there is value in calculating the magnitude and direction of the impairment change (J. S. Owens, et al., 2009). Of the various methods proposed to measure reliable change, Jacobson and Traux’s method is recommended to enhance uniformity across studies (J. S. Owens, et al., 2009).

Better understanding of the discordance between symptom and impairment change (i.e., change in either, but not both, symptoms or impairment) would help in the treatment decision making process (e.g., to continue or discontinue treatment/intervention or to focus on specific domains of functioning) (J. S. Owens, et al., 2009). There is a need for research in this area (Karpenko, et al., 2009) and to date, no studies have considered patterns of change between symptoms and functional impairment comparing children in the community with subthreshold ADHD to children with and without ADHD using longitudinal naturalistic data. A consideration of the complex processes through which
functional impairment trajectories unfold in relation to symptoms is the main focus of this study.

**PURPOSE OF THE STUDY**

**Study Overview**

Project to Learn about ADHD in Youth (PLAY) is a joint collaboration research project with the University of South Carolina and the University of Oklahoma Health Sciences Center, funded by Centers for Disease Control and Prevention’s (CDC) National Center on Birth Defects and Developmental Disabilities (NCBDDD). PLAY is one of the largest community-based, epidemiologic investigations of ADHD in the United States. This study will utilize data from the South Carolina site (South Carolina Project to Learn about ADHD in Youth (SCPLAY)).

**Study Goals**

This study will examine the relationship between change in symptoms and reliable change in functioning in children and adolescents with ADHD, subthreshold ADHD, and children without ADHD who participated in the South Carolina Project to Learn about ADHD (SCPLAY). Subthreshold ADHD is defined here as youth identified as having three-to-five symptoms from either the inattentive or hyperactive/impulsive ADHD subtype symptom lists (using the DSM-IV-TR). This study will enrich the literature in several ways. First, while many studies have examined symptom trajectories, this study is one of only a small handful of ADHD studies that examines the relation between change in symptoms and domains of functioning (Gathje, Lewandowski, & Gordon, 2008; Karpenko, et al., 2009; Kazdin, 1999; J. S. Owens, et al., 2009; Rosenblatt & Rosenblatt, 2002). Second, this study will use the Diagnostic Interview Schedule for Children Version 4 (DISC-IV) (Shaffer, Fisher, Lucas, Dulcan, & Schwab-Stone, 2000)
to longitudinally assess patterns of change in symptoms among youth with ADHD, sub-clinical ADHD, and without ADHD. The DISC-IV is a highly structured, computer-based diagnostic interview used to assess psychiatric symptoms of children and adolescents. Third, the present study will incorporate parent/caregiver reports of functioning across multiple domains (social, classroom, home, leisure activity, and intrapersonal), using the Strengths & Difficulties Questionnaire (SDQ) (Goodman, 1999), to examine patterns of change between symptoms and functioning using individual-level analysis. The SDQ measure was selected because it allows for a consideration of functional impairment in youth with subthreshold ADHD and control children, whereas, the DISC-IV only assesses functioning in youth who meet symptom and other diagnostic criteria for ADHD. Fourth, this study is novel in that it is the first to evaluate the association between changes in symptoms and functioning based on treatment status (medicated/ not medicated) considering youth with probable ADHD, youth with subthreshold ADHD, and youth without ADHD in a community sample using the RCI methodology. Fifth, predictors associated with more severe forms of ADHD functional impairment will be explored to see if they are similar for youth with ADHD and youth with subthreshold ADHD. Finally, predictive factors associated with subthreshold ADHD medication use remain poorly understood; this study will identify child and family-related factors (e.g. impairment severity and parent reported burden) that predict medication use among youth with ADHD and youth with subthreshold ADHD.

**RESEARCH QUESTIONS**

**Research Question 1:** How do youth with subthreshold ADHD, youth with ADHD and youth without ADHD change from baseline to follow-up with regard to patterns
of change in symptoms and domains (both specific and aggregate) of functioning?

The 5 domains of functioning include social (friendships), school (classroom learning), home (home life), intrapersonal (self), and free time (leisure activities).

**Research Question 2:** Are the risk factors that are associated with more severe forms of ADHD functional impairment similar for youth with ADHD, youth with subthreshold ADHD and youth without ADHD?

**Research Question 3:** How do youth with subthreshold ADHD, and youth with ADHD change from baseline to follow-up with regard to patterns of change in symptoms and functioning (both specific domains and aggregate) based on treatment status? The 5 specific domains of functioning include social (friendships), school (classroom learning), home (home life), intrapersonal (self), and free time (leisure activities).

**Research Question 4:** Are the risk factors that are associated with ADHD medication use similar for youth with subthreshold ADHD compared to youth with ADHD?

**Public Health Significance of the Study**

Eight major goals addressing the public health mission of promoting mental health and treatment of mental disorders in children were outlined at the Office of the Surgeon General’s conference on *Children's Mental Health: Developing a National Action Agenda* on September 18 – 19, 2000 in Washington, DC (U.S. Public Health Service, 2000). In seeking to understand patterns of change between symptoms and functional impairment trajectories of youth and exploring predictors of impairment and service use, this research addresses four of the eight major public health goals outlined in
the action agenda: 1. Promote social, emotional, and behavioral well-being as an integral part of a child's healthy development; 2. Support research in developmental psychopathology to help clarify diagnoses, 3. Increase provider understanding of children's mental healthcare needs; and, 4. Increase research on diagnosis, prevention, treatment, and service delivery issues to address disparities in access to mental healthcare services, especially among different racial, ethnic, gender, and socioeconomic groups (U.S. Public Health Service, 2000).

A better understanding of ADHD and subthreshold ADHD impairment and symptom persistence and medication use has major clinical, scientific, and public health relevance. Clinically, it may help in the design of targeted treatment strategies and improvement in patient outcome. Evaluating patterns of change between symptoms and impairment provides direct comparisons between individuals for a better understanding of individual needs. Clinically, pinpointing areas of individual need is important so that this information can be communicated clearly and meaningfully to caregivers and individuals with ADHD and diminished forms of ADHD. Improved understanding of the heterogeneity in the developmental characteristics that differentiate individuals with ADHD versus subthreshold ADHD related to symptom and functional impairment change would help clinicians who advise caregivers on matters related to prognosis, treatment, and course.

This research can help identify individuals with a higher likelihood of experiencing severe impairment and service utilization. It can also identify patterns that have important implications for conceptualizing treatment in research and practice. Additionally, this research will add to the existing understanding of ADHD and
subthreshold diagnoses and explore RCI methodology that can be useful in interpreting community longitudinal data. From a public health perspective, this knowledge can help focus scarce societal resources toward youth at higher risk for persistent impairment. This will allow us to better target early intervention and secondary prevention initiatives, with the goal in mind of improving functioning of children and adolescents with subthreshold ADHD and ADHD.

CHAPTER PREVIEW

A review of the scientific literature relating to child and adolescent ADHD and subclinical ADHD developmental trajectories, predictors of impairment and service use is presented in Chapter 2. Chapter 3 describes study methodology including overall research purpose, study aims, questions, and hypotheses, participant screening and recruitment, study design, measurement, data collection and analysis. Two manuscripts are presented in Chapter 4 and include key study results. Chapter 5 provides a summary of research results and discusses study implications and recommendations for future research.

TERMINOLOGY AND KEY CONCEPTS

Adolescents: Minors ages 13 through 17 years

Attention-Deficit/Hyperactivity Disorder (ADHD): The term ADHD is used here to refer to that subgroup of the population previously identified as attention deficit disorder (ADD) with hyperactivity and without hyperactivity (DSM-III) (American Psychiatric Association, 1980), ADHD (subtypes were discarded) (DSM-III-R) (American Psychiatric Association, 1987), ADHD-combined type and hyperactive-impulsive type (DSM-IV) (American Psychiatric Association, 1994) or, more recently predominantly
inattentive type (ADHD-I), predominantly hyperactive/impulsive type (ADHD-HI), and combined type (ADHD-C) (American Psychiatric Association, 2000).

**Burden:** “Effect the patient has upon the family, or the impact that living with the patient has on the family's daily routines and, possibly, health. Studies have found that caregivers experience relatively high levels of both objective burden (e.g., providing transportation, assisting the patient with daily tasks) and subjective burden (e.g., reduced caregiver well-being, worry)” (Angold et al., 1998).

**Caregiver:** Individual/s, over age 18, responsible for the direct care, safety, and supervision for the participant in this study.

**Children:** Children ages 6 through 12 years

**Diagnostic Retention Studies:** A strategy for investigating the developmental course of ADHD involving “identifying youth that met diagnostic criteria for ADHD (or its historical precedents) at one point in time and determining what proportion of these youth continued to meet diagnostic criteria at subsequent assessments” (Willoughby, 2003).

**Ecologic Level Data:** “Information limited to characteristics of aggregates (groups) of individuals” (Greenland, 2001).

**Group Level Analyses (statistically significant):** “Most studies use inferential statistical analyses to make conclusions about an average child/adolescent based on the differences between group means” (Karpenko, 2009).

**Impairment:** In the ADHD literature, impairment is conceptualized as the “negative impact of the symptom on the child’s functioning” (Fabiano & Pelham, 2009), the “consequences in reality that ensue from symptom expressions” (Goldstein & Naglieri, 2009) and “An objectively measured assessment of a deviation from the mean for a broad
range of functional domains” (Danckaerts, 2010). **Functional impairments** are defined as “specific deficits in multiple domains of functioning developing subsequent to ADHD” (Winter, 2005). In this study impairment and functional impairment are used interchangeably.

**Individual Level Data:** “Individual level data denote information about individuals, either contributed by the individuals themselves in surveys etc., or collected from registers” (Hårfagres, 2012).

**Individual Level Analysis [clinically significant (CS)]:** “Change in treatment that is meaningful and noticeable to the individual client or to significant people in the client’s life” (Karpenko, et al., 2009).

**Medicated Group:** Participants who were taking ADHD medication (stimulant/non-stimulant)

**Mental Health:** “A state of successful performance of mental function, resulting in productive activities, fulfilling relationships with other people, and the ability to adapt to change and to cope with challenges. Mental health is essential to personal well-being, family and interpersonal relationships, and the ability to contribute to community or society” (Healthy People 2020, 2012).

**Parent:** Parent or legal guardian (biological mother in most cases)

**Preschoolers:** Children ages 3 through 5 years

**Quality of Life (QOL):** “Describes an individual’s subjective perception of their position in life as evidenced by their physical, psychological, and social functioning” (Danckaerts et al., 2010).
Symptoms: “Any subjective evidence of disease or of a patient's condition, i.e., such evidence as perceived by the patient; a change in a patient's condition indicative of some bodily or mental state” (Symptom. (n.d.), 2007). The focus of this study is on objective symptoms - “ones that are evident to the observer” (e.g. parent or teacher) (Symptom. (n.d.), 2007). One definition of symptoms provided by a well known ADHD researcher is “the physical, cognitive or behavioral expressions of an individual that may signal the presence of a disorder” (Barkley, 2010).

Symptom Trajectory Studies: A strategy for investigating the developmental course of ADHD by “determining the number of ADHD symptoms that individuals exhibit across repeated assessments” (Willoughby, 2003).

Trajectory: “The presentation of changes in functional status over time in terms of development” (Halfon & Hochstein, 2002).

Youth: Children and adolescents

DSM Diagnostic Classifications

ADHD In Full Remission: “There are no longer any symptoms or signs of the disorder, but it is still clinically relevant to note the disorder” (American Psychiatric Association, 2000).

ADHD In Partial Remission: “For individuals (especially adolescents and adults) who currently have symptoms that no longer meet full criteria…If clinically significant symptoms remain but criteria are no longer met for any of the subtypes, the appropriate diagnosis is ADHD, In Partial Remission” (American Psychiatric Association, 2000).

ADHD Not Otherwise Specified (NOS): “When an individual’s symptoms do not currently meet full criteria for the disorder and it is unclear whether criteria for the
disorder have previously been met, ADHD NOS should be diagnosed. Examples include 1. Individuals whose symptoms and impairment meet the criteria for ADHD, Predominantly Inattentive Type but whose age at onset is 7 years or after; 2. Individuals with clinically significant impairment who present with inattention and whose symptom pattern does not meet the full criteria for the disorder but have a behavioral pattern marked by sluggishness, daydreaming, and hypoactivity” (American Psychiatric Association, 2000).

**ADHD Residual Type:** “DSM-III and DSM-IV (but not DSM-III-R) versions include an ADHD ‘residual type’ that could be assigned to an individual who previously had ADHD and currently have significant impairment but do not meet the full symptom count criteria” (Biederman, Mick, & Faraone, 2000).

**Non-DSM Diagnostic Classifications**

**Functional Persistence:** Subjects who were functionally impaired with a Global Assessment of Functioning (GAF) score less than or equal to 60 (Biederman, 2011). Note: definitions vary from study to study. GAF considers psychological, social, and occupational functioning on a hypothetical continuum (0-100) of mental health-illness. (DSM-IV-TR, p. 34.)

**Remission:** “A loss of diagnostic status based on standardized measures of ADHD, minimal or no symptoms, and optimal functioning when individuals are being treated with or without medication” (Steele, Jensen, & Quinn, 2006).

**Subclinical:** Subclinical is often used more similarly to the term subsyndromal in the ADHD literature to mean exhibiting symptoms that are not severe enough for diagnosis. Little consensus for a definition exists and disparate definitions are used. For example,
one study created a subclinical ADHD outcome variable including 4 or 5 endorsed symptoms (Bussing, et al., 2010) while another study considered subclinical ADHD to be <6 symptoms (Fuemmeler, Østbye, Yang, McClernon, & Kollins, 2010). In this study, subclinical ADHD is used broadly to mean any diminished form of ADHD that does not meet full ADHD diagnostic criteria.

**Subsyndromal:** “Characterized by or exhibiting symptoms that are not severe enough for diagnosis as a clinically recognized syndrome” (Subsyndromal, 2012). This term is used less frequently in the ADHD literature than the term subclinical or subthreshold.

**Subthreshold:** “Subthreshold conditions are defined as slightly below the threshold for diagnosis” (Malmberg, Edbom, Wargelius, & Larsson, 2011). As proposed by the AAP in 1997, subthreshold is three to five ADHD-HI or ADHD-IA symptoms (using the DSM-IV diagnostic criteria) (S. Faraone et al., 2006). Some have included “without substantial functional impairment” in the definition (Scahill, et al., 1999). “Subthreshold ADHD seems to be a milder form of the disorder, or perhaps a heterogeneous group of true ADHD cases and false positives” (S. V. Faraone et al., 2007). Note: this definition is not in the DSM and no clear definition exists in the literature. This study uses the AAP’s definition of subthreshold ADHD.

**Symptomatic persistence:** Subjects meeting subclinical DSM criteria (more than half of the symptoms required for a full diagnosis) (Biederman, 2011). Note: definitions vary from study to study.

**Syndromatic persistence:** Subjects meeting full DSM criteria for ADHD (Biederman, 2011).
Chapter 2

Literature Review

Introduction

This review is intended to be an in-depth overview and discussion of the importance of symptoms and associated impairment for a better understanding of the developmental course of child and adolescent Attention-Deficit/Hyperactivity Disorder (ADHD). It begins with an inquiry into a longstanding theoretical debate on the authenticity of the disorder and current diagnostic perceptions. General background is provided regarding etiology, conceptualization and use of diagnostic criteria, the study of developmental trajectories, and efforts to bring together ideas on impairment from a variety of research, clinical, and measurement perspectives. Information related to ADHD treatment practices, predictors of impairment and treatment use is also provided. An analysis of research following individuals with subclinical forms of ADHD over time will offer the reader an understanding of what is known about functional impairment associated with insufficient symptoms to receive a diagnosis of ADHD, the main focus of this research. Analyzing ADHD developmental trajectory studies (that include a subclinical group) helped pinpoint gaps in the literature and formulate research questions that are explored in manuscripts I and II (see Chapter 4).

This review is a systematic examination in that it: 1) makes a concerted effort to identify and methodically draw together the findings of the studies that are judged to be of acceptable quality for inclusion in the analysis; 2) categorizes studies in order to
narrow and elucidate what has and has not been explored to date, and 3) provides an up-to-date summary of the research investigating issues surrounding subclinical ADHD and impairment trajectories.

Publications reviewed here were found by internet-based literature searches in PubMed, EBSCOhost, PsycLit, and Google Scholar. In addition, literature references of relevant papers, books, or other sources were explored. The focus of the review is mainly on papers published within the last 20 years, emphasizing recent findings. However, earlier work is referenced that highlights relevant historical or theoretical points.

**ADHD: BACKGROUND, DIAGNOSTIC CONCEPTUALIZATION, & DEVELOPMENTAL PERSPECTIVE**

**Debate: Does ADHD exist?**

Attention-deficit/hyperactivity disorder (ADHD) is considered by some to be an “unsatisfactory umbrella term applied to children with widely differing temperaments and functional problems, but sharing certain core features” (Halasz & Vance, 2002). That sentiment reflects a longstanding theoretical debate over whether ADHD is a real disorder or a social catch-all construct with a poorly identified biological threshold (Amaral, 2007). In a letter to the editor, Amaral argues that “it is in defining such a diagnostic threshold that lies the social construction, as the boundaries of normality in a given region are set by psychiatrists (by choosing and applying diagnostic criteria) and society (by recognizing symptoms as deserving of medical care)” (Amaral, 2007). In reply, Polanczyk and Rohde maintain that while diagnostic criteria for mental disorders are based on theoretical concepts, the validity of ADHD is supported by empirical evidence (Polanczyk & Rohde, 2007a).
Evidence Suggests ADHD is Underdiagnosed

There is a common public perception and media portrayal that ADHD is overdiagnosed (Sciutto & Eisenberg, 2007). A review of prevalence studies shows there is not sufficient evidence to suggest that ADHD is systematically over-diagnosed (Sciutto & Eisenberg, 2007). While that may occur in some cases, there is stronger evidence that ADHD is often under-diagnosed (Adler, Spencer, Stein, & Newcorn, 2008), and consequently, under-treated (Cuffe, Moore, & McKeown, 2009; Vierhile, Robb, & Ryan-Krause, 2009). For example, one study, using 2001-2004 National Health and Nutrition Examination Survey (NHANES) data, found among the children who met ADHD DSM-IV criteria at the time of the survey, only 47.9% had a previous diagnosis and only 32.0% had been treated with ADHD medications over the past year (Froehlich et al., 2007). Using data from the National Health Interview Survey, Cuffe et al. (2009) found that although children with a probable diagnosis of ADHD saw a mental health provider or general doctor significantly more often than children without ADHD, 40% of children with ADHD saw neither health professional in the last year and only 48% of males and 41% of females were reported to have taken medication for ADHD in the last 3 months.

ADHD Etiology

ADHD is a disorder of multifactorial (e.g., neurological and genetic) etiology (Nigg, 2006). Differences in functional trajectories are shaped by the dynamic and continuous interplay between biology and environmental factors (e.g., individual, family, and social experiences) over a lifetime (Halfon & Hochstein, 2002). A brief overview of neuro-biological factors (including genetics) of ADHD followed by a discussion of psychosocial and environmental factors in the expression of ADHD is provided below.
ADHD is the most heritable of all psychiatric conditions (Stephen P. Hinshaw & Blachman, 2005). ADHD clusters in families (Rowland, Lesesne, & Abramowitz, 2002) and twin and adoption research indicates that genetic factors contribute to the etiology and continuity of ADHD symptoms (Thapar, Langley, Owen, & O'Donovan, 2007). Due to the heterogeneity of ADHD it is thought that a strong genetic component exerts influence over the expression of ADHD symptoms (Swanson et al., 2001). It seems likely that genetic vulnerability is caused, not by one or two genes, but by the small contributions of many genes (Steinhausen, 2009).

There are differences in brain structure and functioning in children with and without ADHD. Structurally, overall brain volume is lower and specific brain areas (e.g. the pre-frontal cortex, part of the frontal lobe involved in weighing alternatives and inhibiting responses or impulses) appear to be smaller in children with ADHD compared to children without ADHD (Castellanos et al., 2002; Krueger & South, 2009). Regarding functioning, recently published findings provide evidence for multiple and persistent neural processing deficits in ADHD (Doehnert, Brandeis, Imhof, Drechsler, & Steinhausen, 2010). Such findings do not support the developmental lag theory (where attention problems in ADHD become smaller and disappear as the brain matures) (Shaw et al., 2007) and instead suggest a persistent developmental lag that is not outgrown (Steinhausen, 2009).

While clarity regarding etiology of ADHD is emerging, data is lacking to support the use of diagnostic tests or biomarkers to diagnosis ADHD (McGough & Barkley, 2004). Until such tests and biomarkers are established, ADHD will remain what Halasz calls a “nosological conundrum” and McGough a “clinical diagnosis” (McGough &
Barkley, 2004). The *Diagnostic and Statistical Manual of Mental Disorders (4th edition-Text Revision*) (DSM-IV-TR) (American Psychiatric Association, 2000) is a classification system utilizing evidence-based criteria, is designed to establish a reliable and valid diagnosis, (Rohde, 2008) and offers a temporary solution for diagnoses until the causes of ADHD are better understood (Lollar, 2008). Some argue that, because ADHD is classified as a neurobiological condition, functional impairment should be assessed and considered an outcome but not included in the diagnostic criteria (Lollar, 2008; Stein, 2007). However, until the DSM is able to classify ADHD on the basis of etiology, the DSM is limited to using symptoms and functioning to distinguish between wellness and illness (McIntyre, Fallu, & Konarski, 2006).

**Differences in Clinical Expression**

While uncovering physiological and biological underpinnings of ADHD symptoms is of utmost importance, psychosocial and environmental variables deserve greater consideration in research (Wolf & Wasserstein, 2001). It is these critical variables that interact with biological vulnerability to shape symptom expression (Brassett-Harknett & Butler, 2007), impairment (Biederman et al., 1995), and comorbidity (S. Hinshaw, 1999). Gene expression, for example, is considered dynamic in nature, not static; that is, reacting to and interacting with environmental experiences (Kendler, 1995) and significant associations of genes thought to be linked to ADHD account for less than 5% of explained behavioral differences (Steinhausen, 2009).

There is ample research evidence demonstrating environmental influences on ADHD expression. One intervention study demonstrated improvements in children’s ADHD symptoms, when parents were coached in parenting skills (Sonuga-Barke, Daley,
Thompson, Laver-Bradbury, & Weeks, 2001). Findings from gene/environment studies provide evidence suggesting environmental factors such as family adversity moderates the impact of genotype on the expression of ADHD symptoms (Laucht et al., 2007). Environmental factors are often critical in promoting or diminishing the risk to a child’s academic and social functioning and eventual outcome (Halasz & Vance, 2002).

Clinical expression of ADHD is also influenced by associations with comorbidity, gender effects, and the impact of the disorder on psychosocial functioning (also known as impairment) (Steinhausen, 2009). A brief discussion of comorbidity and gender effects is provided here. Later, an analysis of the literature pertaining to patterns of change between symptom change and functional impairment among youth with ADHD, youth with subclinical ADHD and youth without ADHD is provided (the main focus of this literature review).

**ADHD Comorbidity**

ADHD is often correlated with and exists alongside other psychiatric conditions at greater than chance levels, especially in adolescents (Biederman et al., 2006; Gordon, et al., 2006). The probability of having oppositional-defiant disorder (ODD), conduct disorder (CD), anxiety, antisocial, obsessive-compulsive disorder, post-traumatic stress disorder, mood disorder, cognitive performance and learning disorders, tic disorder, or substance use disorder is significantly enhanced in the presence of ADHD (Biederman, et al., 2006; Gordon, et al., 2006). Approximately 50% of children with ADHD develop either ODD or CD. (Pliszka, 1998). Conduct Disorder (CD) is characterized by a pattern of aggression toward others and or serious violations of rules, laws, and social norms and
ODD is a pattern of behaving negatively and defiantly toward adults or others (American Psychiatric Association, 1994).

Youth with ADHD tend to experience more functional impairment if comorbid disorders are present (Biederman et al., 1996). In a recent review, it was noted that children with both conduct problems and ADHD show a worse course than children with either disorder alone (Waschbusch et al., 2002). Youth with ADHD and comorbid ODD or CD tend to have more severe social impairment than children with ADHD alone (Nijmeijer et al., 2008).

**ADHD & Gender**

Gender may affect vulnerability to ADHD, as boys are diagnosed with ADHD 2.4 times more often than girls (Polanczyk & Jensen, 2008). There are fewer females than males with ADHD represented in epidemiological and clinical samples (Steinhausen, 2009), and research involving community samples of females of varying ages is an area in need of further research (Rohde, 2008). Girls, especially those with inattention problems are more likely to be under-referred, and less likely to be diagnosed and treated than boys (Stephen P. Hinshaw & Blachman, 2005; Staller & Faraone, 2006).

Evidence suggests that girls with ADHD, similar to boys with ADHD, exhibit high levels of social, cognitive, academic, and personal impairment, across multiple domains (Stephen P. Hinshaw & Blachman, 2005; Staller & Faraone, 2006). Results from a meta-analysis of clinic referred and non-referred children found no gender differences in social and peer and academic performance (Gaub & Carlson, 1997). More research is needed to better understand symptom and impairment trajectories of girls with ADHD (S.P. Hinshaw, Owens, Sami, & Fargeon, 2006).
Among the three ADHD subtypes, girls are most likely to present with inattentive type, compared to boys (Staller & Faraone, 2006), and children often do not present clinical levels of impairment for inattention until middle school or later (Barkley & Biederman, 1997). For girls, problems may be pronounced by the time they are referred, and levels of impairment may increase through adolescence (Stephen P. Hinshaw & Blachman, 2005). This is concerning, because if impairment is not detected until late elementary or middle school, they may not receive a diagnosis because of the age seven onset diagnostic requirement (diagnostic criteria discussed below) (Stephen P. Hinshaw & Blachman, 2005).

**Current Diagnostic Criteria**

A diagnosis of ADHD is often made using guidelines outlined in the DSM-IV-TR which specifies five diagnostic criteria (criteria A-E) for ADHD (American Psychiatric Association, 2000). Criterion A categorizes symptom presentation into inattention and hyperactivity/impulsivity dimensions, from which three ADHD ‘types’ or ‘subtypes’ are derived. The first dimension includes nine symptoms of inattention and makes up the ADHD Predominantly Inattentive Type (ADHD-I). It includes behaviors such as “often fails to give close attention to details,” “often loses things,” and “often forgetful in daily activities” (American Psychiatric Association, 2000). The second dimension contains six symptoms of hyperactivity (e.g., “often “on the go’” and “often talks excessively”) and three symptoms of impulsivity (e.g., “often has difficulty awaiting turn” and “often interrupts”) (American Psychiatric Association, 2000). This dimension makes up the ADHD Predominantly Hyperactive-Impulsive Type (ADHD-HI). The ADHD Combined Type (ADHD-C), includes all 9 ADHD-HI and all 9 ADHD-I symptoms (18 in total).
ADHD diagnosis requires endorsement of six (or more) of the nine symptoms for ADHD-I and ADHD-HI diagnosis and 12 (or more) for ADHD-C diagnosis. Diagnostic criteria requires that symptoms have persisted for at least 6 months that are maladaptive compared to individuals of similar developmental stage (American Psychiatric Association, 2000).

Criterion B-E states the following: “B: Some hyperactive-impulsive or inattentive symptoms that caused impairment were present before age 7; C: Some impairment from the symptoms is present in 2 or more settings (e.g., at school [or work] and at home); D: There must be clear evidence of clinically significant impairment in social, academic, or occupational functioning;” and E: Symptoms are not better accounted for by another mental disorder (American Psychiatric Association, 2000).

**Categorical vs. Dimensional ADHD Model**

Identifying an individual as having or not having ADHD is an oversimplification of a dimensionally complex disorder. The DSM-IV adopts a categorical (“by kind”) rather than a dimensional (“by degree”) model of ADHD with subtypes being considered qualitatively distinct symptom domains (Sonuga-Barke, 1998; Wilson, 1993). In the general population, hyperactive, inattentive and impulsive behaviors are continuously distributed with no clear distinction between behavior that is normal or abnormal (Buitelaar & Rothenberger, 2004). Epidemiological evidence supports the dimensional view of ADHD, with symptoms and impairments lying at the upper end (Shaw et al., 2011). However, for practical clinical decision making and research considerations, categorical distinctions are often used (Rohde, 2008). This is similar to the identification
of hypertension where blood pressure is thought to be a dimensional construct, yet use of a clinical cut-off point is standard practice (Rohde, 2008).

**Subtype Information**

The purpose of subtypes is to clarify the heterogeneous nature of ADHD to aid clinical and research practice (Lahey & Willcutt, 2010). Recent studies challenge current subtype classifications (Rohde, 2008). Longitudinal evidence suggests high levels of subtype diagnostic instability, temporal instability, and an inability to distinguish subtypes on the basis of treatment response and separable factors for inattention and hyperactivity/impulsivity and functional impairment (Lahey, Pelham, Loney, Lee, & Willcutt, 2005; Riley et al., 2008; Todd et al., 2008; Valo & Tannock, 2010). Several researchers have recently called for the need to replace the categorical subtypes with a focus on dimensional case identification of ADHD using severity or counts of symptoms and resultant impairment (Lahey & Willcutt, 2010; Lubke, Hudziak, Derks, van Bijsterveldt, & Boomsma, 2009; Rowland et al., 2008; Valo & Tannock, 2010). Information related to subtype instability is discussed in greater detail in the symptom trajectory studies section.

**Evolution of Diagnostic Criteria**

Since the first publication in 1952, the DSM went from listing 106 to 182, to 265 to 292, and to 297 diagnostic categories with each successive edition (DSM-I to DSM-II, DSM-III to DSM-III-R, to DSM-IV, respectively) (Wikipedia contributors, 2012). Diagnostic conceptualization of ADHD has changed substantially over time when it was first included in the DSM-II as ‘hyperkinetic reaction of childhood’ (American Psychiatric Association, 1968). DSM-III was the first version to include inattention as a
diagnostic component for what was then called attention deficit disorder (ADD) (Biederman, Petty, Evans, Small, & Faraone, 2010).

In the 80’s and 90’s, large epidemiological studies such as the National Comorbidity Survey (NCS) demonstrated that DSM diagnostic criteria at the time (DSM-III-R) did not differentiate well between people with and without impairment who met symptom count criteria (less severe disorder from more severe disorder) (Regier, 2003). This finding affirmed the need to reconsider and revise diagnostic criteria for mental disorders and the assessment of clinical significance (Regier, 2003). While increasing the number of symptoms required for an ADHD diagnosis was suggested by some, the DSM-IV (published in 1994), required “clinically significant” impairment in addition to the required number of symptoms (Regier, 2003).

DSM-III and DSM-IV (but not DSM-III-R) versions include an ADHD "residual type” that could be assigned to an individual who previously had ADHD and currently have significant impairment but do not meet the full symptom count criteria (Biederman, et al., 2010). These subclinical categories are important because considering only full-syndrome ADHD may overlook an important group of children and be an oversimplification of a more nuanced problem (Barnow, Schuckit, Smith, & Freyberger, 2006). To be clinically important, any reduced definition of ADHD should be associated with impairment (Mick, Faraone, & Biederman, 2004).

Other DSM reduced ADHD definitions include ADHD in Partial Remission (ADHD-IPR) and ADHD Not Otherwise Specified (ADHD-NOS). ADHD-IPR (similar to ADHD ‘residual type’) is assigned when symptoms no longer meet full criteria for any of the subtypes but some symptoms or signs of ADHD remain (American Psychiatric
ADHD-NOS, as defined in the DSM-IV, is “prominent symptoms of inattention or hyperactivity-impulsivity that do not meet criteria for ADHD” (American Psychiatric Association, 2000). Examples included for the use of ADHD-NOS include the following: 1. For individuals meeting symptom and impairment criteria but not meeting the age of onset criteria and, 2. For individuals who present with clinically significant impairment but do not meet symptom count criteria (American Psychiatric Association, 2000).

According to the vague descriptions provided in the DSM, it is not clear how to determine if a child meets criteria for these reduced ADHD definitions (Leslie, 2002). For example, “the number of symptoms required for ‘prominence’ or the degree of impairment necessary” are not provided (Bauermeister et al., 2011). Nor is it clear from the literature if there is a distinct difference between terms such as ADHD-NOS and ADHD-IPR; or if they can be used interchangeably.

This review provides a consideration of timely topics as the research and clinical community awaits the publication of the fifth edition of the DSM in 2013. Discussions such as how to treat and define subsyndromal ADHD continue as the new DSM edition is prepared (Bauermeister, et al., 2011). Despite decades of research and scientific strides that have improved our understanding of ADHD, Barkley writes of the new manual, “Much work remains to be done as we seek to identify more rigorous diagnostic criteria for ADHD that amend the already considerable and useful work that has gone into prior DSMs” (Barkley, 2007).
Inconsistencies in Adoption and Use of DSM Diagnostic Criteria

Conceptually, measurement of ADHD in children and adolescents is straightforward. Based on the DSM-IV diagnostic criteria, measurement requires a certain number of symptoms, the presence of impairment, age and duration criteria, and assessment from multiple perspectives and in multiple contexts. Methodologically, however, diagnosing ADHD is challenging and ambiguous (Stein, 2007). Measurement variability, subjective interpretations, and controversy regarding measurement approach abound in the literature. Understanding current diagnostic measurement obstacles is important both for illuminating the challenges that clinicians and researchers face given the diagnostic limitations of the DSM-IV and to cover salient measurement topics related to this study.

Variation in the use of DSM-IV diagnostic criteria exists across practitioners, research and geographic areas and may result in missed or inappropriate diagnosis (Magyary & Brandt, 2002). After finding wide variations in clinical treatment of ADHD in 1998, an expert panel on the diagnosis and treatment of ADHD concluded that there was a real need for improved ADHD assessment and follow-up (Health, 1998 Nov 16-18). Evidence based practice guidelines (based on DSM-IV criteria) for diagnosis and treatment of ADHD were published by both The American Academy of Child and Adolescent Psychiatry (AACAP; 1997) and the American Academy of Pediatrics (AAP; 2000) (Dulcan, 1997; Homer et al.). Years after the National Institute of Health (NIH) expert panel call for improvements, literature on ADHD measurement is far from standardized (Rushton, Fant, & Clark, 2004) and comprehensive assessments are often not provided to children (Rosenblatt & Rosenblatt, 2002; Stein, 2007).
Equally disconcerting is the fact that since 1980, when guidelines requiring the consideration of impairment were adopted and the Global Assessment of Functioning (GAF) (an impairment measure) included in the DSM-III, symptom criteria alone are still used to diagnose ADHD by some researchers and clinicians (Gathje, et al., 2008). Impairment instruments are not routinely used in research and clinical practice (Gordon, et al., 2006), in spite of the DSM-IV diagnostic requirement that “there must be clear evidence of clinically significant impairment in social, academic, or occupational functioning” (American Psychiatric Association, 1994). The lack of adherence to diagnostic standards has treatment implications. One community study documented that, while 72% of children received stimulant medication during a four year period, parents did not report any impairing ADHD symptoms for the majority of those children (Angold, Erkanli, Egger, & Costello, 2000).

The reason for inconsistencies in the adoption and use of DSM diagnostic criteria related to impairment is likely due to several reasons. Barkley pinpointed one reason when he wrote, “for many years, we have erroneously assumed that higher scores on our tests and absence or reduction in symptoms equated with less impairment and better quality of life” (Goldstein & Naglieri, 2009). Other reasons could be a belief that there is no difference between symptoms and impairment (Mannuzza et al., 2011) or a lack of clarity on identifying and measuring impairment (Gathje, et al., 2008).

Examples of inconsistencies in the adoption, use, and understanding of DSM diagnostic criteria abound in the literature. As recently as the late 90’s, researchers wrote, “Indeed, when the symptoms of ADHD remit, the functioning of the child normalizes” (Biederman, Mick, & Faraone, 1998) and “impairment can be captured through careful
measurement of symptom severity” (Scahill, et al., 1999). Disparate definitions for all of the subsyndromal ADHD categories are widespread in the literature. ADHD-IPR in one study was defined as “reserved for adults who met the criteria for ADHD in childhood and continue to have significant symptoms and impairment that fell below the threshold for the full diagnosis” (McGough & Barkley, 2004) whereas another study defined ADHD-IPR as “continuing impairment, but failure to meet full diagnostic criteria based on ADHD symptoms” (Sciberras, Roos, & Efron, 2009).

**SUBCLINICAL ADHD**

Some researchers concerned with studying subclinical ADHD syndromes have relied on the DSM-based classifications of ADHD (those described above), while others have adopted the APA definition of subthreshold ADHD. Subthreshold ADHD is a category proposed by the AAP in 1997 that, like the DSM definitions, provides an alternative to narrowly dichotomizing ADHD (Scahill, et al., 1999). This “subclinical syndrome” is typically defined as having a “chronic history” of three-to-five ADHD-HI or ADHD-IA symptoms (using the DSM-IV diagnostic criteria) (S. Faraone, Kunwar, Adamson, & Biederman, 2009). Researchers considering subthreshold ADHD have employed various definitions, differing on the number of inclusionary symptoms, inclusion or exclusion and degree of impairment. For example, some have included “without substantial functional impairment” in the definition (Rogers, Hwang, Toplak, Weiss, & Tannock, 2011; Scahill, et al., 1999).

Subthreshold ADHD is more prevalent than ADHD (Lewinsohn, Shankman, Gau, & Klein) with up to 22% of youth exhibiting subclinical inattentive and hyperactive subthreshold symptoms (Scahill et al., 1999), yet there are very few follow-up studies on
the longitudinal course of subthreshold ADHD. Subthreshold ADHD is a risk factor for developing ADHD (Shankman et al., 2009) and expressed from the same set of genes as ADHD (Levy, Hay, McStephen, Wood, & Waldman, 1997). Further, youth with subclinical ADHD may have less (Galéra, Melchior, Chastang, Bouvard, & Fombonne, 2009) or just as much impairment as youth who meet ADHD diagnostic criteria (Bagwell, Molina, Pelham Jr, & Hoza, 2001) and were as likely to develop later psychopathology as children meeting symptom count but not impairment (Angold, et al., 1999; Shankman, et al., 2009).

While some have raised questions about the validity of subthreshold ADHD (S. Faraone, et al., 2006), clinical research evidence shows this milder form of ADHD (Mason, Walker, Wine, Knoper, & Tercyak, 2007) to be a “clinically meaningful” and “valid” target population (Costello & Shugart, 1992; Scahill, et al., 1999) and deserving further research attention (S. V. Faraone et al., 2006). Identifying children with subthreshold levels of ADHD allows for examination of psychosocial correlates and comparisons with children who meet full ADHD criteria and with children who do not have ADHD. From a public health standpoint, subthreshold ADHD may have similar risk factors as ADHD and be a useful designation for targeted interventions and for preventing “further functional decline” (Scahill, et al., 1999).

**METHODS AND MEASUREMENT**

**Diagnostic Retention Studies**

Since the early 70’s, the temporal stability of ADHD has been extensively explored through both epidemiological community samples and clinic-referred samples in the United States (S. V. Faraone, Biederman, & Mick, 2006; Mannuzza, Klein, &
Moulton, 2003; Willoughby, 2003). The first longitudinal studies of ADHD persistence were clinic-based, diagnostic retention studies, identifying youth meeting diagnostic criteria for ADHD at one point in time and seeing what proportion still met criteria at a later point in time (Willoughby, 2003). The results of these studies have since been called into question, as critics often attribute the wide variance in reported prevalence over time to differences in early study methodology (S. V. Faraone, J. Biederman, & E. Mick, 2006; Polanczyk & Rohde, 2007b). While diagnostic continuity of ADHD has been studied using different diagnostic criteria and assessment procedures, ADHD is considered to be a persistent disorder (Bauermeister, et al., 2011).

One study, comparing different diagnostic approaches found that childhood ADHD persists into young adulthood in 58% of the cases when DSM-IV criteria (parent report) are used and in 66% of the cases when developmentally relative criteria (+2 SDs above the normal mean) (parental report) (Barkley, Fischer, Smallish, & Fletcher, 2002). These findings are higher than Lara et al. (2009) who found approximately 50% of childhood cases, across 10 countries, continued to meet full diagnostic criteria for ADHD into adulthood. Diagnostic stability is higher for younger (4-6) children than for late childhood to early adolescence (Steinhausen, 2009).

Diagnostic retention studies have several significant drawbacks. They do not clarify changes in ADHD as a function of development (Willoughby, 2003). They apply diagnostic criteria (DSM) that is continually revised and was developed for children (males specifically) to adolescents and adults (Willoughby, 2003). And, they are categorical in nature and provide a narrow view of development (Willoughby, 2003). Studies showing marked ADHD remission rates (loss of full diagnostic status) over time
may be deceptive because they do not distinguish levels of subclinical ADHD symptoms and impairment (Biederman, 2011; Willoughby, 2003). As one researcher writes, “It is technically correct that those diagnosed with ADHD in childhood who reach adulthood with one less symptom of the disorder may no longer satisfy criteria for ADHD, but it is clinically dubious to equate the absence of full syndromic status with full recovery” (Biederman, 2011).

**Symptom Trajectory Studies**

There has been an emergence of interest in ADHD symptom trajectory research over the past two decades and a shift away from a focus on solely identifying diagnostic retention or outcomes. Symptom trajectory studies determine the number of ADHD symptoms exhibited across repeated assessment time points (Willoughby, 2003). Symptom trajectory studies of ADHD are less common than diagnostic retention studies and often use clinic-based samples; however, they may be more useful than diagnostic retention studies in establishing the developmental course of ADHD (Willoughby, 2003).

Hart et al, (1995) undertook the first longitudinal symptom trajectory study using DSM-III-R diagnostic criteria, and structured diagnostic interviews in both baseline and follow-up assessments. One hundred and six clinic-referred boys (aged 7 to 12 years at baseline) were assessed annually for four years and results showed a decline in symptoms of ADHD-HI over time with increasing age, whereas symptoms of ADHD-I declined from the first to the second assessment period but remained stable after that (Hart, Lahey, Loeber, Applegate, & Frick, 1995). Since then, other follow-up studies have shown that inattention symptoms are more likely to persist into adolescence and adulthood (S.P. Hinshaw, et al., 2006; Lara et al., 2009; Holbrook, 2012).
Biederman et al. reanalyzed study data using symptom trajectories as a function of chronological age and, similar to Hart (Hart, 1995), found hyperactivity/impulsive symptom mean declined with age, whereas the inattentive symptom mean remained stable (from age 8 to 15 years) (Biederman, et al., 2000). This was a change from their previous analysis which “modeled outcome variables as a function of group (ADHD versus control), age (child versus adolescent), and their interaction” and found no difference in the mean number of ADHD symptoms between children and adolescents with ADHD (Biederman et al., 1998).

Studies also show persistence rates increase when subclinical diagnoses are included in the follow-up criterion (Bauermeister, et al., 2011; S. V. Faraone & Biederman, 2005). A meta-analysis showed ADHD persistence rates varied from 4% to more than 86% (S. V. Faraone, J. Biederman, & E. Mick, 2006). They demonstrated that rates of diagnostic persistence are dependent on how persistence is defined (S. V. Faraone, J. Biederman, & E. Mick, 2006). Including 32 prospective studies of “syndromic persistence” (maintaining full ADHD criteria) and “symptomatic persistence” (maintaining partial ADHD symptom criteria), results showed that if only diagnostic retention (syndromic persistence) criteria were used only about 15% of adults retained a diagnosis of ADHD whereas the rate increased to approximately 65% if symptomatic persistence (ADHD-IPR) criteria were employed (S. V. Faraone, J. Biederman, & E. Mick, 2006). Study findings since the 2006 review have been mostly consistent (Sciberras, et al., 2009).

Hinshaw et al. (2006) prospectively assessed a sample of 126 preadolescent girls with ADHD 5 years after their diagnosis. While the overall diagnostic retention rate was
92%, they found a majority of girls (63%) with ADHD-IA retained that status at the 5 year follow-up. In contrast, most girls with ADHD-C at baseline either reverted to ADHD-I subtype at follow-up due to a loss of HI symptoms (24%) or to a nonclinical ADHD status (34%) rather than retaining the ADHD-C subtype (39%) (S.P. Hinshaw, et al., 2006).

One study found 37% of children with ADHD-C and 50% of children with ADHD-I met criteria for a different subtype at least twice during six years (baseline age 4-6) of follow-up assessments and almost all children with ADHD-HI either remitted or changed to another subtype by year eight (Lahey, et al., 2005). A longitudinal study of twins with ADHD found that the 5-year subtype stability (using DSM-IV criteria) from childhood to adolescence was poor; 11.1% for ADHD-HI, 17.7% for ADHD-IA, and 24.0% for ADHD-C (Todd, et al., 2008). Riley et al., found no significant subtype differences between ADHD-IA and ADHD-C for social skills or academic functioning (Riley, et al., 2008) supporting suggestions that ADHD-HI may be a precursor to ADHD-C rather than a distinct subtype (Lahey, et al., 2005; Riley, et al., 2008).

**Methodological Variations Impacting ADHD Prevalence & Persistence**

In addition to methodological variation resulting from the use of different definitions for outcome terms such as persistence and remission (as discussed above in the diagnostic retention studies section), variability in prevalence and persistence estimates may be caused by other methodological issues such as the use of clinic versus community samples (Woo & Rey, 2005); sample ascertainment (who is interviewed (e.g., parent, child, teacher); type of assessment (e.g., rating scale, observational); evaluator status (e.g., blind to ADHD status) (Mannuzza, et al., 2003) and variation in diagnostic
criteria (S. V. Faraone, J. Biederman, & E. Mick, 2006; Ramtekkar, Reiersen, Todorov, & Todd, 2010). It is often not possible to determine if changes in diagnostic retention or symptom trajectory levels are due to a combination of measurement issues and developmental variation or to one or the other alone (Willoughby, 2003).

Treatment of impairment is an especially important methodological factor to consider. While they differ across studies, some researchers include a definition of impairment when assessing ADHD estimates and some do not (Polanczyk & Rohde, 2007a). Also, the treatment of impairment affects prevalence and persistence rates (Canino et al., 2004; McKeown, 2004). One study of ADHD prevalence rates (using DSM-IV criteria and different definitions of impairment) found ADHD rates varied from 3.7% to 8.9%, with higher rates associated with less stringent impairment criterion (Canino, et al., 2004). Utilizing data (sample included over 10,000 children aged 4-17) from the National Health Interview Survey, McKeown et al. found 12.2% of boys and 5.6% of girls met criteria for ADHD using only the symptom-count criteria. The prevalence dropped to 5.6% of boys and 2.3% of girls when the “impact” (impairment) requirement was included (McKeown, 2004).

**Measuring Magnitude of Treatment Effect (Symptom Improvement)**

Several approaches are used to measure clinically important or significant level of ADHD symptom improvement (magnitude of treatment effect or symptom remission) (P. Hazell, Lewin, & Sly, 2005). One is to use continuous outcome measures. (P. Hazell, et al., 2005). For example, results from a review by Swanson, et al. (2003) of 3 meta-analyses found pooled effect size estimates (of stimulant medication compared with placebo) ranged from .75 to .90 standard deviations (considered moderate to large effect),
(Cohen, 1988). If related to changes in units on a rating scale, effect size estimates mean more clinically, like the approach described next, however, cut points for what are considered normal and deviant are often arbitrary regardless of approach (P. Hazell, et al., 2005).

Some researchers report the pre- and post- percentage change in symptoms or a variant of this; number of youth who achieved a score in the range as youth without ADHD (Ramos-Quiroga & Casas, 2011). In ADHD clinical trial research, definitions of treatment effect commonly include a mean cutoff score of ≤1 on standardized symptom scales (e.g. Swanson, Nola and Pelham, Version IV (SNAP-IV) (Steele, 2006). This indicates minimal or no symptoms for DSM-IV diagnosis (matching similar scores of children without ADHD) and often assumes that functioning is similar to the average optimally functioning child without ADHD (Steele, et al., 2006). Severity of symptoms are not taken into consideration when one only looks at the percentage of symptom reduction and children who are classified as symptom remitters may continue to have clinical difficulty (Ramos-Quiroga & Casas, 2011).

While approaches utilizing clinically significant change or effect size magnitude (Greenland, 2001) are valuable, they mainly offer group level rather than individual level information about patterns of symptom and impairment change (J. S. Owens, et al., 2009). Further, treatment effect data, not considering impairment, may overstate treatment success for those that would not be included as successes if functioning ratings were also considered (J. S. Owens, et al., 2009).

Study methodological improvement can be seen in a comparison of two examples. The Wisconsin study (Barkley, et al., 2002) reassessed 126 of the initial cohort of 158
clinically referred children with hyperactivity and controls in adolescence. In an attempt to examine ADHD persistence as a function of parent versus self-reported symptoms, they created age-based referenced ADHD criteria (Barkley, et al., 2002). Using age-matched controls, they identified the mean number of DSM-III-R symptoms and created thresholds 2 standard deviations above that mean (Barkley, et al., 2002). They identified significantly more impaired individuals using the developmentally referenced criteria than they did using the DSM-III-R based criteria (Barkley, et al., 2002). The New York Study, used an improved methodology by using “probably” (fewer symptoms than required for diagnosis and clinically significant impairment) and “definite” levels of ADHD (meeting DSM ADHD diagnostic criteria) with both categories requiring impairment by the individual’s ADHD symptoms (Mannuzza, et al., 2003). The categories were not dependent on a comparison group (like the Wisconsin study), which may not be representative (Mannuzza, et al., 2003).

Measuring Persistence/Remission

ADHD developmental trajectory studies concerned with persistence and remission should include a consideration of changes in symptoms and functional impairment -- two different aspects of a complex measurement issue. Measuring one without the other does not provide a complete clinical picture and may result in poor or inaccurate treatment decisions (e.g., length, type, or dose of treatment) (J. S. Owens, et al., 2009). In spite of a recognized need to improve nosology and adopt standard measurement practices, disparate definitions of persistence and remission are often used in the literature and no definitions have been widely adopted. As mentioned earlier, many studies do not include the measurement of impairment at all when considering remission
or persistence of ADHD. A review by Steele et al. concludes that a definition of remission should include optimal functioning in addition to minimal or no symptoms (Steele, et al., 2006).

**FUNCTIONAL IMPAIRMENT: BACKGROUND, DOMAINS, MEASUREMENT, & PREDICTORS**

*Functional Impairment Background*

The literature has only recently, over the last two decades, begun to consider functional impairment's role in diagnosis or treatment in ADHD (Ramos-Quiroga & Casas, 2011). This may be because, prior to the publication of DSM-IV, impairment criteria were implied rather than explicit (Fabiano & Pelham, 2009). According to the DSM-IV definition of ADHD, alongside symptom-count criteria, youth with ADHD must also exhibit functional impairment (American Psychiatric Association, 2000) in what are considered the most important “developmental contexts,” school and home (Deault, 2010).

One prominent ADHD researcher considers ADHD symptoms to be “the behavioral expressions associated with the disorder,” and impairment “the consequences that ensue for the individual as a result of these behaviors” (Gordon, et al., 2006). Canino et al. have explained Hoagwood’s (1996) definition of functioning as “a continuously distributed characteristic, ranging from the highest levels of competence in adapting to demands posed by the child’s home, school, neighborhood, and peers, down to levels at which normal adaptation is not possible and functional impairment is diagnosed” (Canino, et al., 1999). Functional impairments have also been defined as “specific deficits in multiple domains of functioning developing subsequent to ADHD” (Winter, 2005). Impairment can include dysfunction or an absence of adaptation in daily functioning and
results in performance below that of normally developing peers (Fabiano & Pelham, 2009).

Similar to symptoms of ADHD which tend to change as children age, the same may be true for functional impairment (Nijmeijer, et al., 2008), and depend on environmental demands (Harpin, 2005). However, unlike symptoms, impairments tend to become more noticeable as children age as they acquire more autonomy (Adler, et al., 2008). Impairment is thought to have an additive effect over time (Adler, et al., 2008; Wender, Wolf, & Wasserstein). For example, recent data show a negative impairment developmental cycle whereby peer rejection was related to impaired social skills, which in turn predicted later peer rejection, which then compromised functioning in additional areas across development (Murray-Close et al., 2010).

Not all children and adolescents who meet ADHD symptom-count criteria are impaired (Gordon, et al., 2006). For example, evidence from one community follow up study of 140 girls with ADHD and 88 comparison girls, 16.4% (n=20) of girls with childhood ADHD were considered positively adjusted during adolescence, compared to 86.4% of comparison girls as defined by meeting criteria for at least 5 of 6 impairment domains (5 met criteria in all 6 domains) (E. B. Owens, et al., 2009). However, impaired functioning is a very real eventuality for many (Molina et al., 2009).

Children diagnosed with ADHD have been found to show larger global, social, academic and self-perception functional impairments compared to children without ADHD (S.P. Hinshaw, et al., 2006). Longitudinal studies have documented that children with ADHD have more impairment in multiple domains such as school, interpersonal, and family functioning at follow-up compared to children without ADHD (Biederman, et
While long-term outcomes are not the focus of this review, it is important to note that subsequent impairment is a strong predictor of long-term impairment (Gordon, et al., 2006). Youth with ADHD, compared to youth without ADHD, have poorer educational, job-related, financial, and social outcomes (e.g., not graduating, divorce, lower incomes) (Bussing, 2010; Klein, 2012).

Studies assessing impairment have identified high-risk groups that would go undetected if only symptoms were assessed (Wille, Bettge, Wittchen, & Ravens-Sieberer, 2008). For example, the Bella Study (2008) found 6% of the 2,863 surveyed families with children aged 7-17 suffered from “pronounced impairment” due to mental health problems but were not identified by symptom screening alone (Wille, et al., 2008). In a population-based study, 16.1% of the children who were screened were impaired but did not meet diagnostic symptom count criteria (Burns et al., 1995).

Assessing impairment also adds important additional information about functioning that symptom assessment alone would not. For example, in the Bella study, twenty percent of the sample reported impairment (11-13% single domain; 4-7% two domains; and 1.5-3% 3 or 4 domains of impairment) and most families exclusively reported school (8-9%) or home life (1-3%) impairment, followed by both school and home impairment (1-4%) (Wille, et al., 2008). A population-based screening identified approximately a third of the children (those with a diagnosis and impairment (n=152) and those with no diagnosis but with impairment (n=193)) had significant functional impairment in three areas: school, home, and with peers (Burns et al., 1995).
Situational ADHD

Lahey et al. (2004) compared children with ADHD, children with "situational ADHD" (met symptom criteria but displayed impairment in only one setting), and children without ADHD over three years (baseline age 4-6) (Lahey, et al., 2004). Compared to 3.1% of children without ADHD, 34% of children with situational ADHD (children meeting symptom criteria for ADHD but not cross-situational impairment requirement) met full ADHD criteria in at least 2 of the 4 study waves and were more impaired (Lahey, et al., 2004). The authors point out that this may be due to the fact that school demands may not cause academic impairment to surface in early childhood (Lahey, et al., 2004). However, they question the multiple domain requirements for impairment and wonder why severe impairment in one domain should prevent a child from having a diagnosis (Lahey, et al., 2004).

Domains of Functional Impairment

It is clear from the literature that deficiencies in functional impairment occur in individuals with ADHD at all age levels across multiple domains (social, educational, and occupational) (Sciberras, et al., 2009). Academic, motor coordination, and social skills are the three domains of functioning most highly associated with ADHD symptoms (Sonuga-Barke, Daley, Thompson, & Swanson, 2003). This review focuses on social, classroom, home, leisure activity, and intrapersonal domains of functioning. An overview of the literature in each of these areas is provided below.

Social Impairment (difficulties interfere with friendships)

A review of prospective longitudinal studies indicates a range of social difficulties is persistent among children with ADHD compared to youth without ADHD (Sciberras,
et al., 2009). Social impairment can be evident in peer and friendship, parent-child, teacher, and other adult relationships, and can be related to ADHD itself, comorbid conditions, and the result of those two factors on the social environment (Wehmeier, Schacht, & Barkley, 2010). Compared to children without ADHD, children with ADHD exhibit poorer social and communication skills (Klimkeit et al., 2006), antisocial behavior (Biederman, et al., 2006), unstable friendships (Sciberras, et al., 2009), and are more involved with deviant peer groups (Gordon, et al., 2006).

Over half of youth with ADHD have serious peer relationship impairment (Hoza et al., 2005; Wehmeier, et al., 2010) and by the third grade, up to 70% of children with ADHD have no close friends, especially if comorbid ODD or CD is present (Wehmeier, et al., 2010). Youth with ADHD often exhibit self-centered, intrusive, intimidating and adverse behavior toward other peers (Wehmeier, et al., 2010). Youth with ADHD are frequently ignored (e.g., not invited to parties or out to play), rejected (e.g., bullied or teased) by peers and seen by peers as being different (Fabiano & Pelham, 2009; Harpin, 2005). As a result, they often lack mutual friendships and are unpopular with peers (Nijmeijer, et al., 2008).

**School Impairment (difficulties interfere with classroom learning)**

Inattention, impulsivity, and hyperactivity can lead to a number of difficulties for children in the school domain. ADHD is associated with school impairment such as disruptive classroom behavior, underperformance, need for tutoring, lowered standardized test scores, repeating grades in school, increased use of school-based services, and suspensions and expulsions (Barkley, 2004; Loe & Feldman, 2007). Several of the core ADHD symptoms (e.g., having difficulty with organizing tasks) impair one's
ability to study and the academic performance of children with ADHD may suffer from behaviors such as not turning in completed assignments (Sciberras, et al., 2009). Children with ADHD are more likely to struggle with tasks such as finishing seatwork and remembering things needed to do homework assignments compared to children without ADHD (Fabiano & Pelham, 2009). Comparing high school academic performance among male youth with and without ADHD, Kent et al. found youth who were diagnosed with ADHD in childhood continued to experience academic difficulties such as lower grades, failing classes, and being late or absent compared to youth who did not have a diagnosis of ADHD (Kent et al., 2011).

**Interpersonal Impairment (difficulties upset or distress the child)**

ADHD is associated with emotional impairment including poor self-regulation, demoralization, learned helplessness, low self-esteem, fear and anxiety, increased emotional expression (e.g., frustration and anger), and other emotional problems (Gordon, et al., 2006; Wehmeier, et al., 2010). Children with ADHD are significantly more likely to be upset or distressed by their difficulties than children without ADHD (Strine et al., 2006). Children with probable ADHD perceive themselves as receiving less social support from friends, classmates, and teachers compared to children without ADHD (Demaray & Elliot, 2001). Other domain impairment (e.g., social academic) caused by the adverse effects of ADHD symptoms likely contribute to the development of emotional impairment (Wehmeier, et al., 2010). Strained family relationships may also negatively affect a child’s emotional wellbeing (Harpin, 2005).

**Home Impairment (difficulties interfere with home life)**

Parent-child relationship impairment among ADHD youth may be apparent at home (Harpin, 2005). Children with ADHD may not comply with parent requests or
instructions or may exhibit argumentative behavior (Fabiano & Pelham, 2009). In one study, children with ADHD were nine times as likely to have a high level of home life impairment compared with children without ADHD (Strine, et al., 2006). A study by Cuffe et al. found the second most common parent reported impairment, after classroom impairment (94%), was impairment in the home setting (82.23% in males and 73.3% in females) (Cuffe, Moore, & McKeown, 2005).

Leisure Impairment (difficulties interfere with leisure activities)

There is little research related to the extent to which ADHD difficulties interfere with leisure activities. Strine et al. found children aged 4 to 17 with ADHD were significantly more likely than those without ADHD to have a medium amount or a great deal of impairment in their leisure activities (12.5% (ADHD) versus 1.5% (non-ADHD)) (Strine, et al., 2006). Using data from a large, nationally representative sample including more than 10,000 children between the ages of 4 and 17, one study found about half of youth with probable ADHD were reported to have impairment in leisure activities (Cuffe, et al., 2005).

Measuring Impairment

The subject of impairment, while certainly not new to the field of mental health, arguably has been neglected in child/adolescent ADHD specific research literature (Goldstein & Naglieri, 2009). Little consensus seems to exist in the field of functional assessment on the definitions or measures of the constructs involved (Goldstein & Naglieri, 2009). The DSM-IV diagnostic criteria does not provide sufficient instructions on how to measure impairment (Gordon, et al., 2006). And, researchers and clinicians are assessing impairment in a variety of ways (Canino, et al., 1999).
Measures of impairment provide crucial information regarding developmental capacity, trajectory, and domain functioning. Measures of impairment also provide important information for treatment planning purposes and help distinguish clinically significant cases (Bird et al., 2000). Most measures of functioning concentrate on areas like social relationships at home, at school, and in leisure time, with parents, siblings, peers, etc. (Canino, et al., 1999). It is more clinically useful to assess multiple domain impairment information (e.g., family and academic) because it allows for a more comprehensive snapshot of current functioning (Fabiano & Pelham, 2009). Identifying domain specific impairments can lead to referral and can become outcomes to measure for targeted intervention aimed at improving long term functioning (Sayal, Goodman, & Ford, 2006).

**Impairment Measures**

Impairment measures should be reliable, capture multiple domains, and informative for clinicians and educators, but should not be costly or time consuming to administer (Fabiano & Pelham, 2009). There are no standardized measures of impairment similar to the DSM-based symptom assessment checklists (Gordon, et al., 2006). What does exist is a number of disparate measures, such as ratings, reports, and counts of negative life events, attempting to assess clinical impairment with varying degrees reliability and validity (Goldstein & Naglieri, 2009). Some potential measurement challenges are discussed here.

Construct validity poses specific problems in the measurement of impairment (Canino, et al., 1999). For example, not all measures have clear cut-points for where impairment begins and ends (Canino, et al., 1999). It is also difficult to determine if the
cut-points of measures that exist correspond to what is considered “substantial impairment” which is required to satisfy criterion for access to services by federal agencies (Canino, et al., 1999).

In a review of measures designed to capture functional impairment, Canino et al. distinguish between three measurement categories: 1. global impairment measures, 2. domain-specific or multidimensional measures, and 3. symptom- or diagnostic-specific impairment measures (Canino, et al., 1999). Rather than argue that one measurement category is better than another, the authors point out that each one has utility for different purposes (Canino, et al., 1999).

The Global Assessment of Functioning Scale (GAF) (American Psychiatric Association, 1994) is an example of a global impairment measure. It is a measure of overall difficulties in daily functioning (Fabiano & Pelham, 2009) and is included in the DSM-IV-TR. The GAF allows clinicians to report an individual's highest level of functioning using 10 point ranges from 0-100, with 90-100 being perfect functioning (American Psychiatric Association, 2000). Global measures, unlike domain-specific measures which are discussed next, do not evaluate functioning in different areas such as home or school (Fabiano & Pelham, 2009).

An example of a domain-specific measure is the Strengths and Difficulties Questionnaire (SDQ) (Goodman, 2001). The SDQ consists of 25 symptom items and seven items assessing difficulties in functioning (e.g., school and classroom settings) associated with reported symptoms (Goodman, 2001). The SDQ is one of a few measures of impairment that was specifically developed to assess impairment in relation to ADHD and other psychiatric symptomatology (Goodman, 2001). The SDQ measures difficulties
prompting caregivers to seek help for their children and is a helpful tool for pinpointing intervention needs (Ford, Hutchings, Bywater, Goodman, & Goodman, 2009). Domain specific measures often include measures of multiple disorders and differentiating impairment from specific disorders may not be possible (Canino, et al., 1999). Additional weaknesses of using domain specific measures include the following: they can be lengthy, require multiple raters, or may only assess a single domain of functioning (Fabiano & Pelham, 2009).

Symptom-specific measures assess impairment in relation to a specific symptom or diagnosis (Canino, et al., 1999). An example is the Diagnostic Interview Schedule for Children (DISC-IV) (Shaffer, et al.) which asks a series of impairment questions if diagnostic criteria, including enough ADHD symptoms are endorsed. One weakness of diagnostic specific measures is that the interviewee may not have a level of understanding needed to differentiate impairment caused by one type of symptom (or set of symptoms) versus another (Canino, et al., 1999).

Another major shortcoming of symptom-specific measures such the DISC is that if the symptom criteria, duration criteria, or age of onset criteria for ADHD are not met, the impairment questions are never asked. Unless researchers use another source to identify functional impairment, this may result in under-identification of children and adolescents who experience subthreshold ADHD with clinically significant levels of impairment. Additionally, symptom-specific measures may not allow for a consideration of impairment in control children so that impairment norms can be established and used for comparison purposes.
Predicting Impairment

A number of features may predict impairment among youth and when considered together may have greater prognostic power (Steinhausen, 2009). In a prospective ADHD study (using DSM-III-R criteria), Biederman et al. found maternal psychopathology, larger family size, higher levels of comorbidity, and increased impulsive symptoms predicted lower rates of normalized functioning (Biederman, Mick, et al., 1998). Predictors of later adolescent functioning identified in the MTA study include symptom severity, conduct problems, intellect, social advantage, and strength of symptom response to treatment; and, to a lesser extent, type of treatment received during the 14 months intervention (Molina, et al., 2009). CD also predicts poor academic outcomes and relationship difficulties (Gordon, et al., 2006). Early peer problems is a predictor of relationship difficulties in adolescence (Gordon, et al., 2006).

Mota and Schachar (2000) used the receiver-operating characteristic (ROC) approach (combining symptoms most associated with impairment) to predict impairment (Mota & Schachar, 2000). The algorithm used fewer symptoms than the DSM-IV criteria and improved diagnostic sensitivity and specificity. Mota and Schachar point out that other studies attempting to determine which symptoms best predicted ADHD impairment often use factor analysis where symptom combinations were based on their correlation with other symptoms rather than impairment (Mota & Schachar, 2000). For that reason, symptom prevalence or subtype distinctions, are inadequate in predicting impairment (Mota & Schachar, 2000).
STUDYING PATTERNS OF SYMPTOM AND FUNCTIONAL IMPAIRMENT CHANGE

Research has demonstrated that measures of impairment generally have a relatively modest correlation with symptom reports (Gathje, et al., 2008). These findings supporting the argument that symptoms and impairment are two related, yet separate, aspects of the ADHD diagnosis (Gathje, et al., 2008). Impairment is only partially predicted by symptom severity (Barkley, 2010), accounting for only 25% of the variance in impairment in one study (Gordon, et al., 2006).

Measurement indicators of functioning are more meaningful to patients, their families, and teachers than measurement indicators of symptoms (J. S. Owens, et al., 2009). Parents and teachers are less likely to consider a resulting treatment change meaningful if the child does not show improvement in functioning (Hoagwood, Jensen, Petti, & Burns, 1996). Research and clinical data present a strong case for using impairment over symptom measures because, in the majority of the cases, when impairment improves symptoms improve, where as the converse is less likely (J. S. Owens, et al., 2009; Young & Gudjonsson, 2008). Impairment, such as declining grades, rather than symptoms often results in referral for services (J. S. Owens, et al., 2009).

Still, recent intervention studies have shown that significant change in functioning occurs without symptom change and visa versa (Karpenko, et al., 2009; J. S. Owens, et al., 2009). There is value in knowing if a symptom change is associated with meaningful change in specific domains of functioning (J. S. Owens, et al., 2009) and it is important to study the correspondence between both constructs. To date, research is lacking in this area.
Analytic Approaches to Studying Patterns of Symptoms and Impairment Change

When considering patterns of individual ADHD developmental change over time, it is important to employ fitting analytic approaches (Willoughby, 2003). Jacobson and Traux’s methods are most often utilized in treatment and intervention studies, however, developmental trajectory research is an ideal forum this methodological approach. One part of Jacobson and Traux’s formula for defining “clinically significant” (CS) change, the Reliable Change Index (RCI) (Jacobson & Truax, 1991), is one frequently used analytical approach that is useful in considering change over time and helping to better understand the developmental course of ADHD. RCI is a statistical approach to measuring an individual’s change (e.g., symptomatology, impairment) in performance on a standardized outcome measure (Jacobson & Truax, 1991). While the RCI does not calculate clinically significant change, it is valuable because it categorizes individuals by the direction and magnitude of change (e.g., increasing symptoms counts, decreasing symptom counts, no change in symptoms), regardless of functioning status (the second part of the Jacobson and Truax formula) (J. S. Owens, et al., 2009).

Using the two-part formula, CS change occurs when an individual had achieved reliable change (using the reliable change index (RCI) from pre- to post- measurement points and when the post-assessment score reaches the normative range (Jacobson & Truax, 1991). Employing CS change rather than using the RCI alone, may be overly conservative and less useful for ADHD research because, while declines in symptoms and improvement in functioning occur, normative scores may only be achievable for a small number of individuals (J. S. Owens, et al., 2009). Even if someone does not return to the normal range of functioning, there is value in calculating the magnitude and
direction of the impairment change (J. S. Owens, et al., 2009). While other comparable methods exist, use of the Jacobson and Truax RCI method is encouraged to allow for cross-study comparability (Karpenko, et al., 2009; J. S. Owens, et al., 2009).

**SYMPTOM & FUNCTIONAL IMPAIRMENT TRAJECTORY STUDIES REVIEW ANALYSIS**

A search for studies including the following five criteria yielded only three reports (Biederman, et al., 2000; Bussing, et al., 2010; S. Faraone, et al., 2006): 1. DSM-III, III-R or IV diagnostic criteria were used via a structured diagnostic interview or through a validated ADHD rating scale, using parent report; 2. ADHD children were compared to a well-matched control group; 3. Most participants were ≥4 and ≤12 years of age at the start of the study and were followed prospectively for at least 1 year after the initial assessment; 4. A subthreshold ADHD, ADHD NOS, subclinical ADHD, Residual Type, ADHD in-partial remission, syndromatic remission, functional persistence, or subsyndromal group was considered separately from the ADHD group and non-ADHD group; and 5. Impairment status was measured and considered in relation to symptom status. Eight additional studies are included in the review analysis because they met a number of the inclusion criteria and offer important insight or methodological perspectives related to the study of the patterns of symptom and impairment change comparing youth with ADHD, subclinical ADHD and children without ADHD.

Studies included in the review analysis were examined in order to assess the following dimensions of research and evaluation: type of study; populations/communities/levels of focus; location of study; problem/areas of focus/objectives; underlying theories & principles used in design/implementation/evaluation of study; evaluation approaches; design and methods
for evaluation; instrumentation; data collection methods; data analysis and reporting
procedures; dissemination of results; conclusions; other comments. This strategy was
used to organize the information into specific content areas and also, later, to acquire a
sense of the gaps in the literature.

The following section first discusses studies that are relevant to the current study
but which did not meet all of the inclusion criteria listed above. Next, the three studies
meeting all of the inclusion criteria are presented followed by a summary of gaps and
shortcomings and importance of the reviewed literature.

**Subclinical Group Not Considered Separately**

Studies prior to Biederman et al. (1998) did not inquire if functional impairment
could normalize for youth with persistent ADHD (Mick, et al., 2004). Biederman et al.
analyzed data from a 4 year longitudinal study of referred boys (aged 6-17) with
persistent ADHD (compared to youth without ADHD to assess levels of school, social,
and emotional functioning (Biederman, Mick, et al., 1998). Normalized functioning was
defined as attaining scores above the fifth percentile of scores in the non-ADHD group
(Biederman, Mick, et al., 1998). At follow-up they found one-fifth of the children with
persistent ADHD functioned poorly in all 3 domains, one fifth did well in all domains,
and three-fifths were impaired at follow up in one or two areas, suggesting the
developmental trajectory of ADHD is associated with inconsistent functioning
(Biederman, Mick, et al., 1998).

Biederman et al., included subthreshold cases with ADHD cases when defining
persistent ADHD and defined subthreshold as fewer symptoms than was required for
ADHD (at least 5 versus at least 8 using DSM-III-R criteria) and with significant
impairment using the GAF. They included impairment because of Barkley’s idea that the DSM criteria for ADHD may not be developmentally appropriate for adolescents [certain symptoms may no longer be endorsed as children age] (Biederman, Mick, et al., 1998). Since subthreshold cases were included in persistent ADHD cases, it is not known how many of the 85 individuals classified as persistent ADHD cases were subthreshold, and distinguishing subthreshold functional trajectories is not possible. In an earlier study (using the same cohort), Biederman et al. (1996) found “early and late remitters” at the four-year follow-up were less academically and socially impaired compared to individuals with persistent ADHD. Here too, the subthreshold group (those not meeting symptom count criteria for DSM-III-R (at least 5 symptoms) but having severe impairment) was included with the ADHD group (Biederman, et al., 1996).

In a similar methodological study, Mick et al. found a 5-year persistence rate of 71% (N=99) among a referred sample of girls with (123) and without (112) ADHD (6 to 17 years of age at baseline ADHD screening) (Mick et al., 2011). Persistence was defined as meeting full DSM-IV ADHD diagnostic criteria or residual criteria defined as 3-5 ADHD symptoms (fewer than full diagnostic criteria but more than half the required symptoms) and associated impairment (i.e., GAF score, 60) (Mick, et al., 2011). According to the researchers, that definition of persistence was used because, in line with clinical practice, a disorder is not necessarily considered in remission when full diagnostic criteria are not met (Mick, et al., 2011).

Findings showed girls with persistent ADHD had more functional impairment than girls with ADHD in remission (N=44), yet remitted ADHD was associated with more functional impairment (e.g., academic tutoring) compared to girls without ADHD.
(Mick, et al., 2011). This study, like the Biederman study above, was limited by using a
global assessment of impairment and for its inability to distinguish functional trajectories
of the residual group (as they were included with individuals meeting full DSM-IV
ADHD diagnostic criteria in the persistent ADHD group).

**Retrospective Adult Study**

Young & Gudjonsson compared adults in partial remission (IPR; n=43) or in full
remission (IR; n=22) to adults with ADHD (n=88) and without ADHD (n=33) and found
symptom remission is associated with improvement in psychosocial functioning (Young
& Gudjonsson, 2008). In partial remission was defined as having met criteria for ADHD
in childhood and rating fewer symptoms of ADHD on the DSM-IV checklist (1 SD above
the mean for a normal control group) (Young & Gudjonsson, 2008). While adults with
ADHD fared the worst, individuals with partial remission and full remission continued to
have difficulties with making and managing friendships compared to those who had
never had ADHD (Young & Gudjonsson, 2008). Additionally, while individuals with
IPR had fewer symptoms than the ADHD group, they had a greater number of visits to
health services compared to adults who had never had ADHD (Young & Gudjonsson,
2008). While this study used retrospective recall of clinically referred patients and
focused on adult functioning, findings show individuals continued to experience
functional impairment even though they no longer meet full diagnostic symptom criteria
(Young & Gudjonsson, 2008). Impairment was not included in the definition of IPR or
IFR.
Cross Sectional Data

Using cross sectional data, Scahill et al. examined functioning correlates of ADHD in a community sample of children using the Children’s Global Assessment Scale (CGAS) (Scahill, et al., 1999). They found children with subthreshold ADHD were significantly less impaired than children with ADHD, but significantly more impaired than children without ADHD (Scahill, et al., 1999). The researchers defined subthreshold ADHD by a symptom score of 13-18 using the Parent Diagnostic Interview Schedule for children (DISC-R; based on the DSM-III-R criteria) and impairment was not used to define ADHD, subthreshold, or non-ADHD categories (Scahill, et al., 1999). Findings suggested it is beneficial to consider ADHD dimensionally in terms of severity of disorder rather than categorically (Scahill, et al., 1999).

Symptom/Functioning Correspondence Studies

One of the first symptom/functioning correspondence studies examined the interrelationship between the Child Behavior Checklist (CBCL) (symptom measure) and the Child and Adolescent Functional Assessment Scale (CAFAS)(impairment measure) using Jacobson and Truax’s RCI methodology (Rosenblatt & Rosenblatt, 2002). Psychosocial domains assessed using a sum score from the CAFAS included Role Performance, Behavior Toward Others/Self, Moods/Emotions, Substance Use, and Thinking (Rosenblatt & Rosenblatt, 2002). The sample included 3,008 referred youth (mean age was 12.5 years at intake) with various diagnoses, including ADHD ODD/CD, and mood disorder receiving mental health services and “a coordinated care plan” following intake. At follow-up, findings showed 13% of disagreement in outcomes between symptoms (CBCL) and functioning (CAFAS). Researchers found minimal
correspondence between reliable change in symptoms and functioning with 197 (45%) achieving reliable positive change in functioning (CAFAS) while 59 (13%) of the 432 youth’s scores on the CBCL did not change (Rosenblatt & Rosenblatt, 2002). On the other hand, 50 (15%) youth showed negative change and 103 (30%) showed positive symptoms change while 329 youth did not show any reliable functioning change (Rosenblatt & Rosenblatt, 2002). These findings suggest that a consideration of the correspondence between symptom and functioning change has value over a consideration of symptom change alone.

Drawing methodologically from the Rosenblatt study, Karpenko et al. analyzed data from the Multimodal Treatment Study of Children with ADHD (MTA) to study the correspondence between clinically significant (CS) change in symptoms and reliable change in functioning (Karpenko, et al., 2009). Participants included 417 children (aged 7-9) with ADHD-C who received treatments (i.e., medication and/or behavioral treatment). Using parental report, they found that children with CS symptom change were two times more likely than children who did not reach CS symptom change to have reliable improvement in social, academic, home, and global levels of impairment (Karpenko, et al., 2009). Of note, functioning did improve for 14-52% of children who did not have CS change in symptoms, depending on the measure (Karpenko, et al., 2009). From the client’s standpoint, the researchers suggest, reliable change in impaired functioning alone (without significant symptom change) may hold meaning (J. S. Owens, et al., 2009).

Because the study was limited to the MTA dataset, there was no control group and a clinical population was used (Karpenko, et al., 2009). A subclinical ADHD group
was not identified and individuals who had worsening impairment (a small percentage) were combined with “no-changers” (Karpenko, et al., 2009). The researchers justified the use of measuring CS change for symptom outcomes and RCI for functional impairment outcomes because CS change has been mainly applied to analysis of symptom change and it may be “helpful to begin studying change in functioning by applying the less stringent criterion (reliable change)” (Karpenko, et al., 2009). Other than to maintain consistency with previous MTA analyses, it is not clear why they chose to treat symptoms using the more conservative approach for symptom change.

Owens et al. studied the relationship between reliable change in symptoms and reliable change in functioning in 64 girls with ADHD enrolled in a school-based parent/teacher intervention program (J. S. Owens, et al., 2009). A comparison of group and individual level analysis revealed that while both analyses indicate statistically significant correspondence between reliable change in symptoms and reliable change in functioning, individual analysis revealed a substantial number of children with ADHD experienced a “change in one dimension without change in the other” (J. S. Owens, et al., 2009). Depending on informant and functional domain, up to 40% achieved reliable symptom change without reliable improvement in functioning and up to 16% achieved reliable change in functioning without reliable change in symptoms (J. S. Owens, et al., 2009). Of note, less than 50% of girls with symptom improvement showed reliable improvement in the six domains of functioning that were assessed (symptoms, peers, parent/teacher, academics, family/classroom/ self-esteem). This study did not include a subclinical ADHD group nor did it include a comparison group.
**Studies Meeting all Inclusion Criteria**

Biederman et al. considered three categories of remission: syndromatic (loss of full diagnostic status; (DSM-III-R criteria), symptomatic (not meeting symptom count criteria (36% of symptoms), regardless of impairment), and functional (not meeting symptom count criteria (36% of symptoms), plus no impairment (GAF score higher than 60) (Biederman, et al., 2000). Measuring 128 clinically referred boys (ranging in age from less than 6 to 20 years) at the four year follow-up, they found the following rates of remission: syndromatic (60%), symptomatic (30%), and functional remission (10%) (Biederman, et al., 2000). In spite of the large percentage of syndromatic remission (60%) these individuals who no longer met symptom count criteria continued to suffer from impairment (Biederman, et al., 2000). The 30% who fell into the symptomatic remission category had fewer than the number of symptoms for a subthreshold diagnosis, regardless of impairment, and no findings are presented on the levels of impairment experienced by these individuals (Biederman, et al., 2000). Information related to domain specific impairment was not collected. Results of this study emphasize that reported remission rate is more a function of the definition of remission used, rather than course of the disorder.

Faraone et al. (S. Faraone, et al., 2006) compared four adult groups: full ADHD (127), late onset ADHD (all criteria met except onset age of 7) (79), subthreshold (never having had ADHD using DSM-IV criteria and having a chronic history of 3 or more ADHD-HI or ADHD-IA symptoms (41), and comparisons (123) (S. Faraone, et al., 2006). The subthreshold group was significantly impaired compared to the comparison group but presented with less impairment than individuals with late-onset and full ADHD.
diagnosis (S. Faraone, et al., 2006). Impairment items assessed included the need for academic tutoring in childhood, traffic citations received, grade achieved in school, and occupational status (S. Faraone, et al., 2006). The subthreshold group in Faraone’s study “does not provide insight into the problems faced by adolescents and adults who are “growing out” of the disorder by experiencing symptom remission of childhood ADHD and/or associated lessening of functional impairment” (Young & Gudjonsson, 2008).

Bussing et al. (Bussing, et al., 2010) provide observational outcome data related to functioning and quality of life from a diverse, prospective, longitudinal community study. They compared 94 children at baseline (age 5–11) with full ADHD (using DSM-IV criteria) to 75 children with subthreshold, and 163 low-risk peers at an 8-year follow-up assessment (Bussing, et al., 2010). Based on combined parent and child reports using the Columbia Impairment Scale, youth with ADHD, but not children without ADHD in childhood, was associated with increased functional impairment and lower quality of life at follow-up (Bussing, et al., 2010). ADHD and subthreshold ADHD in childhood were associated with lower average grades compared to children without ADHD (Bussing, et al., 2010). Both ADHD and subthreshold ADHD were associated with increased risk of juvenile justice system involvement and failure to graduate and subthreshold but not full ADHD was associated with being held back in school (Bussing, et al., 2010).

**Gaps Shortcomings and Strengths of the Analysis Review Literature**

It was not possible to distinguish functional trajectories of the subclinical groups in the Biederman and Mick Studies, as they were included with individuals meeting full DSM-IV ADHD diagnostic criteria (Biederman, et al., 1996; Mick, et al., 2011). Additionally, global assessment of impairment did not allow for domain specific
assessment of functional impairment. The researchers did inquire if functioning could normalize for youth with persistent ADHD and learned the developmental trajectory of ADHD is often associated with inconsistent functioning.

Young & Gudjonsson retrospectively demonstrated individuals continued to experience functional impairment even though they no longer meet full diagnostic symptom criteria (Young & Gudjonsson, 2008). Using cross-sectional data, Scahill found children with subthreshold ADHD were significantly less impaired than children with ADHD, but significantly more impaired than children without ADHD and demonstrated the usefulness of treating ADHD dimensionally rather than categorically (Scahill, et al., 1999). In line with both Young & Gudjonsson and Scahill, all three studies that did meet inclusion criteria also demonstrated that youth with subclinical ADHD who no longer met symptom count criteria continued to suffer from impairment (Biederman, et al., 2000; Bussing, et al., 2010; S. Faraone, et al., 2006). Further, Biederman et al., emphasize that reported remission rate is more a function of the definition of remission used, rather than course of the disorder.

Methodologically, the symptom/functioning correspondence studies provide detailed information related to percentages of individuals who make reliable improvement in functioning but not symptoms and visa versa and make a compelling case for using similar methodology to uncover symptom and/or functioning developmental trajectories (Karpenko, et al., 2009; J. S. Owens, et al., 2009; Rosenblatt & Rosenblatt, 2002) among youth with subclinical ADHD to compared to youth with and without ADHD. The Owens et al. study, highlighted a need for research that considers profiles of children who show no change in symptoms or a reduction in symptoms (J. S.
Owens, et al., 2009). The Karpenko study pinpoints a need to compare nontreated individuals with treated individuals when considering corresponding symptom and impairment, as they did not consider nontreated individuals (a limitation of using the MTA dataset) (Karpenko, et al., 2009). These studies also contribute to an understudied area in ADHD research; the relation between patterns of change in symptoms and functioning (J. S. Owens, et al., 2009). Given the potential importance of subclinical ADHD and the almost complete absence of longitudinal research on this subcategory of ADHD, further research is in this area is warranted.

**ADHD and Subclinical ADHD Treatment Seeking**

*Medication Treatment and Developmental Trajectories*

Research evidence shows that early identification and treatment can improve developmental trajectories (Magyary & Brandt, 2002). Recommended treatment for ADHD includes medication and/or behavior therapy (Adler, et al., 2008) to improve targeted outcomes (Vierhile, et al., 2009). There are a variety of ADHD medications and stimulant medications thought to be better than nonstimulant medications (Vierhile, et al., 2009). Stimulant medications such as methylphenidate (the active ingredient in Ritalin) and mixed amphetamine salts (Adderall) are a first-line treatment for ADHD, with methylphenidate being the best-studied (Ramos-Quiroga & Casas, 2011). When stimulant medication is ineffective, atomoxetine, a non-stimulant medication, is recommended (Vierhile, et al., 2009). Behavior therapy includes various interventions designed to modify the physical and social environment in order to reward achievement of desired goals or assign consequences for not meeting goals (Perrin et al., 2001). Other
psychosocial interventions do not have evidence-based support (W. Pelham & Fabiano, 2008).

In 2007, 66% of youth (ages 4-17) were treated with medication for a current ADHD diagnosis (Visser & Lesesne, 2005). Youth aged 11-17 had higher mediation rates compared to children aged 4-10 and boys were more likely than girls to take medication (Visser & Lesesne, 2005). Medication treatment compliance may be as low as 50% in children with ADHD (Johnston & Fine, 1993). Regarding behavioral intervention, recent findings suggests that treatment effects from school-based intervention and parent training for young children with ADHD symptoms was not sustained two years following treatment (Shelton et al., 2000).

The ultimate goal of treatment for ADHD is to achieve remission (Steele, et al., 2006). Remission should include reducing impairment in emotional, academic, and social domains, not just reducing ADHD core symptoms (Adler, et al., 2008; Steele, et al., 2006). The efficacy of stimulant medication in reducing core symptoms of ADHD (P. L. Hazell et al., 2010) as well as improving function in a number of domains is well documented in the literature (Perrin, et al., 2001). In fact, in about 70% of cases, ADHD medication reduces ADHD symptoms (e.g., interrupting and fidgeting) as well as improves impairment (e.g., relationships at home with parents) (Action, 2002).

Steele et al. (2006) reviewed studies and found achievement of symptomatic remission rates in ADHD children treated with methylphenidate (highest remission rates) and atomoxetine, but did not find remission rates in the literature for amphetamines. Most clinical trials, they found, define remission by taking symptoms, but not impairment, into account (Steele, et al., 2006). They reviewed various studies that have assessed
improvements in functioning and found medication use versus no medication use is associated with greater rates of symptom remission and increased social and academic functioning (Steele, et al., 2006).

Improved functioning was greater with medication that offered higher symptom remission rates (Steele, et al., 2006). Perwein et al., found children with ADHD who received atomoxetine showed significantly greater improvement in psychosocial functioning compared to those children taking a placebo (Perwien et al., 2004). Academic impairments have been shown to be effectively treated with stimulants, while social impairment have been shown to be effectively treated with nonstimulant medication (Wehmeier, et al., 2010). Quality of life research has shown medication treatment resulted in improvements in family functioning as well as improvements in social and self esteem (Harpin, 2005).

**Treating Children with Subclinical ADHD**

The subject of treating children with subclinical ADHD is a controversial one. Data suggests that compared to children meeting full ADHD symptom counts, fewer children meeting subthreshold symptoms counts are treated with medication (Bussing, et al., 2010). One study looking at community treatment data considered four subgroups (full ADHD/subthreshold/last-onset ADHD/controls) and found among the subthreshold group 19% had received psychotropic medication for ADHD (lifetime), and 15% were currently taking medication (S. Faraone, et al., 2006). In another study, 25% of youth with subthreshold ADHD reported ever being treated with medication for ADHD, compared to 50% of youth with ADHD (Bussing, et al., 2010). While one would expect lower rates of medication treatment among individuals with diminished forms of ADHD
compared to ADHD, some question the appropriateness of treating this group (S. Faraone, et al., 2006) while others reason that increasing medication rates among subthreshold cases may reduce the risk for negative functional outcomes (Bussing, et al., 2010).

**Family Impairment**

Research evidence indicates family functioning difficulties are associated features of ADHD (Barkley, 2004; Deault, 2010; Johnston & Mash, 2001; Schroeder & Kelley, 2009) and many parents find parenting a child with ADHD to be difficult and psychologically distressing (Harrison & Sofronoff, 2002). A recent community-based study found parents of children with ADHD or CD/ODD (though CD/ODD with or without ADHD had a greater influence) were more likely to report problems with parental support, involvement, communication, and limit-setting compared to parents of children without those disorders (Geryk et al., 2012). An eight-year follow-up study of interaction patterns of 100 children with hyperactivity and 60 comparison children found among families with a hyperactive child, negative parent-child interactions predicted continuing parent-teen conflicts, and parents of hyperactive children reported more personal distress at outcome compared to parents without a child with hyperactivity (Barkley, Fischer, Edelbrock, & Smallish, 1991).

**Predictors of Treatment Seeking**

Several studies (Angold, et al., 1998; Farmer, Stangl, Burns, Costello, & Angold, 1999; Sayal, et al., 2006; Sayal, Taylor, & Beecham, 2003) and data from the National Health Interview Survey (NHIS) (Simpson, Cohen, Bloom, & Blumberg, 2009) suggest a strong relationship between the impact of youth’s behavioral difficulties and mental
health service use. Other findings suggest burden resulting from a child’s mental health condition strongly predicts mental health service use (Angold, et al., 1998) and continuing care (Farmer, et al., 1999). Results from the NHIS survey found families were almost two times as likely to have contact with a mental health provider if the child’s difficulty was considered a “burden on the family” (Simpson, et al., 2009). Hispanic, black, and younger children (aged 4-7 years), with emotional or behavioral difficulties were less likely to use mental health services compared to white and older children (Simpson, et al., 2009).

Children with ADHD compared to children without ADHD are more likely to utilize health care services (e.g., visit mental health professionals, take medication, and have frequent visits) (Pastor & Reuben, 2008). Research shows referral for treatment or services for ADHD is usually a result of functional impairment rather than symptoms (Angold, et al., 1999). Angold et al. found that children, regardless of meeting symptom criteria or not, who had impaired function were likely receiving services (Angold, et al., 1999). One study found more “costly and restrictive treatment” was associated with a child and adolescents severity of impairment in multiple domains (McDermott, McKelvey, Roberts, & Davies, 2002). In a study by Bourdon et al. comparing four Strengths and Difficulties Questionnaire (SDQ) scoring methods, scoring method using parent perceived severity of difficulties identified the highest percentage of children with “service contact/use” (Bourdon, Goodman, Rae, Simpson, & Koretz, 2005). Parent’s perception of problems and report of impairment are strong predictors of child mental health service use (Sayal, et al., 2003). Sayal et al, collected data from 232 parents of children with ADHD and found rather than severity of disorder and comorbidity, impact
of the disorder on caregivers best predicted recognition of problems (perceived burden) which were the main correlate of service contact (Sayal, et al., 2006).

Additional predictors of treatment seeking and service use have been identified in the literature. In a study of 268 clinic referred and 137 community-based children with ADHD and 268 controls, aged 6-15, Gau et al. found the most associated variables for psychiatric referral were male gender (OR=3.58), maternal education level as college or higher (OR=2.46), and interfering with friendship (OR=2.28). Interestingly, among community-based children with ADHD, data did not show differences in symptom severity and degree of impairment between those seeking medical services and those who did not (Gau et al., 2010). A study of Puerto Rican children aged 4-17 found ADHD, ADHD-NOS, impairment and male gender predicted stimulant medication use during the past year (Bauermeister, et al., 2003). Similarly, another study found ADHD, ADHD-NOS and male gender was associated with stimulant medication use, as well as younger age (Leslie, et al., 2005). After controlling for symptom severity, Jensen at al. found parental mental health history, level of stress, family size, and marital status predicted service use (Jensen, Bloedau, & Davis, 1990).
Chapter 3

Methodology

Purpose

The overall purpose of this study is to investigate developmental ADHD symptom and functioning profiles in a community sample of children and adolescents participating in the South Carolina Project to Learn about ADHD in Youth (SCPLAY) using data from baseline and follow-up assessments. This study employs the Jacobson & Traux reliable change index (RCI) methodology to examine patterns of Attention-Deficit/Hyperactivity Disorder (ADHD) functioning change. This method is clinically relevant in that it allows for a determination of the proportion of youth who improve or do not improve functionally, and who improve in one area but not the other. This research is also concerned with subthreshold ADHD as having potential risk for having or developing subsequent impairment problems as children age and demands on attention and performance increase. Patterns of symptom and functioning change are considered for children with ADHD, children with subthreshold ADHD and children without ADHD, as well as for children with ADHD and subthreshold ADHD who are and are not medicated. This study examines functional impairment in five individual domains of functioning, as well as overall impairment. Additionally, predictors of impairment severity and service utilization are examined. It is hoped that through improved understanding of the correspondence between these constructs, resources can be targeted to help children and adolescents with ADHD and subthreshold ADHD lead less impaired lives.
THEORETICAL/CONCEPTUAL FRAMEWORK

Developmental psychopathology is a multidisciplinary framework used to understand symptoms and functional impairments associated with mental disorders in the context of change over time and in relation to normal development (Cicchetti, 1990; Cicchetti & Toth, 1995). This perspective emphasizes a longitudinal perspective as essential to understanding development, as well as an appreciation of underlying biological predisposition and environmental contexts (Hinshaw & Blachman, 2005). While there is ample research stemming from the developmental perspective focusing on associations between aspects of the family and symptomatology, there is a lack of research conceptualizing ADHD in terms of ongoing difficulties that children and adolescents with ADHD experience in multiple domains of functioning at different points in time (Deault, 2010).

The developmental perspective is also a useful framework to invoke when asking questions such as “What factors contribute to the development of more severe forms of impairment?” and “Are the predictors of treatment-seeking the same for children experiencing subthreshold ADHD as for children with ADHD?”- questions this research seeks to answer. Answers to these questions provide guidance for interventions in clinical practice and enhance parents’ efforts to help their children reduce social and academic impairments (Deault, 2010). A developmental psychopathology approach also helps clarify the developmental course and diversity in course of ADHD and subclinical ADHD (Cicchetti & Toth, 1995).

Stemming from developmental psychopathology, developmental epidemiology is the study of patterns of disease distribution (in this case, ADHD) over time as a tool for
understanding specific aspects of the developmental course (Costello et al., 2006). It is specifically concerned with individual trajectories and requires researchers to take symptoms and impairment, as well as developmental stage, into account when considering the line between normal and abnormal behavior (Costello & Angold, 1993). This research is guided by that principle and, as an example, does not apply strict DSM-IV diagnostic criteria to youth of differing ages. Developmental epidemiology is both a descriptive and an analytic approach (Costello, Foley, & Angold, 2006). This framework is useful for attempting to understand developmental trajectories of impairment associated with ADHD over time because it is based on the premise that core features of ADHD change over time, and stresses the importance of interpreting aspects of that change (e.g. symptom expression) in relation to normal development (Mick, et al., 2004). Developmental epidemiology emphasizes the need to use consistent methodology when analyzing change over time (Youngstrom, Meyers, Youngstrom, Calabrese, & Findling, 2006).

Finally, impairment resulting from having ADHD extends beyond the individual, and should be conceptualized through an ecological perspective (Goldstein & Naglieri, 2009). This research considers both individual and social environmental functional domains that can help with targeted planning and treatment for individuals with ADHD and subthreshold ADHD. Such an approach is similar to the DSM-IV-TR, which uses a multi-axial classification system designed to consider biological and psychosocial aspects (in addition to ADHD diagnostic criteria) that are related to diagnosing an individual (e.g. medical conditions that are relevant to the disorder, co-morbidity, and relevant psychosocial and environmental problems).
The International Classification of Functioning, Disability, and Health Model (ICF) was developed by the WHO working group, and classifies functioning and disability according to three levels of functioning (impairments at the body function level, limitations at the personal activity level, and participation restrictions at the societal level). The ICF is useful for describing children’s behavior and functioning (Lollar, 2008). These three levels in the ICF model are all affected by aspects of the environment (Lollar, 2008) and relate directly to the domains of functioning that are targeted in this study.

This study uses the ICF-CY perspective, along with developmental psychopathology and developmental epidemiology frameworks to consider patterns of change in ADHD symptoms and functioning and predictors of impairment and ADHD medication use. Taken together, these perspectives provide a developmental framework that guides this research, and offer perspective on conceptualizing research questions and conducting analysis.

SPECIFIC STUDY RESEARCH AIMS/QUESTIONS

MANUSCRIPT 1:

The purpose of this study is to examine patterns of change between symptoms and functioning among youth with ADHD, with subthreshold ADHD (having three to five symptoms of ADHD), and without ADHD across two time-points, and to evaluate predictors of impairment.

**Manuscript 1 Aim 1 (M1A1):** To examine patterns of change between symptoms and functioning among youth with ADHD, with subthreshold ADHD, and without ADHD across two time-points.
Research Question 1 (M1A1RQ1): How do youth with subthreshold ADHD, youth with ADHD, and youth without ADHD change from baseline to follow-up with regard to patterns of change in symptoms and domains (both specific and aggregate) of functioning? The 5 domains of functioning include social (friendships), school (classroom learning), home (home life), intrapersonal (self), and free time (leisure activities).

Manuscript 1 Aim 2 (M1A2): To examine baseline demographic and psychiatric variables associated with severe levels of functional impairment at follow-up.

Research Question 2 (M1A2RQ2): Are the risk factors (child factors: age, gender, comorbidity, medication; family factors: exposure to parental psychopathology, primary parents educational attainment, marital status) that are associated with more severe forms of ADHD impairment similar for youth with ADHD, youth with subthreshold ADHD, and youth without ADHD?

MANUSCRIPT 2:

The purpose of this study is to examine patterns of symptom and functional impairment change from baseline and follow-up for youth with subthreshold ADHD and youth with ADHD based on treatment status, and to evaluate predictors of treatment utilization for youth with subthreshold ADHD compared to youth with ADHD.

Manuscript 2 Aim 1 (M2A1): To examine patterns of symptom and functioning change from baseline to follow-up for youth with subthreshold ADHD and youth with ADHD based on treatment status [taking ADHD medication versus not taking ADHD medication (within the last year)].
Research Question 1 (M2A1RQ1): How do youth with subthreshold ADHD, and youth with ADHD change from baseline to follow-up with regard to patterns of change in symptoms and functioning (both specific domains and aggregate), based on treatment status (taken medication within the last year versus not taken medication in the last year)? The 5 specific domains of functioning include social (friendships), school (classroom learning), home (home life), intrapersonal (self), and free time (leisure activities).

Manuscript 2 Aim 2 (M2A2): To examine baseline demographic and psychiatric variables that are associated with ADHD medication use at follow-up.

Research Question 2 (M2A2RQ2): Are the risk factors (child factors: impairment, gender, race, age, comorbidity; family factors: parent reported burden, insurance, parent educational level, exposure to parental psychopathology) of ADHD medication use (past year) similar for youth with subthreshold ADHD compared to youth with ADHD?

Research Design

This South Carolina Project to Learn about ADHD in Youth (SCPLAY) utilized a two-phase research design involving school district-wide, voluntary teacher and parent screenings (phase I), and in-person assessments including a structured diagnostic interview with participants and parents/caregivers (phase II). Study procedures were reviewed and approved by the Institutional Review Board of the University of South Carolina and the Centers for Disease Control and Prevention. Informed consent was obtained from parents for children under the age of 18. Assent forms were read aloud and signed by children and parents.
SCREENING (PHASE I)

Research Population

In Phase I, the sampling population included all 15 elementary schools in a large school district in SC. At the time of the screening, the school district had approximately 8,700 elementary school students attending Pre-K through grade 5. The school district population was culturally and racially diverse, and included rural, suburban, and some urban neighborhoods. The behavioral screening was conducted in classrooms (excluding special education classes) during the 2003-2004 school years. Teachers and/or parents (n=4606) completed Phase I screens.

Screening Overview

Participating parents and teachers answered two questions, one about previous ADHD diagnosis (teacher question: “To your knowledge, has this child been diagnosed with ADHD?”; parent question: “Has a doctor or health professional ever told you that your child had ADHD or ADD?”) and one question about current ADHD medication treatment (teacher question: “Is this child on stimulant medication such as methylphenidate (Ritalin)?”; parent question: “Is your child currently taking medication for ADHD/ADD?”). Additionally, teachers completed the Vanderbilt ADHD Diagnostic Teacher Rating Scale (VADTRS) (M. L. Wolraich, Feurer, Hannah, Baumgaertel, & Pinnock, 1998), and rated associated functioning by completing the “impact supplement” of the Strengths and Difficulties Questionnaire (SDQ) (Goodman, 1999). These two measures are explained in greater detail below.
**Vanderbilt ADHD Diagnostic Teacher Rating Scale (VADTRS), teacher version**

(Wolraich, Feurer, Hannah, Baumgaertel, & Pinnock, 1998)

The VADTRS scale is a DSM-IV based rating scale used to assess children for symptoms of ADHD (includes all 18 symptoms), ODD (eight symptoms), CD (12 symptoms), and anxiety/depression (7 symptoms). For the present study, only items assessing ADHD symptoms were utilized. Teachers were asked to rate the 18 items using a Likert scale ("Never"; "Occasionally"; "Often"; and "Very Often") reflecting the child’s behavior “since the beginning of the school year.” (M. L. Wolraich, et al., 1998)

**The Strengths and Difficulties Questionnaire (SDQ) (Goodman, 2001)**

The SDQ is a screening tool for multiple behavioral disorders and includes a rating of functioning (impact supplement). For the present study, the impact supplement was used to identify impaired functioning. The SDQ is described in more detail in the Interviews (Phase II) section below. The teacher version of the SDQ differs from the parent version only in terms of wording referencing "your child" versus "this child," and the teacher version does not have the family life or leisure impairment items (as teachers often cannot report on those domains of functioning) (Goodman, 1999).

**Classification of High and Low Screen**

Children were categorized as probable ADHD cases (high-screen): (1) if teachers rated six or more ADHD symptoms in either or both inattentive and hyperactive-impulsive ADHD subtype domains on the VADTRS with intermediate impairment ratings on the SDQ, or (2) if parents or teachers reported the child had received an ADHD diagnosis or were taking medication for ADHD. Otherwise, children were considered probable non-ADHD cases (low screen). All high screens and a sample of low
screens, frequency matched on gender, were randomly selected (n=2206) and eligible for Phase II. A letter from the school district was sent home to eligible families asking for permission to have study recruitment staff contact them. If a letter was returned, indicating consent to be contacted for the study, interested families (n=633) were then invited for an in-person structured assessment of ADHD, other mental disorders, treatment history, demographics, and other factors.

**INTERVIEWS (PHASE II)**

Baseline and follow-up (Phase II) in-person interviews were conducted with consenting families (n=481 baseline; n=292 follow-up). Baseline interviews were administered 13 months (mean time) following the screening (from 9/03 to 1/06 and follow-up interviews began 20 months later (9/07-2/09). The participating caregiver was often the child’s mother. Interviews (baseline and follow-up) were completed primarily in-person; written questionnaires for parents were sent home in advance of the interview and collected and checked for completeness during the interview. Interviews were conducted via telephone and parent measures returned by mail if families moved away, did not wish to meet at the study interview site or the child’s school, or have interviewers come to their home. Participants were given an incentive (gift cards at baseline or cash at follow-up) for participation in the study. Following each interview, diagnostic data were independently reviewed by a project child psychiatrist. Parents were sent a findings letter, and referral information was provided if findings suggested a probable diagnosis. Protocols were followed when parents or children reported “risks of harm to self or others or reported abuse.”
Baseline/Follow-up Measures (Detailed)

Measures were selected to assess ADHD, CD, and ODD symptomatology and associated functional impairment (core domains of functioning), along with other disorders and measures related to treatment history, demographics, and other factors.

Diagnostic Interview Schedule for Children, Parent Version (NIMH DISC-IV-P; Shaffer, Fisher, Lucas, Dulcan, & Schwab-Stone, 2000)

Parents completed selected modules of the Diagnostic Interview Schedule IV (DISC-IV) (Shaffer, et al., 2000), a highly-structured computer-based investigation of child psychopathology during the past 12 months. Selected modules included generalized anxiety disorder, separation anxiety disorder, obsessive compulsive disorder, post-traumatic stress disorder, major depression/dysthymic disorder, mania/hypomania, ADHD, ODD, and CD. The DISC-IV interview is based on DSM-IV diagnostic criteria and was administered to the parent by a trained project staff member during baseline and all follow-up assessments. If stem questions (symptom questions) were endorsed, contingent questions followed which determined if a participant met frequency, duration, and intensity criteria as specified by DSM diagnostic criteria (Grills-Taquechel & Ollendick, 2008). If enough stem questions were answered positively and DSM diagnostic criteria symptom counts met, further questions were asked assessing DSM-IV impairment criteria. However, if not enough DSM symptoms were endorsed by parents through the DISC-IV stem questions, the impairment questions were not asked. For this reason, the DISC-IV was only used to assess past year ADHD symptom counts and not to assess functional impairment. For all other psychiatric disorders assessed, past year
categorical probable diagnoses were obtained using the DISC-IV scoring algorithm based on DSM-IV diagnostic criteria.

The DISC is a reliable and valid interview with clinical value (Grills-Taquechel & Ollendick, 2008). The DISC has excellent inter-rater reliability (Shaffer, et al., 2000) and the test-retest reliability (k statistic) of the ADHD DISC-IV module (parent report) in a clinical sample and community sample (past year) among children aged 9-17 years is k=.79 and k=.60, respectively (Shaffer, et al., 2000). The sensitivity of the DISC is found to be excellent (range = 0.73 to 1.0) and one community-based study shows DISC correspondence to clinically meaningful ADHD symptomatology (ADHD; k =.72) (Schwab-Stone, Shaffer, Dulcan, & Jensen, 1996). The DISC showed moderate to good validity across a number of diagnoses, including ADHD (Schwab-Stone, et al., 1996). Parent interview was used because research has shown test-retest is unreliable on the child DISC interview (Schwab-Stone, et al., 1996).

**The Strengths and Difficulties Questionnaire (SDQ) (Goodman, 2001)**

The Strengths and Difficulties Questionnaire (SDQ) (Goodman, 2001), comprised of 25 symptom items, was developed for parents, teachers, and youth to assess emotional, social, and behavioral difficulties and prosocial strengths. The symptom/difficulty subscales include symptoms of ADHD, conduct disorder, emotional problems, peer problems, and prosocial behavior. Parents are asked about their child’s symptoms/behavior during the past six months and response variables include a three-point Likert scale (“not true,” “somewhat true,” and “certainly true”) that indicates applicability of each symptom to the child (Goodman, 1999). The extended version of the
Strengths and Difficulties Questionnaire includes a rating of the impact of those symptoms/difficulties on specific areas of functioning (Goodman, 1999).

Only the eight items assessing “impact” or impairment associated with the symptom items from the extended version of the SDQ were examined in these analyses. The parent version of this measure was completed at baseline and follow-up. The SDQ impairment section contains one item related to parental perceived severity of problems (“Overall, do you think that your child has difficulties in one or more of the following areas: emotions, concentration, behavior or being able to get on with other people?”) with responses including “no,” “yes, minor difficulties,” “yes, definite difficulties,” and “yes, severe difficulties,” and one item assessing the length of time the difficulties have been present (Goodman, 2001). Additionally, the impairment section consists of six items related to functioning associated with the reported difficulties with Likert scale responses ranging from “not at all” to “a great deal”. The five areas (or domains) of functioning assessed related to the child include child distress, home life, friendships, classroom learning, leisure activities. The last item asks about the difficulties being a burden to the caregiver or family.

For these analyses, the parent perceived burden item was treated dichotomously, coded as “present” (“medium amount” or “great deal”) = 1, and, “absent” (“not at all” or “a little”) = 2. The five functioning items (also referred to as impairment items) were summed to derive a “total impairment score,” categorizing impairment as abnormal/severe (high) if at least two impairment items were endorsed as a “medium amount” or one item was endorsed as a “great deal” (total impairment score ≥2) or normal/low/moderate (total impairment score ≤1). Total impairment scores were used to
consider predictors of service utilization, as an outcome variable, and to assess change from baseline to follow-up in relation to change in symptom categories. Individual functioning items were used to assess reliable change in functional impairment from baseline to follow-up using a reliable change index (described in detail below).

Normative data on the SDQ parent version have been obtained for both child (Stone, Otten, Engels, Vermulst, & Janssens, 2010) and adolescent (Bourdon, et al., 2005) populations. The SDQ is well-validated and was selected because it is widely used in both research and practice, and assesses domains of functioning in children and adolescents with ADHD. Reliability and validity data are summarized in two reports by the SDQ author (Goodman, 1999, 2001), and indicate that the parent version has high internal consistency for the total impact/impairment score (Cronbach alpha coefficient = .85), good four- to six-month retest stability for the parent version (Impact/impairment score; .57), and good validity for the impact/impairment score (negative predictive value (NPV) = .95; positive predictive value (PPV) = .53). Internal reliability has been reported to be .82 (Goodman, 2001).

Medication Status & Service Use

The DISC-IV was used to ascertain use of ADHD medication, including stimulant and non-stimulant medication, during the preceding year. The parent-reported mental health history questionnaire was used to identify if the parent has ever been told by a doctor or other health professional that they have a psychiatric disorder.
Demographic Survey

Socio-demographic information (age, gender, race, insurance status, primary parent’s educational attainment, and marital status) was obtained from parent self-report on a demographic questionnaire.

Statistical Procedures for Research Questions

SAS version 9.2 was used for data management and, when necessary, analyses were conducted using SAS-callable SUDAAN 10.0.

Procedures for Research Questions 1 for Manuscript 1

Part I: JT Method: Looking for Reliable Change

The data used to analyze question 1 for manuscript 1 were drawn from parent DISC-IV and SDQ data from baseline and follow-up assessments. Procedures outlined in Jacobson and Traux’s (1991) methodology for creating a reliable change index (RCI) were used to determine which children met criteria for reliable change in functioning (using the five functional domains from the SDQ data) in relation to symptom category (non-ADHD, subthreshold ADHD, and probable ADHD) change from baseline to follow-up. While other comparable statistical methods exist, researchers are encouraging the use this method for comparability purposes (Karpenko, et al., 2009). The following formula for reliable change (RC) as outlined by Jacobson and Traux was used:

\[ RC = \frac{X_{post} - X_{pre}}{S_{diff}} ; S_{diff} = \sqrt{2(S_E)^2} \]

\[ S_E = SD\sqrt{1 - r_{xx}} \]

\( X_{post} = \) individual’s score at follow-up

\( X_{pre} = \) individual’s score at baseline
$r_{xx}$ = test-retest reliability of the measure

$S_{\text{diff}}$ = standard error of the difference between the two scores

$SD_1$ = standard deviation of the sample at baseline

$SE$ = standard error of measurement

**Categories of change:**

Scores ≥ to 1.96 = positive change (e.g. impairment increased/worsened)

Scores ≤ to -1.96 = negative change (e.g. impairment decreased/improved)

Scores between 1.96 and -1.96 = no change

Scores ≥ to 1.96 are unlikely to be due to chance (p<.05) (Karpenko, et al., 2009).

Follow-up data for each measure of functioning was subtracted from the baseline data to find the difference scores for each of the 5 domains of functioning that are included in question 1. For each measure of functioning a participant was classified as having increased, decreased, or stayed the same. Total impairment scores were used when considering change in overall functional impairment from baseline to follow-up with abnormal/severe (high) impairment being at least two impairment items were endorsed as a “medium amount” or one item was endorsed as a “great deal.” These criteria were used because they follow the DSM-IV impairment criteria, yet may be overly stringent considering that situational ADHD (severe impairment in only one domain) may be an equally valid measure of impairment. (Lahey, et al., 2004)

This first step, using the RCI, distinguished individuals who made a statistically reliable change from those who had not. It was performed to account for any error in measurement when analyzing change from the pre- to the post-time point (Rosenblatt & Rosenblatt, 2002). “Reliable change” is achieved when the “magnitude of change
sufficiently exceeds the random fluctuation associated with measurement error” (Rosenblatt, 2002).

**Part II: Chi-square tests**

Next, to analyze the correspondence between symptoms (parent report using the DISC-IV) and functioning (parent report using SDQ), the two categorical variables of interest, Chi-square tests were conducted on the symptom groups (increase in symptoms (symptom deterioration), no change in symptoms, and decrease in symptoms (symptom improvement)) and functioning (increase in functional impairment (functional deterioration), no change in functioning, and decrease in functional impairment (functional improvement)) for each domain of functioning (i.e., friendships/classroom learning/home life/intrapersonal/leisure activities) and overall impairment (question 1, manuscript 1) for youth with ADHD, youth with subthreshold ADHD, and youth without ADHD. At baseline, participants were categorized into one of three main groups: those identified as having six symptoms from either the inattentive or hyperactive/impulsive symptom list (probable ADHD), those as identified as having three-to-five symptoms from either list (probable subthreshold ADHD), and those individuals identified as having none-to-two from either list (probable non-ADHD). Overall impairment was categorized as abnormal (high/severe impairment), borderline (moderate impairment), and normal (no/low impairment). The domains considered together for overall impairment were social, school, home, intrapersonal, and free time.

**Procedures for Research Question 1 for Manuscript 2**

The same methods described above were utilized to answer research question 1 for manuscript 2. Two differences, however, are noted here. Participants were further
categorized by ADHD medication status (medicated versus not medicated during the previous year) and individuals with probable subthreshold ADHD were compared to individuals with probable ADHD.

Procedures for Research Questions 2 for Manuscripts 1 & 2

Predictors of More Severe forms of Functional Impairment

Research question 2, manuscript 1, examined the predictors (or risk variables) of more severe forms of impairment at baseline, to see if they were similar for youth with ADHD, youth with subthreshold ADHD, and youth without ADHD. The outcome variable, “severe” (abnormal/high) impairment was met if at least two functional domain items were endorsed as a “medium amount” or one item was endorsed as a “great deal.” Five of the functional impairment questions above were summed and a total impairment score was treated dichotomously, with “severe impairment present” = 1, and, “absent” = 2. The predictor variables included in the regression analysis include child factors (age, gender, comorbidity, and medication use) and family factors (exposure to parental psychopathology, primary parent’s educational attainment, marital status). Age (calculated from the DISC-IV interview date and date of birth) was treated as a continuous variable. Gender was treated dichotomously (male versus female). Two of the risk variables, co-morbid mental disorders and exposure to parental psychopathology were dichotomously coded as “present” (1) or “absent” (2). Co-morbid conditions are listed in the DISC-IV section above and were considered dichotomously. Medication use was considered dichotomously [if parent/caregiver reported that their child had or had not taken any ADHD medication in the last 12 months (prior to the baseline interview)].
Parental psychopathology was considered dichotomously and included any parent report of previous diagnosis (12 of the most common mental disorders were reported, with depression reported most frequently). Primary parent’s educational attainment was considered dichotomously, as college degree or higher educational attainment versus some college education without a degree or lower education attainment. Marital status was considered dichotomously as a parent endorsing a family history of divorce or not.

**Predictors of Treatment Utilization**

Research question 2, manuscript 2, examines the predictors of treatment utilization (taken ADHD medication within the last year) for youth with subthreshold ADHD, compared to youth with ADHD. Data regarding medication use within the last year were obtained from the DISC-IV. Predictor variables included child factors [total impairment score (including social, academic, home, intrapersonal and leisure), gender, race, age, comorbidity] and family factors (parent reported burden, insurance, parent educational level, exposure to parental psychopathology). Individual functioning items were summed to create a total impairment score and treated dichotomously, with abnormal/severe (high) impairment = 1 if at least two functional impairment items were endorsed as a “medium amount” or one item was endorsed as a “great deal,” and less than that as “absent” = 2. Specific demographic characteristics (gender, race, age, insurance) were also considered as predictors, with gender treated dichotomously (male versus female); age (calculated from the DISC-IV interview date and date of birth) treated continuously; and race categorized as non-Hispanic white, non-Hispanic black, and other.
Parent reported burden ("do the difficulties put a burden on you or the family as a whole") scores were treated dichotomously coded as either “present” (1) or “absent” (2). Insurance was considered in the following three categories: Medicaid vs. private insurance vs. no insurance. Primary parent’s educational attainment was considered dichotomously, as college degree or higher educational attainment versus some college education without a degree or lower education attainment. Exposure to parental psychopathology was treated dichotomously coded as either “present” (1) or “absent” (2).

Logistic regression was used to explore the predictor variables explained above and the binary outcome variables (more severe impairment and ADHD medication use within the last year). Variables were selected for inclusion in a regression analysis based on literature indicating they are significantly related to the outcome variables for youth with ADHD compared to youth without ADHD. Participants were categorized into one of three main symptom groups: those identified as having six symptoms from either the inattentive or hyperactive/impulsive symptom list (probable ADHD), those as identified as having three to five symptoms from either list (probable subthreshold ADHD) and those individuals identified as having zero to two symptoms from either list (probable non-ADHD). Based on those categories, the baseline sample consisted of 211 non-ADHD, 84 subthreshold, and 186 probable ADHD cases. All models were analyzed for goodness of fit, and statistically sound models were retained.

Demographic and psychosocial characteristics of the interviewed sample, symptom count categories, symptom patterns, distribution of impairment item selection, and impairment changes by ADHD symptom baseline status are presented in the tables below.
Table 3.1 Demographic and Psychosocial Variables of Sample by Data Collection Wave (raw frequencies and weighted percents)

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th></th>
<th>Follow-up</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Total</td>
<td>481</td>
<td>100.0</td>
<td>292</td>
<td>100.0</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>323</td>
<td>49.1</td>
<td>191</td>
<td>49.3</td>
</tr>
<tr>
<td>Girls</td>
<td>158</td>
<td>50.9</td>
<td>101</td>
<td>50.7</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>269</td>
<td>44.2</td>
<td>169</td>
<td>46.3</td>
</tr>
<tr>
<td>Non-Hispanic Black</td>
<td>184</td>
<td>50.6</td>
<td>114</td>
<td>51.4</td>
</tr>
<tr>
<td>Other</td>
<td>28</td>
<td>5.2</td>
<td>9</td>
<td>2.4</td>
</tr>
<tr>
<td>Age in years (mean, range)</td>
<td>9.1 (5-13)</td>
<td></td>
<td>11.8 (7-15)</td>
<td></td>
</tr>
<tr>
<td>Insurance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>49</td>
<td>11.8</td>
<td>20</td>
<td>6.6</td>
</tr>
<tr>
<td>Private insurance</td>
<td>305</td>
<td>69.9</td>
<td>203</td>
<td>76.6</td>
</tr>
<tr>
<td>Medicaid</td>
<td>100</td>
<td>18.3</td>
<td>58</td>
<td>16.7</td>
</tr>
<tr>
<td>CD/ODD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>90</td>
<td>11.5</td>
<td>40</td>
<td>7.8</td>
</tr>
<tr>
<td>No</td>
<td>389</td>
<td>88.5</td>
<td>252</td>
<td>92.2</td>
</tr>
<tr>
<td>Any psychiatric comorbidity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>123</td>
<td>17.4</td>
<td>54</td>
<td>12.4</td>
</tr>
<tr>
<td>No</td>
<td>356</td>
<td>82.6</td>
<td>238</td>
<td>87.6</td>
</tr>
<tr>
<td>ADHD medication</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>141</td>
<td>14.4</td>
<td>92</td>
<td>17.1</td>
</tr>
<tr>
<td>No</td>
<td>340</td>
<td>85.6</td>
<td>200</td>
<td>83.0</td>
</tr>
</tbody>
</table>
Table 3.2 Representation of Symptom Count Categories by Data Collection Wave

<table>
<thead>
<tr>
<th>Symptom Category</th>
<th>Baseline</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Probable ADHD cases (≥6 IA symptoms or ≥6 HI symptoms)</strong></td>
<td>186</td>
<td>106</td>
</tr>
<tr>
<td><strong>Subthreshold ADHD cases (not a probable case, but had 3-5 IA symptoms or 3-5 HI symptoms)</strong></td>
<td>84</td>
<td>57</td>
</tr>
<tr>
<td><strong>Non-ADHD cases (&lt;3 IA symptoms and &lt;3 HI symptoms)</strong></td>
<td>211</td>
<td>129</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>481</td>
<td>292</td>
</tr>
</tbody>
</table>

Symptom count categories by data collection wave (only including those who were re-interviewed at the follow-up)

<table>
<thead>
<tr>
<th>Symptom category</th>
<th>Baseline</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Probable ADHD cases (≥6 IA symptoms or ≥6 HI symptoms)</strong></td>
<td>113</td>
<td>106</td>
</tr>
<tr>
<td><strong>Subthreshold ADHD cases (not a probable case, but had 3-5 IA symptoms or 3-5 HI symptoms)</strong></td>
<td>46</td>
<td>57</td>
</tr>
<tr>
<td><strong>Non-ADHD cases (&lt;3 IA symptoms and &lt;3 HI symptoms)</strong></td>
<td>133</td>
<td>129</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>292</td>
<td>292</td>
</tr>
</tbody>
</table>
Table 3.3 Change in Symptom Categories from Baseline to Follow-up

<table>
<thead>
<tr>
<th>Symptom Category</th>
<th>Baseline symptom count category</th>
<th>% who decreased from category</th>
<th>% who remained in category</th>
<th>% who increased from category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probable ADHD cases (≥6 IA symptoms or ≥6 HI symptoms)</td>
<td>113</td>
<td>34</td>
<td>66</td>
<td>-</td>
</tr>
<tr>
<td>Subthreshold ADHD cases (not a probable case, but had 3-5 IA symptoms or 3-5 HI symptoms)</td>
<td>46</td>
<td>28</td>
<td>33</td>
<td>39</td>
</tr>
<tr>
<td>Non-ADHD cases (&lt;3 IA symptoms and &lt;3 HI symptoms)</td>
<td>133</td>
<td>-</td>
<td>77</td>
<td>23</td>
</tr>
<tr>
<td>Total</td>
<td>292</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3.4 Distribution of Item Selection within Strengths and Difficulties Questionnaire Impairment (percentages)

<table>
<thead>
<tr>
<th>BASELINE (n=468)</th>
<th>Not at all</th>
<th>A little</th>
<th>A medium amount</th>
<th>A great deal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difficulties upset/distress child</td>
<td>62.2</td>
<td>21.9</td>
<td>10.9</td>
<td>5.0</td>
</tr>
<tr>
<td>Difficulties interfere with home life</td>
<td>64.0</td>
<td>20.2</td>
<td>11.0</td>
<td>4.9</td>
</tr>
<tr>
<td>Difficulties interfere with friendships</td>
<td>74.9</td>
<td>17.1</td>
<td>6.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Difficulties interfere with classroom learning</td>
<td>62.5</td>
<td>13.2</td>
<td>11.4</td>
<td>13.0</td>
</tr>
<tr>
<td>Difficulties interview with leisure activities</td>
<td>75.1</td>
<td>17.7</td>
<td>5.4</td>
<td>1.8</td>
</tr>
</tbody>
</table>
### Table 3.5 Impairment Changes for SDQ Domains of Functioning by Baseline ADHD Symptom Status

<table>
<thead>
<tr>
<th>Domains of Functioning</th>
<th>Baseline ADHD status (n=279)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-ADHD (n=130)</td>
<td>Subthreshold (n=46)</td>
<td>Probable ADHD case (n=103)</td>
</tr>
<tr>
<td><strong>Distress/intrapersonal</strong></td>
<td>(column %)</td>
<td>(column %)</td>
<td>(column %)</td>
</tr>
<tr>
<td>Decrease (improve)</td>
<td>74.4 (63.1, 83.1)</td>
<td>55.5 (37.2, 72.5)</td>
<td>47.1 (33.7, 60.9)</td>
</tr>
<tr>
<td>No change</td>
<td>17.6 (10.7, 27.5)</td>
<td>28.3 (14.4, 48.0)</td>
<td>33.7 (22.6, 47.0)</td>
</tr>
<tr>
<td>Increase (deteriorate)</td>
<td>8.1 (3.4, 17.9)</td>
<td>16.2 (8.8, 28.0)</td>
<td>19.2 (11.0, 31.5)</td>
</tr>
<tr>
<td><strong>Home life</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decrease (improve)</td>
<td>72.2 (61.9, 80.6)</td>
<td>40.0 (22.7, 60.3)</td>
<td>42.8 (29.7, 57.0)</td>
</tr>
<tr>
<td>No change</td>
<td>23.1 (15.5, 32.8)</td>
<td>47.5 (29.9, 65.8)</td>
<td>45.1 (32.0, 58.8)</td>
</tr>
<tr>
<td>Increase (deteriorate)</td>
<td>4.7 (1.9, 11.2)</td>
<td>12.4 (5.0, 27.8)</td>
<td>12.1 (6.7, 21.1)</td>
</tr>
<tr>
<td><strong>Friendships</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decrease (improve)</td>
<td>76.5 (65.8, 84.6)</td>
<td>36.4 (20.1, 56.6)</td>
<td>31.5 (20.1, 45.7)</td>
</tr>
<tr>
<td>No changers</td>
<td>16.1 (9.9, 25.0)</td>
<td>50.3 (32.1, 68.4)</td>
<td>48.8 (35.4, 62.5)</td>
</tr>
<tr>
<td>Increase (deteriorate)</td>
<td>7.5 (3.0, 17.6)</td>
<td>13.3 (6.6, 24.9)</td>
<td>19.6 (12.7, 29.1)</td>
</tr>
<tr>
<td><strong>Classroom learning</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decrease (improve)</td>
<td>72.8 (61.7, 81.7)</td>
<td>48.7 (30.7, 67.0)</td>
<td>52.4 (39.2, 65.4)</td>
</tr>
<tr>
<td>No change</td>
<td>18.2 (12.0, 26.9)</td>
<td>30.7 (15.2, 52.7)</td>
<td>36.7 (25.2, 50.0)</td>
</tr>
<tr>
<td>Increase (deteriorate)</td>
<td>9.0 (3.6, 20.5)</td>
<td>20.5 (10.7, 35.6)</td>
<td>10.8 (6.2, 18.2)</td>
</tr>
<tr>
<td><strong>Leisure activities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decrease (improve)</td>
<td>77.5 (67.6, 85.1)</td>
<td>30.8 (18.0, 47.5)</td>
<td>40.3 (27.6, 54.5)</td>
</tr>
<tr>
<td>No change</td>
<td>17.0 (11.1, 25.1)</td>
<td>57.8 (40.0, 73.7)</td>
<td>41.9 (29.0, 56.1)</td>
</tr>
<tr>
<td>Increase (deteriorate)</td>
<td>5.5 (1.8, 15.6)</td>
<td>11.5 (4.5, 26.5)</td>
<td>17.7 (11.1, 27.1)</td>
</tr>
</tbody>
</table>
Chapter 4

RESULTS

This chapter includes two manuscripts based on the analyses described in Chapter 3. The first manuscript: *Developmental differences in patterns of symptom and impairment change among a community sample of youth with ADHD, subthreshold ADHD and without ADHD*; has been formatted for submission to the *Journal of Child Psychology and Psychiatry* and focuses on research questions 1 and 2. The second manuscript: *Medication use within the context of ADHD and subthreshold ADHD: Developmental course and predictors in a community sample*; focuses on research questions 3 and 4 and has also been formatted for submission to the *Journal of Child Psychology and Psychiatry*. 
MANUSCRIPT I: DEVELOPMENTAL DIFFERENCES IN PATTERNS OF SYMPTOM AND IMPAIRMENT CHANGE AMONG A COMMUNITY SAMPLE OF YOUTH WITH ADHD, SUBTHRESHOLD ADHD, AND WITHOUT ADHD

1 Lorie L. Geryk, MPH, Ken W. Watkins, PhD, Joseph R Holbrook, PhD, Steven P. Cuffe, MD, Daniela B. Friedman, PhD, Robert E. McKeown, PhD. Formatted for submission to the Journal of Child Psychology and Psychiatry
Abstract

Background: Despite a substantial prevalence of subthreshold Attention-Deficit/Hyperactivity Disorder (ADHD) and research indicating that many youth with this disorder have impaired functioning and negative outcomes, few studies have considered patterns of symptom and functioning change for youth with probable ADHD, subthreshold ADHD and youth without ADHD transitioning from childhood to adolescence. Methods: A community-based sample composed of children at high-risk for ADHD and low-risk peers (frequency-matched on gender) were identified through screening and invited to in-person interviews. At two assessment periods, baseline (N=481) and follow-up (N=292) (starting 20 months after baseline), parents/caregivers completed measures related to the youths’ psychiatric symptom and impairment status, and supplemental questionnaires examined socio-demographic information and child and family risk factors. At baseline, children were identified who met symptom criteria for subthreshold ADHD (N=84), probable ADHD (186), and non-ADHD (n=211) and patterns of change in symptoms and impairment were examined at follow-up using a Reliable Change Index (RCI) and Chi Square tests. A supplementary analysis investigated predictors of severe impairment. Percents are weighted to reflect the complex sampling design. Results: Subthreshold ADHD symptoms were seen in as many as 18% (N = 84) of the youth studied at baseline. Youth who were non-ADHD at baseline who were probable cases at follow-up were significantly more likely to decline functionally in four of the five impairment domains and total impairment (62% overall
impairment decline) compared to youth who were non-ADHD at baseline and either non-ADHD or subthreshold ADHD at follow-up (4% and 9% decline in overall impairment, respectively). Thirty three percent of youth who were subthreshold at baseline remained in that category at follow-up and 15%-27% of those individuals showed significant decline in at least one domain of functioning and 47% declined in overall impairment at follow-up. **Conclusions:** The findings show the importance of examining symptom and impairment constructs separately in the consideration of their unique contributions to ADHD and subthreshold ADHD diagnoses and of acknowledging the need to examine nuanced changes in diagnostic status during development; especially functional declines. These findings may be relevant to efforts to intervene earlier in childhood and to help identify high-risk individuals who may be good candidates for targeted interventions. **Key words:** Attention Deficit Hyperactivity Disorder, Subthreshold ADHD, symptom and impairment trajectories, predictors of impairment. **Abbreviations:** RCI, reliable change index; ADHD, attention-deficit/hyperactivity disorder; DISC-IV, Diagnostic Interview Schedule for Children version IV; SDQ, Strengths and Difficulties Questionnaire; DSM-IV, Diagnostic and Statistical Manual-IV; OR, odds ratio; 95% CI, 95% confidence interval.
Introduction

Health professionals and educators who consider Attention-Deficit/Hyperactivity Disorder (ADHD) syndrome only in the context of full presentation of symptoms may overlook an important group of subclinical children, and oversimplify nuanced problems (Barnow, et al., 2006). Recent studies have challenged the validity of current diagnostic criteria including ADHD subtype classifications (hyperactive-impulsive, inattentive, and combined) (Lahey, et al., 2005; Riley, et al., 2008; Todd, et al., 2008; Valo & Tannock, 2010), age of onset criteria (Applegate, et al., 1997; Barkley & Biederman, 1997), and the need to have impairment present in two or more settings (Lahey, et al., 2004). Researchers have called for the replacement of categorical subtypes with a focus on dimensional case identification of ADHD using severity or counts of symptoms (Lahey & Willcutt, 2010; Lubke, et al., 2009; Rowland, et al., 2008; Valo & Tannock, 2010), for elimination or extension of the age of onset criteria (Barkley & Biederman, 1997; Bell, 2011; McGough & Barkley, 2004), and for focus more on impairment type and severity than on number of settings (Lahey, et al., 2004; Ramsay & Rostain, 2006).

Subthreshold ADHD

A growing body of evidence indicates that a sizable number of youth who meet less than full symptom criteria for a diagnosis of ADHD experience significant functional impairment that may require intervention (Mick, et al., 2011). This subthreshold group has been shown to express the same set of genes as ADHD (Levy, et al., 1997) and to be at increased risk of developing ADHD (Bussing, et al., 2010). Subthreshold ADHD is more prevalent than ADHD (Lewinsohn, et al.), with up to 22% of youth exhibiting inattentive and/or hyperactive subthreshold symptoms (Scahill, et al., 1999), yet little
research has been devoted to understanding developmental trajectories of youth with subthreshold ADHD. To be clinically meaningful, any reduced form of ADHD (e.g. meeting fewer than the required DSM-IV symptoms for a full diagnosis) should include consideration of impairment (Mick, et al., 2004).

**ADHD Associated Impairment**

Similar to symptoms of ADHD, functional impairment may tend to change as children age, and such change may be affected by environmental demands (Harpin, 2005). However, unlike symptoms which tend to diminish over time (Biederman, et al., 2000), impairment tends to become more noticeable as children age and acquire more autonomy, and is thought to have an additive effect (Adler, et al., 2008; Wender, et al.), with impairment in one domain predicting later compromised functioning in other domains (Murray-Close, et al., 2010).

**Measuring Patterns of Symptom and Impairment Change**

Research has demonstrated that measures of impairment generally have a relatively modest correlation with symptom reports, supporting the argument that these are two related yet separate aspects of the ADHD diagnosis (Gathje, et al., 2008) and cannot be validly equated (Bell, 2011). Measuring either impairment or symptoms without the other does not provide a complete clinical picture and may result in poor or inaccurate treatment decisions (e.g. length, type, or dose of treatment) (J. S. Owens, et al., 2009). Further, research shows that decreasing symptom burden is not always associated with improved functional status, whereas increasing symptom burden is more likely to be associated with functional decline (J. S. Owens, et al., 2009).
Recently, in the ADHD literature, two studies have emerged focusing on the poorly understood connection between reliable change in symptoms relative to reliable change in functioning (E. B. Owens, et al., 2009; Rosenblatt & Rosenblatt, 2002). Using a reliable change index (RCI) (Jacobson, 1991) studies confirm that change in functioning (both improved functioning and worsened functioning) often occurs when there is no reliable or significant change in symptoms (Karpenko, et al., 2009; E. B. Owens, et al., 2009; Rosenblatt & Rosenblatt, 2002). Heterogeneity in patterns of change is an understudied area, (Willoughby, 2003) and Jacobson and Traux’s RCI method, while most often utilized in treatment and intervention studies, is an ideal method for exploring patterns of symptom and impairment change among community-based youth with ADHD, subthreshold ADHD, and without ADHD.

**Predictors of Impairment**

There is a large body of research considering predictors of ADHD persistence, but few studies have explored predictors of impaired functioning. Though not well understood, a number of child and family risk factors may contribute to impairment among ADHD youth (Healey, 2010). Child-related factors including gender (Gathje, et al., 2008), higher levels of comorbidity, increased impulsive symptoms (Biederman, Mick, et al., 1998) and treatment (Molina, et al., 2009) were found to be associated with functioning. Researchers analyzing ADHD symptoms most associated with impairment showed symptom prevalence or subtype distinctions are inadequate for predicting impairment (Mota & Schachar, 2000).

Family factors associated with functioning among ADHD youth include: maternal psychopathology (Biederman, Mick, et al., 1998), social advantage (Molina, et al., 2009),
and marital status (Healey, Gopin, Grossman, Campbell, & Halperin, 2010). No study was found examining predictors of impairment for youth with subthreshold ADHD. This is a needed area of study, given that subthreshold ADHD may follow a similar, persistent impairment trajectory as ADHD.

**Study Purpose**

The main purpose of this study is to consider the complex processes through which impairment trajectories unfold in relation to symptoms. This study is a novel extension to previous RCI studies, and examines the relationship between change in symptoms and reliable change in functioning in children and adolescents with ADHD, subthreshold ADHD, and children without ADHD who participated in the South Carolina Project to Learn about ADHD in Youth (SCPLAY). Additionally, predictors associated with more severe forms of ADHD impairment will be explored to see if they are similar for youth with ADHD and youth with subthreshold ADHD.

**Methods**

**Recruitment and Sampling**

SCPLAY utilized a two-phase research design involving school district-wide, voluntary teacher and parent screenings (phase I) and in-person assessments (phase II). In-person assessments involved (structured diagnostic interviews with youth and parents/caregivers at baseline and four follow-up points. The sampling population included 15 elementary schools (pre-k through grade five) in SC with approximately 8,700 students from culturally and racially diverse rural, suburban, and urban neighborhoods. Children in non-self-contained classrooms were screened for risk of ADHD through two approaches: 1. teacher rated symptoms of inattention, hyperactivity,
and impulsivity using the Vanderbilt ADHD Diagnostic Teacher Rating Scale (VADTRS) (M. L. Wolraich, et al., 1998), impairment ratings by using the “impact supplement” of the Strengths and Difficulties Questionnaire (SDQ) (Goodman, 1999), and reported history of ADHD diagnosis and ADHD medication use; and, 2. parent-reported history of ADHD diagnosis and ADHD medication use. The behavioral screening was conducted during the 2003-2004 school years and 4606 teachers and/or parents completed Phase I screens.

All high-risk children (high-screen for ADHD) and a sample of low-risk children (low-screen for ADHD), frequency matched on gender, were randomly selected (n=2206) and invited, along with their parent/caregiver, by letter to participate in Phase II in-person structured assessments. Six hundred and thirty-three families returned forms indicating an interest in being contacted about Phase II assessments. Baseline interviews were conducted with consenting parents/caregivers and children 13 months (mean time) following the screening.

A detailed description of the SCPLAY study population, design, sampling frame, and methods are described elsewhere (M. L. Wolraich, et al., 2012). SCPLAY study procedures were approved by the Institutional Review Board of the University of South Carolina and the Centers for Disease Control and Prevention, and informed parental consent was obtained for all interviews. The institutional review board of the University of South Carolina determined this study exempt from its review.

**Participants**

Data for these analyses were obtained from SCPLAY baseline (n=481; 9/03-1/06) and follow-up 1 parent assessments (n=292; 9/07-2/09). Parent/caregiver, a biological
parent in 426 out of 481 (89%) baseline families, provided family demographic and psychosocial information, mental health history, information about the selected child related to ADHD symptoms and impairment, other psychiatric disorders, and treatment history via computer-based (interviewer administered) interview and paper and pencil (self-administered) questionnaires. The final sample for this report is 292 of the original 481, with 285 parents/caregivers completing the SDQ impact supplement at follow-up. Comparison of the retained sample versus those lost to attrition revealed no statistically significant differences related to baseline demographic variables.

Using the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) (American Psychiatric Association, 2000) symptom criteria for ADHD, youth were categorized into two symptom groups: probable ADHD cases (≥ 6 Inattentive (IA) symptoms or ≥ 6 hyperactive/impulsive (HI) symptoms) and subthreshold ADHD cases (3-5 IA symptoms or 3-5 HI symptoms). After categorization, 39% of the sample met inclusion criteria for probable ADHD, 18% for subthreshold, and 44% for non-ADHD at baseline; at follow-up, 36% of the sample met inclusion criteria for probable ADHD, 19% for subthreshold, and 44% for non-ADHD. The baseline samples are introduced in Table 4.1. There were no significant differences between the probable ADHD, subthreshold ADHD, and non-ADHD groups on demographic characteristics at baseline.

Measures

The Diagnostic Interview Schedule for Children (DISC-IV; Shaffer et al., 2000). The DISC-IV, based on the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) (Association & DSM-IV., 2000), is a well-validated, fully-structured diagnostic interview developed to diagnosis psychopathology in children (Shaffer, et al.,
Parents were administered the DISC-IV by a trained interviewer during baseline and the first follow-up annual assessment to obtain past year ADHD symptom counts and past year categorical probable diagnosis for generalized anxiety disorder, separation anxiety disorder, social phobia, post-traumatic stress disorder, obsessive compulsive disorder, major depression/dysthymic disorder, mania/hypomania, oppositional defiant disorder, and conduct disorder. The test-retest reliability of the ADHD DISC symptom count (parent report) in a community sample (past year) among children aged 9-17 years was ICC=.84 (Shaffer, et al.). The DISC showed moderate to good validity across a number of diagnoses, including ADHD (Schwab-Stone, et al., 1996). Parent interview was used because research has shown low test-retest reliability in the child disc interview (Schwab-Stone, et al., 1996).

**ADHD Medication Status.** One dichotomous medication status variable was coded (1 (yes) or 0 (no)) from the following item on the DISC-IV interview, “In the past twelve months, has your child taken any medicine for being overactive, being hyperactive, or having trouble paying attention?” Based on a subsample on whom we have detailed medication data (n=458), 14.6% of the subthreshold ADHD sample at baseline were taking stimulant medication and 4.3% were taking non-stimulant medication. 32.6% of the probable ADHD sample at baseline were taking stimulant medication and 13.6% were taking non-stimulant medication.

**The Strengths and Difficulties Questionnaire (SDQ) (Goodman, 2000).** The SDQ (extended version) is a domain-specific behavioral screener consisting of 25 symptom items assessing five subscales (behavioral problems, emotional problems, hyperactivity, peer-problems, and prosocial behavior) and seven “impact questions”
assessing difficulties in functioning (i.e. school and classroom settings) associated with reported symptoms (Goodman, 1999). The SDQ is one of a few measures that was specifically developed to assess impairment in relation to ADHD and other psychiatric symptoms. For these analyses, only the parent version impact questions of the SDQ extended version were examined (baseline and follow-up).

For the first impact question “Overall, do you think that (child’s name) has difficulties in any of the following areas: emotions, concentration, behavior, or being able to get along with other people?” (responses included ‘no,’ ‘minor,’ ‘severe,’ and ‘definite’), if respondents reported at least “minor” problems, then further impact questions related to five domains of functioning were asked. The impairment variables were defined by using parent responses to the following questions: 1. “Do the difficulties upset or distress the child?”; 2-5. “Do the difficulties interfere with the child’s life in the following areas: 2. Home life?; 3. Friendships?; 4. Classroom learning?; leisure activities?; and 6. “Do the difficulties put a burden on you or the family as a whole?” Response options for these items were coded (“not at all”=0; “a little”=0; “a medium amount”=1; “a great deal”=2). Individual impairment items were used to assess reliable change in functioning from baseline to follow-up using a reliable change index (RCI; described below) (Jacobson & Truax, 1991).

The SDQ is well-validated, and reliability and validity data are summarized in two reports by the author (Goodman, 1999, 2001). For the impact supplement, the parent version has high internal consistency (Cronbach alpha coefficient =.85), good 4-6 month retest stability (Impact/impairment score; .57), good validity (negative predictive value
(NPV) = .95; positive predictive value (PPV) = .53), and internal reliability has been reported to be .82 (Goodman, 2001).

**Predictors of Impairment**

**Outcome Variable:** The five impairment items were summed to derive a “total impairment score,” and dichotomously treated as abnormal/severe if at least two impairment items were endorsed as a “medium amount” or one item was endorsed as a “great deal” (total impairment score ≥2) or normal/low/moderate (total impairment score ≤1). **Predictor Variables:** Several baseline factors were examined as predictors of severe impairment. Child demographic and psychosocial variables included age and gender (ascertained from parental reports on the demographic questionnaire), comorbidity [considered dichotomously as either having or not having had a comorbid disorder (baseline, past year) as reported on parent DISC-IV report], and medication use, considered dichotomously [parent/caregiver report that their child had or had not taken any ADHD medication in the last 12 months (prior to the baseline interview)]. Additionally, the following family factors were examined as predictors of severe impairment: marital status (dichotomized into married or divorced); primary caregiver’s education level (dichotomized into less than a bachelor degree or a bachelor degree or higher); and, history of parent psychopathology (considered dichotomously and ascertained from parent report on a mental health history questionnaire).

**Procedures/Analysis**

All analyses were performed using SAS-callable SUDAAN version 10.0 software to adjust for the complex sampling design. Basic descriptive statistics were calculated and prevalence of treatment utilization reported. Raw frequencies and weighted
percentages are reported for all results. Procedures outlined in Jacobson and Traux’s (1991) methodology for creating a reliable change index (RCI) were used to determine which youth met criteria for reliable change in impairment (using the five domains of functioning from the SDQ data) in relation to symptom category (non-ADHD, subthreshold ADHD, and probable ADHD) change from baseline to follow-up. While other comparable statistical methods exist, researchers are encouraging the use this method for comparability purposes (Karpenko, et al., 2009). The following formula for reliable change (RC) as outlined by Jacobson and Traux was used:

\[ \text{RC} = \frac{X_{\text{post}} - X_{\text{pre}}}{S_{\text{diff}}} \]

\[ S_{\text{E}} = SD_{1}\sqrt{1 - r_{xx}} \]

The RCI method described by Jacobson and Traux (1991) was used to divide the baseline by follow-up differences for each participant by the standard error (SE) of the difference score for each domain of functioning. This allowed for the identification of individual change (significance level set to \( p \leq 0.05 \)) that is greater than what would be attributed to chance or measurement error (Jacobson, Roberts, Berns, & McGlinchey, 1999).

Descriptive percentages were used to compare proportions of change (i.e., improvement, no change, and decline) in symptom categories and functional impairment measures (five domains and overall impairment) among symptom groups (Jacobson, et al., 1999). SDQ scores \( \geq \) to 1.96 reflected positive change (i.e., impairment increased), scores \( \leq \) to -1.96 reflected negative change (e.g. impairment decreased), and scores between 1.96 and -1.96 reflected no impairment change. Participants were then classified
as “functionally improved” (i.e. changed statistically significantly in a positive direction), “no changers” (i.e. did not change statistically significantly), and “functionally declined” (changed statistically significantly in a negative direction). Further, chi-square tests were used to determine if there was a significant association between improvement in symptoms and improvement in functioning.

A multivariable logistic regression analysis was used to examine the relative impact of all covariates on the likelihood of having severe impairment at follow-up. Odds ratios and 95% confidence intervals (CIs) were computed to investigate the strength of the relationships between risk factors and severe impairment. All covariates were initially screened through interaction models and those that were poorly associated with ADHD medication use were excluded in the final multiple logistic regression models.

Results

The baseline sample was ethnically and gender diverse, with non-Hispanic blacks and girls being well-represented, 38% and 33%, respectively. At baseline, youth ranged in age from 5-13 (mean 9.1) and at follow-up youth ranged in age from 7-15 (mean 11.8). Twenty six percent of youth had one or more comorbid psychiatric disorder at baseline and 19 of youth had one or more comorbid psychiatric disorder at follow-up. Twenty nine percent of youth were taking ADHD medication at baseline and 32% at follow-up. Twenty six percent of youth had co-occurring mental disorder(s) at baseline and 18% at follow-up.

*Patterns of Symptom and Functioning Change*

After establishing symptom category change form baseline to follow-up, RCI was used to distinguish individuals who made a statistically reliable change in each domain of
functioning (and overall impairment) from baseline to follow-up. The relation between symptom category change (decrease, no change, and increase) for individuals with probable ADHD, subthreshold ADHD, and non-ADHD and impairment change (individual domains of functioning and overall impairment) was analyzed through a series of chi-square tests. The percentage of children demonstrating patterns of symptom change (increased, no change, and decreased) and impairment change (five domains of functioning and overall impairment) is shown in Tables 4.2 (functional decline) and 4.3 (functional improvement).

Youth who were non-ADHD at baseline, who were probable ADHD cases at follow-up, were significantly more likely to decline functionally than either subthreshold ADHD or non-ADHD at follow-up in 4 domains of functioning and total impairment: distress/intrapersonal, \( \chi^2 (2, N = 14) = 53.10, p < 0.001 \); friendships, \( \chi^2 (2, N = 13) = 46.20, p < 0.001 \); classroom learning, \( \chi^2 (2, N = 14) = 32.93, p < 0.001 \); leisure activities, \( \chi^2 (2, N = 10) = 50.90, p < 0.001 \); total impairment, \( \chi^2 (2, N = 14) = 41.71, p < 0.001 \).

Youth who were subthreshold ADHD at baseline, who were probable ADHD at follow-up, were significantly more likely to decline functionally than subthreshold ADHD at follow-up in classroom learning, \( \chi^2 (2, N = 13) = 14.74, p < 0.001 \). Youth who were subthreshold ADHD at baseline, who were subthreshold at follow-up, were significantly more likely to decline functionally than probable ADHD youth in total impairment, \( \chi^2 (2, N = 15) = 8.78, p < 0.02 \). Youth who were probable ADHD at baseline, were not significantly more likely to decline functionally at follow-up compared to the two other symptom categories.
Youth who were non-ADHD at baseline who were probable ADHD cases at follow-up were significantly less likely to improve functionally than either subthreshold ADHD or non-ADHD at follow-up in 4 domains of functioning: distress/intrapersonal, $x^2 (2, N = 94) = 23.37, p < 0.001$; friendships, $x^2 (2, N = 96) = 21.62, p < 0.001$; classroom learning, $x^2 (2, N = 91) = 28.92, p < 0.001$; and leisure activities, $x^2 (2, N = 97) = 20.32, p < 0.001$. Youth who were subthreshold ADHD at baseline who were probable ADHD cases at follow-up were significantly less likely to improve functionally than either subthreshold ADHD or non-ADHD at follow-up in distress/intrapersonal functioning, $x^2 (2, N = 22) = 7.13, p < 0.05$. Finally, youth with probable ADHD at baseline who remained probable ADHD at follow-up were significantly less likely to improve functionally compared to youth with non-ADHD and subthreshold youth at follow-up in two areas: distress/intrapersonal, $x^2 (2, N = 45) = 8.90, p < 0.02$; friendships, $x^2 (2, N = 31) = 7.66, p < 0.05$; and significantly less likely to improve functionally compared to youth with subthreshold ADHD at follow-up in two areas: classroom learning, $x^2 (2, N = 51) = 9.40, p < 0.01$; and leisure activities, $x^2 (2, N = 42) = 16.99, p < 0.001$.

**Predictors of Severe Impairment**

**Multivariable Models – Non-ADHD, Subthreshold ADHD and Probable ADHD**

Covariates that were found to be associated with severe impairment include the following: male gender, taking ADHD medication, psychiatric comorbidity, and having a primary parent with a psychiatric history. Marital status and age were not significantly related to severe impairment at follow-up and were dropped from the final logistic regression models. Table 4.4 presents results of the 3 multivariable logistic regression models. In model 1, among non-cases, ADHD medication use (OR = 9.8; 95% CI: 1.8–
54.6) was the strongest significant predictor of severe impairment, followed by primary parent psychiatric problem history (OR = 4.1; 95% CI: 1.4–12.3).

In model 2, among subthreshold cases, females (OR = 0.3; 95% CI: 0.1–1.0) were significantly less likely than males to have severe impairment at follow-up. Though not statistically significant, those whose parent/s had less than a college bachelors degree (OR = 3.0; 95% CI: 0.9–10.6) were more likely to be severely impaired at follow-up than those youth whose parents had a bachelors degree or higher education. In model 3, among probable ADHD cases, severe impairment at follow-up was more likely in those who met criteria for a comorbid psychiatric disorder (OR 5.2; 95% CI: 2.2-11.9) compared to those who did not. Non-cases, subthreshold cases, and probable ADHD cases did not share any of the same significant predictors.

Discussion

This study is one of the relatively few prospective community-based studies following subthreshold cohorts of youth to examine patterns of change in symptoms and functional impairment. This was achieved by following a diverse sample of youth with subthreshold ADHD, probable ADHD, and without ADHD over a period of approximately 3 years to study the course of ADHD functional impairment in five areas – intrapersonal, home life, friendships, classroom learning, and leisure activities, with the majority of children entering adolescence at follow-up. In an attempt to consider the ADHD syndrome in a more nuanced way, this study considered symptom and functioning change without narrowly defined DSM subtype, age of onset, and impairment (two or more settings) diagnostic criteria.
Findings show that decreasing symptom burden is not always associated with improved function, whereas increasing symptom burden is more likely to be associated with functional decline. A portion of youth who were probable ADHD cases at baseline and decreased symptoms (subthreshold ADHD at follow-up), 21% (N=22) experienced significant functional decline in at least one functional domain; whereas, 39% (N=18) of youth with baseline subthreshold ADHD whose symptoms increased (probable ADHD at follow-up) declined functionally at follow-up. These findings are in line similar methodological research (J. S. Owens, et al., 2009) and show the importance of examining both symptom and functioning constructs in the consideration of their unique contributions to ADHD and subthreshold ADHD diagnoses.

Subthreshold ADHD symptoms were seen in as many as 17% (N = 84) of the youth studied here at baseline. This is similar to the Scailhill et al. (1999) study finding that 22% of youth exhibited subthreshold symptoms. The prevalence of subthreshold ADHD increased slightly at follow-up to 20% (N = 57). Thirty three percent of youth who were subthreshold at baseline remained in that category at follow-up (compared to 77% and 66% of youth remaining in non- and probable ADHD categories, respectively); whereas, 28% decreased to non-ADHD, and 39% increased into the ADHD category. These findings have important implications. First, they support research showing youth with subthreshold ADHD are at increased risk of developing ADHD (Bussing, et al., 2010). Second, the subthreshold ADHD category was not as stable as the non-ADHD and probable ADHD symptom categories (at follow-up).

Among the 33% of youth (baseline and follow-up subthreshold ADHD), 33% declined functionally at follow-up in at least one of the five domains of functioning and
47% declined in overall impairment. This finding supports recent research showing a sizable number of subthreshold ADHD youth had significant functional impairment that may require intervention (Mick et al., 2011; Young & Gudjonsson, 2008; Scahill, et al., 1999; J. S. Owens, et al., 2009; Biederman, et al., 2000; Bussing, et al., 2010).

Additionally, early identification of subthreshold ADHD with associated functional decline may help identify youth at high-risk for “converting” to full ADHD.

Findings from the series of chi-square tests suggest that youth (both non-ADHD and subthreshold ADHD at baseline) who achieve probable ADHD status at follow-up are more likely to decline functionally than individuals achieving subthreshold ADHD or non-ADHD status at follow-up. This was especially true of youth with non-ADHD at baseline who were significantly more likely to decline functionally in total impairment and four of the five domains of functioning (all but home life). Baseline youth with subthreshold ADHD who were probable ADHD cases at follow-up were significantly more likely to decline functionally than subthreshold ADHD at follow-up in classroom learning and overall functioning. Baseline youth with non-ADHD and subthreshold ADHD who achieved probable ADHD status at follow-up were also significantly less likely to improve functionally at follow-up than youth with either subthreshold ADHD or non-ADHD at follow-up.

Finally, baseline youth with probable ADHD who remained probable ADHD at follow-up were significantly less likely to improve functionally compared to youth with non-ADHD at follow-up in distress/intrapersonal and friendships and significantly less likely to improve functionally compared to youth with subthreshold ADHD at follow-up in classroom learning and leisure activities. This finding is expected as youth with
probable ADHD would likely exhibit elevated levels of impairment at baseline and follow-up, thus less likely to achieve functional improvement from baseline to follow-up assessments.

Taken together it is clear that achieving probable ADHD status at follow-up is associated with the most functional decline. Achieving subthreshold status at follow-up was associated with less functional decline than probable ADHD status, but more functional decline than non-ADHD status at follow-up. This is in line with epidemiological evidence supporting a dimensional view of ADHD, where symptoms and impairments are continuously distributed in the general population, with more severe disorder lying at the upper end of the continuum (Buitelaar & Rothenberger, 2004; Shaw et al., 2011).

The longitudinal data used here offered the opportunity to consider predictors of severe impairment among non-ADHD, subthreshold, and probable ADHD symptom categories. Most notable among the findings is that probable ADHD and subthreshold ADHD did not share any significant predictors in common; not an expected finding based on the supposition that subthreshold youth would share a similar impairment predictor profile as individuals with probable ADHD. Regression analysis, controlling for all other covariates, revealed four significant predictors for subsequent severe impairment: ADHD medication use and primary parent psychiatric history in the non-ADHD model; gender in the subthreshold model, and psychiatric comorbidity in the probable ADHD case model.

The finding that ADHD medication use among the non-ADHD symptom group is a highly significant predictor of severe impairment is notable, but may be partially or
wholly explained by different reasons including the following: 1. treatment with ADHD mediation for another problem; 2. misdiagnosis; or 3. ADHD medication treatment is effective for reducing symptoms but not impairment. The subthreshold ADHD model showed being male significantly predicted severe impairment is not inline with results from a meta-analysis which found no gender differences in social and peer and academic performance functioning (Gaub & Carlson, 1997). Based on the lack of similar predictor findings for subthreshold and probable ADHD youth, it is reasonable to assume children with subthreshold ADHD tend not to be similar to children with ADHD with regard to risk profiles for severe impairment. The probable ADHD model results are consistent with prior findings showing comorbid psychopathology was negatively associated with normalized functioning (Biederman, Mick, et al., 1998). The identification of only one significant predictor for the probable ADHD group was not expected, since the predictor variables were selected based on prior study findings among individuals with ADHD.

**Study Limitations & Strengths**

As with any study, the current findings are not without limitations. The SDQ is a domain specific measure (assessing functional impairment in relation to symptoms of multiple disorders) (Canino, et al., 1999) so there is no way to know which symptoms, if any, are directly related to the reported impairment. However, using the DISC-IV (a symptom specific measure), was not possible because if the symptom criteria, duration criteria, or age of onset criteria for ADHD are not met, the impairment questions are never asked and subthreshold impairment and control children’s impairment could not be assessed. Symptom specific measures of impairment are needed that are not constrained by an inability to assess the impairment of youth with subthreshold ADHD and
comparison youth. Additionally, domains of functioning were measured using a single SDQ item. While this does not allow for complete detail, the SDQ is a well validated measure often used to assess functioning, is practical to administer, and provides information about multiple domains of functioning that can help inform developmental trajectory research as well as treatment and service decisions.

The use of only parent/caregiver report is another limitation, as the DSM-IV recommends the use of multiple informants and the American Academy of Pediatrics recommends the need for both parent and teacher report of functional impairment (American Psychiatric Association, 2000; M. Wolraich, Brown, & Brown, 2011). Teacher reports of functional impairment were collected, but due to poor response rates, not used. Parent subjectivity may also be biased (e.g., underreport due to social desirability, over-report due to help-seeking, endorse symptoms that affect them the most, and may be more reliable reporters for younger children) (Barkley, 2006). While there is often disagreement among multiple informants and subjective bias in parent report, parents are thought to be crucial for a valid assessment of ADHD (Barkley, et al., 2002; Cantwell, Lewinsohn, Rohde, & Seeley, 1997).

Symptom decreases over time might reflect true developmental changes, but also may be due to other things such as artifacts of repeated measurement (Hart, et al., 1995) and diagnostic inadequacies (e.g., applying symptoms that are not developmentally sensitive (Willoughby, 2003)). Additionally, the relationship between symptom change and impairment in specific domains of functioning may be a function of the treatment or care that individuals were provided, comorbidity, or other factors. While the impact of those things is not known, and the findings are constrained by unadjusted percents and
small numbers, this represents some of the only data available describing symptoms and functional impairment for youth in a community setting.

Another limitation of this study is the proportion of baseline participants lost to follow-up. If those individuals were less likely to have ADHD symptoms or more likely to have ADHD symptoms, the findings are less likely to be representative of the initial sample. Finally, as the course of ADHD and subthreshold ADHD is continually changing, one’s symptom and impairment status at baseline and follow-up may not be static and future studies exploring changes in patterns of ADHD symptoms and impairment are needed that use repeated observations.

This study adds to an absence of population-based longitudinal impairment data of children with subthreshold ADHD who are identified in early childhood and followed into adolescence. While most ADHD trajectory studies consider only patterns of symptom change over time, this study considered patterns of change for both symptoms and functioning. It utilized well validated instruments, trained data collectors, and extensive data quality control measures. Study sampling design increased case finding and analysis accounted for sampling design to give unbiased estimates. It used a prospective design with a retention rate of 61% at follow-up. In addition to being cross sectional in nature, most studies focus on children, and this study followed youth up to age 15. This was a community-based rather than clinic-based study, which is a strength, as clinic-based youth are likely to have more severe symptom and functional impairments than youth in the community (Gau, et al., 2010) and may result in higher treatment seeking rates (Rowland, Lesesne, & Abramowitz, 2002). White boys account for the
majority of research related to ADHD in youth (Hartung & Widiger, 1998) and girls and African American youth are well represented in this study.

**Clinical Implications**

Based on current policies, individuals with subthreshold ADHD may not qualify for treatment and services (Canino, et al., 1999) yet it seems clinically questionable to disqualify individuals for services because they fall below symptom threshold for the recommended DSM criteria if they present with significant and developmentally inappropriate functional impairment. Current findings help inform our understanding of impairment persistence associated with symptom change and highlight the importance of considering subthreshold ADHD in efforts to understand the trajectories through which risk factors may affect the expression of, or impaired functioning associated with ADHD. Evaluating the patterns between symptoms and impairment change provides direct comparisons between individuals for a better understanding of individual needs which can help in the treatment decision making process to continue or discontinue treatment/intervention or to focus on specific domains of impaired functioning.

As part of the evaluation process, it is important to educate parents and youth that ADHD is a chronic condition shaped by biological and environmental factors (Halfon, 2002) with associated impairments that may last into adulthood. ADHD education should stress that as the child/adolescent grows, develops and confronts different environmental challenges it is important to recognize that different symptoms and impairment may be exhibited. Targeted interventions should be tailored and flexible in addressing differences in individual symptom and impairment profiles.
Finally, the regressions revealed that severe impairment was significantly predicted by psychiatric comorbidity among probable ADHD cases, being male among subthreshold ADHD, and primary parent psychiatric problem history and psychiatric medication use among individuals without ADHD at follow-up. These findings may be relevant to efforts to intervene earlier in childhood and to help identify high-risk individuals who may be good candidates for targeted interventions.

Clinically, pinpointing areas of individual need may help in the design of targeted treatment strategies, improve patient outcome, and aid the clinician’s ability to clearly and meaningfully inform caregivers and children. From a public health perspective, this knowledge can help focus scarce societal resources toward ADHD children at higher risk for persistent and severe impairment. This has implications for early intervention and secondary prevention initiatives, with the goal in mind of improving functioning of children and adolescents with subthreshold ADHD and ADHD.
REFERENCES


Wolraich, M., Brown, L., & Brown, R. (2011). Subcommittee on Attention-Deficit/Hyperactivity Disorder; Steering Committee on Quality Improvement and Management. ADHD: clinical practice guideline for the diagnosis, evaluation, and
treatment of attention-deficit/hyperactivity disorder in children and adolescents. 

_Pediatrics, 128_, 1007-1022.


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Table 4.1 Demographics of Sample by Baseline ADHD Status; Raw Frequencies and Weighted Percents

<table>
<thead>
<tr>
<th></th>
<th>Non-ADHD Cases</th>
<th>Subthreshold Cases</th>
<th>Probable ADHD Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>Total</td>
<td>211</td>
<td>100.0</td>
<td>84</td>
</tr>
<tr>
<td>Age in years (mean, range)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9.0 (5-12)</td>
<td>9.5 (5-12)</td>
<td>9.4 (5-13)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>136</td>
<td>41.9</td>
<td>59</td>
</tr>
<tr>
<td>Girls</td>
<td>75</td>
<td>58.1</td>
<td>25</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>119</td>
<td>45.3</td>
<td>49</td>
</tr>
<tr>
<td>Non-Hispanic Black</td>
<td>81</td>
<td>48.6</td>
<td>34</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>6.1</td>
<td>1</td>
</tr>
<tr>
<td>Any psychiatric comorbidity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>13</td>
<td>6.8</td>
<td>18</td>
</tr>
<tr>
<td>No</td>
<td>197</td>
<td>93.3</td>
<td>66</td>
</tr>
<tr>
<td>ADHD medication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>11</td>
<td>3.3</td>
<td>21</td>
</tr>
<tr>
<td>No</td>
<td>200</td>
<td>96.7</td>
<td>63</td>
</tr>
<tr>
<td>Parent mental health history</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>32</td>
<td>12.1</td>
<td>14</td>
</tr>
<tr>
<td>No</td>
<td>176</td>
<td>87.9</td>
<td>69</td>
</tr>
<tr>
<td>Parent education level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than bachelors degree</td>
<td>99</td>
<td>45.2</td>
<td>54</td>
</tr>
<tr>
<td>At least bachelors degree</td>
<td>107</td>
<td>54.8</td>
<td>28</td>
</tr>
</tbody>
</table>
Table 4.2 Percentages of Youth with Decrease in Symptoms, No change in Symptoms, and Increase in Symptoms Who Achieved Reliable Change DECLINE on SDQ Functional Measures (Increased Impairment)

<table>
<thead>
<tr>
<th>Baseline SDQ Impairment</th>
<th>Non-ADHD at baseline (n=130)</th>
<th>Subthreshold ADHD at Baseline (n=46)</th>
<th>ADHD at baseline (n=103)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No change in sx (non-ADHD at follow-up)</td>
<td>Increase in sx (subthreshold ADHD at follow-up)</td>
<td>Increase in sx (probable ADHD cases at follow-up)</td>
</tr>
<tr>
<td></td>
<td>% who declined functionally (95% CI)</td>
<td>% who declined functionally (95% CI)</td>
<td>% who declined functionally (95% CI)</td>
</tr>
<tr>
<td>Distress/intrapersonal**</td>
<td>4.0 (1.2, 12.3)</td>
<td>3.6 (0.6, 19.0)</td>
<td>69.1 (32.9, 91.0)</td>
</tr>
<tr>
<td>Home life</td>
<td>4.6 (1.6, 12.7)</td>
<td>3.6 (0.6, 19.0)</td>
<td>7.9 (1.6, 31.6)</td>
</tr>
<tr>
<td>Friendships**</td>
<td>3.8 (1.1, 12.2)</td>
<td>3.6 (0.6, 19.0)</td>
<td>62.4 (25.2, 89.1)</td>
</tr>
<tr>
<td>Classroom learning**</td>
<td>5.7 (1.6, 17.7)</td>
<td>5.4 (1.4, 19.0)</td>
<td>57.9 (20.3, 88.1)</td>
</tr>
<tr>
<td>Leisure activities**</td>
<td>1.8 (0.5, 7.1)</td>
<td>3.6 (0.6, 19.0)</td>
<td>57.2 (19.7, 87.9)</td>
</tr>
<tr>
<td>Total impairment**</td>
<td>4.0 (1.2, 12.3)</td>
<td>9.0 (2.9, 25.0)</td>
<td>62.3 (25.0, 89.1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Baseline SDQ Impairment</th>
<th>Non-ADHD at baseline (n=130)</th>
<th>Subthreshold ADHD at Baseline (n=46)</th>
<th>ADHD at baseline (n=103)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No change in sx (subthreshold ADHD at follow-up)</td>
<td>Increase in sx (probable ADHD cases at follow-up)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% who declined functionally (95% CI)</td>
<td>% who declined functionally (95% CI)</td>
<td>% who declined functionally (95% CI)</td>
</tr>
<tr>
<td>Distress/intrapersonal**</td>
<td>3.5 (0.6, 18.6)</td>
<td>18.2 (6.7, 40.9)</td>
<td>37.2 (18.0, 61.4)</td>
</tr>
<tr>
<td>Home life</td>
<td>1.7 (0.3, 9.6)</td>
<td>27.4 (6.4, 67.6)</td>
<td>19.6 (7.3, 42.9)</td>
</tr>
<tr>
<td>Friendships**</td>
<td>3.5 (0.6, 18.6)</td>
<td>19.2 (6.3, 45.8)</td>
<td>25.9 (10.4, 51.2)</td>
</tr>
<tr>
<td>Classroom learning**</td>
<td>0.0</td>
<td>16.6 (5.5, 40.5)</td>
<td>59.7 (36.2, 79.5)</td>
</tr>
<tr>
<td>Leisure activities**</td>
<td>0.0</td>
<td>15.3 (5.0, 38.1)</td>
<td>28.7 (9.4, 60.8)</td>
</tr>
<tr>
<td>Total impairment*</td>
<td>0.0</td>
<td>47.2 (21.1, 75.0)</td>
<td>43.8 (21.3, 69.1)</td>
</tr>
</tbody>
</table>

** p < .01 for Chi-square analyses
* p < .05 for Chi-square analyses
Table 4.3 Percentages of Youth with Decrease in Symptoms, No Change in Symptoms, and Increase in Symptoms Who Achieved Reliable Change IMPROVEMENT on SDQ Functional Measures (Decreased Impairment)

<table>
<thead>
<tr>
<th>Non-ADHD at Baseline (n=130)</th>
<th>Increase in sx (subthreshold ADHD at follow-up)</th>
<th>Increase in sx (probable ADHD cases at follow-up)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No change in sx (non-ADHD at follow-up)</td>
<td>(n=100)</td>
<td>(n=17)</td>
</tr>
<tr>
<td>Baseline SDQ Impairment</td>
<td>% who improved functionally (95% CI)</td>
<td>% who improved functionally (95% CI)</td>
</tr>
<tr>
<td>Distress/intrapersonal**</td>
<td>78.6 (66.5, 87.2)</td>
<td>76.3 (51.0, 90.9)</td>
</tr>
<tr>
<td>Home life</td>
<td>75.0 (63.2, 84.0)</td>
<td>55.1 (28.5, 79.0)</td>
</tr>
<tr>
<td>Friendships**</td>
<td>80.7 (69.6, 88.4)</td>
<td>76.1 (50.1, 91.0)</td>
</tr>
<tr>
<td>Classroom learning**</td>
<td>77.7 (65.8, 86.4)</td>
<td>74.5 (50.0, 89.5)</td>
</tr>
<tr>
<td>Leisure activities**</td>
<td>82.2 (72.6, 89.0)</td>
<td>70.6 (44.8, 87.7)</td>
</tr>
<tr>
<td>Total impairment</td>
<td>5.7 (2.7, 11.6)</td>
<td>5.1 (0.9, 25.0)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subthreshold ADHD at Baseline (n=46)</th>
<th>No change in sx (subthreshold ADHD at follow-up)</th>
<th>Increase in sx (probable ADHD cases at follow-up)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease in sx (non-ADHD at follow-up)</td>
<td>(n=13)</td>
<td>(n=22)</td>
</tr>
<tr>
<td>Baseline SDQ Impairment</td>
<td>% who improved functionally (95% CI)</td>
<td>% who improved functionally (95% CI)</td>
</tr>
<tr>
<td>Distress/intrapersonal*</td>
<td>73.5 (38.1, 92.6)</td>
<td>53.1 (26.4, 78.1)</td>
</tr>
<tr>
<td>Home life</td>
<td>56.7 (26.1, 82.9)</td>
<td>14.8 (4.4, 39.6)</td>
</tr>
<tr>
<td>Friendships</td>
<td>38.6 (13.5, 71.7)</td>
<td>56.7 (29.9, 80.1)</td>
</tr>
<tr>
<td>Classroom learning</td>
<td>59.7 (26.9, 85.6)</td>
<td>49.4 (23.1, 76.0)</td>
</tr>
<tr>
<td>Leisure activities</td>
<td>19.1 (7.0, 42.5)</td>
<td>56.3 (29.6, 79.8)</td>
</tr>
<tr>
<td>Total impairment</td>
<td>28.8 (9.7, 60.4)</td>
<td>21.3 (6.8, 50.3)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Probable ADHD at baseline (n=103)</th>
<th>Decrease in sx (subthreshold ADHD at follow-up)</th>
<th>No change in sx (probable ADHD cases at follow-up)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease in sx (non-ADHD at follow-up)</td>
<td>(n=13)</td>
<td>(n=22)</td>
</tr>
<tr>
<td>Baseline SDQ Impairment</td>
<td>% who improved functionally (95% CI)</td>
<td>% who improved functionally (95% CI)</td>
</tr>
<tr>
<td>Distress/intrapersonal*</td>
<td>75.0 (45.7, 91.4)</td>
<td>54.3 (27.1, 79.2)</td>
</tr>
<tr>
<td>Home life</td>
<td>44.6 (13.8, 80.3)</td>
<td>41.5 (17.1, 71.0)</td>
</tr>
<tr>
<td>Friendships*</td>
<td>62.3 (27.3, 87.9)</td>
<td>23.8 (9.4, 48.3)</td>
</tr>
<tr>
<td>Classroom learning**</td>
<td>49.0 (15.9, 83.0)</td>
<td>77.7 (56.9, 90.2)</td>
</tr>
<tr>
<td>Leisure activities**</td>
<td>80.1 (52.1, 93.7)</td>
<td>10.2 (3.8, 24.3)</td>
</tr>
<tr>
<td>Total impairment</td>
<td>35.0 (8.7, 75.3)</td>
<td>43.9 (18.7, 72.7)</td>
</tr>
</tbody>
</table>

** p < .01 for Chi-square analyses
* p < .05 for Chi-square analyses
Table 4.4 Results of Multivariate Logistic Regression for Prediction of Impairment

<table>
<thead>
<tr>
<th></th>
<th>OR (95% Confidence Interval)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-cases</td>
<td>Subthreshold cases</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>1.5 (0.5, 4.7)</td>
<td>0.3 (0.1, 1.0)</td>
</tr>
<tr>
<td>Males</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>ADHD medication use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>9.8 (1.8, 54.6)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>No</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Psych comorbidity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>2.1 (0.4, 11.9)</td>
<td>0.8 (0.2, 2.7)</td>
</tr>
<tr>
<td>No</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Primary parent psych Problem history</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>4.1 (1.4, 12.3)</td>
<td>0.7 (0.2, 2.5)</td>
</tr>
<tr>
<td>No</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Primary parent educational attainment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;Bachelors degree</td>
<td>2.1 (0.6, 7.0)</td>
<td>3.0 (0.9, 10.6)</td>
</tr>
<tr>
<td>≥Bachelors degree</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>
MANUSCRIPT II: MEDICATION USE WITHIN THE CONTEXT OF ADHD AND SUBTHRESHOLD ADHD: DEVELOPMENTAL COURSE AND PREDICTORS IN A COMMUNITY SAMPLE

2 Lorie L. Geryk, MPH, Ken W. Watkins, PhD, Joseph R Holbrook, PhD, Steven P. Cuffe, MD, Daniela B. Friedman, PhD, Robert E. McKeown, PhD. Formatted for submission to the Journal of Child Psychology and Psychiatry
Abstract

Background. Despite a substantial prevalence of subthreshold ADHD and research indicating that many youth with subthreshold ADHD are being treated with ADHD medication, little is known about patterns of symptom and impairment change in relation to medication status and predictors of medication use. Methods. A community-based sample composed of children at high-risk for ADHD and low-risk peers (frequency-matched on gender) were identified through screening and invited to in-person interviews. At two assessments periods, baseline (N=270) and follow-up (N=163) parents/caregivers of youth with probable ADHD or subthreshold ADHD completed measures related to the youth’s psychiatric symptom and functional impairment status and supplemental questionnaires examined socio-demographic information and child and family risk factors. At baseline, children were identified who met symptom criteria for subthreshold ADHD (N=84) and probable ADHD (186) and patterns of change in symptoms and functioning based on medication status were examined at follow-up (starting 20 months years later) using a Reliable Change Index (RCI) and Chi Square tests. A supplementary analysis investigated predictors of ADHD medication use.

Results. ADHD medication data for this cohort showed that 19% (n=21) of youth with subthreshold ADHD at baseline and 27% (n=14) of youth with subthreshold ADHD at follow-up) and 42% (n=109) of youth with probable ADHD at baseline and 41% (n=65) of youth with probable ADHD at follow-up had taken medication in the year prior to
assessment. Thirty three percent (N=15) of youth who were subthreshold ADHD at baseline retained that status at follow-up and showed significant decline in function. When considering medication status among those individuals, 50% of the medicated youth declined in overall functioning at follow-up compared to 10% of those who were not medicated the year prior to follow-up. Baseline youth with probable ADHD who were not medicated the year prior to follow-up and who were non-ADHD cases at follow-up were significantly more likely than probable ADHD at follow-up to decline functionally in distress/intrapersonal and friendships; they were also more likely to decline in leisure activities compared to youth with subthreshold ADHD at follow-up. Parent perceived burden was predictive of ADHD medication use for youth with probable ADHD but significantly so for youth with subthreshold ADHD. Conclusions. The findings show the importance of examining symptom and functional impairment constructs separately in the consideration of their unique contributions to ADHD and subthreshold ADHD diagnoses and of acknowledging the need to more closely examine nuanced changes in diagnostic status and medication needs during development, taking impairment, more so than symptoms into account. These findings may be relevant to efforts to intervene earlier in childhood and to help identify high-risk individuals who may be good candidates for targeted interventions. Key words: Attention Deficit Hyperactivity Disorder, Subthreshold ADHD, symptom and impairment trajectories, predictors of impairment. Abbreviations: RCI, reliable change index; ADHD, attention-deficit/hyperactivity disorder; DISC-IV, Diagnostic Interview Schedule for Children version IV; SDQ, Strengths and Difficulties Questionnaire; DSM-IV, Diagnostic and Statistical Manual-IV; OR, odds ratio; 95% CI, 95% confidence interval.
Introduction

Inattention, hyperactivity/impulsivity, or the combination of the two impairs an individual's ability to adjust to a continually changing environment; and impairment may be a direct consequence (Nijmeijer et al., 2008). It is clear from the literature that deficiencies in functional impairment occur in individuals with ADHD at all ages across multiple domains (e.g. social, academic) (Sciberras, Roos, & Efron, 2009). ADHD is a persistent condition for many, and although symptoms tend to diminish and show different patterns over time (Holbrook, 2012), symptom declines do not necessarily result in a return to normal function (Willoughby, 2003).

Children and adolescents who fail to achieve full ADHD diagnosis or full remission, a group referred to as subclinical, subsyndromal, or subthreshold (among other terms), are at risk for developing ADHD (Barnard-Brak, To, & Fearon, 2011; Bussing, Mason, Bell, Porter, & Garvan, 2010). While the literature lacks clear definitions of these terms, the ADHD literature often considers subthreshold ADHD to be three to five symptoms of either the inattentive or hyperactive/impulsive symptoms (using the DSM-IV ADHD diagnostic criteria) and the current analyses adopts this specific definition.

Subthreshold ADHD is more common than ADHD (Lewinsohn, Shankman, Gau, & Klein) with up to 22% of youth exhibiting subthreshold ADHD symptoms (Scahill, et al., 1999). Compared to individuals without ADHD, individuals with subclinical ADHD have worse educational, occupational, economic, and social outcomes (e.g. grade retention, not graduating, divorce, lower incomes) (Bussing, et al., 2010; Klein et al., 2012). Further, children with subthreshold ADHD may be denied treatment and services based on current policies (Bussing, Mason, Bell, Porter, & Garvan, 2010; Canino, Costello, & Angold,
Recent ADHD treatment intervention studies have shown that change in function occurs in the absence of symptom change and vice versa (Karpenko, Owens, Evangelista, & Dodds, 2009; Owens, Johannes, & Karpenko, 2009). Further, research shows that decreasing symptom burden is not always associated with improved functional status, whereas increasing symptom burden is more likely to be associated with functional decline (Owens, et al., 2009). For research, referral, treatment, and intervention purposes it is important to identify children who make reliable change in both symptom and impairment change, as well as those who make change in only one area (Owens, et al., 2009). To date, research is lacking in this area and very little is known about longitudinal patterns of symptom and functional impairment change for youth with subthreshold ADHD.

Symptom and impairment developmental trajectories can be improved through early identification and appropriate treatment of ADHD (Magyary & Brandt, 2002). A range of medication options exists for the treatment of ADHD, with stimulant medications [e.g. Ritalin (i.e., methylphenidate) and Adderall (i.e., dextroamphetamine)] generally considered superior to nonstimulant medications (e.g. Strattera (i.e., atomoxetine)) (Action; Vierhile, Robb, & Ryan-Krause, 2009). ADHD medication reduces ADHD symptoms (e.g., fidgeting and interrupting) as well as impairment (e.g., relationships at home with parents) in about 70% of youth (Action, 2002). In 2007, 66% of youth (ages 4-17) received medication treatment for a current ADHD diagnosis (Visser & Lesesne, 2005). Youth aged 11-17 had higher mediation rates than children aged 4-10, and boys were more likely than girls to take medication (Visser & Lesesne, 2005).
Treating Children with Subclinical ADHD

The subject of treating children diagnosed as subthreshold ADHD is controversial. Data suggest that, compared to children meeting full ADHD symptom counts, fewer children meeting subthreshold symptoms counts are treated with medication (Bussing, et al., 2010). One study, using retrospective recall data among adults, considered four subgroups (full ADHD/subthreshold ADHD/late-onset ADHD/controls) and found among the subthreshold group, 19% had ever received psychotropic medication for ADHD, compared to 58% of the group with full ADHD (Faraone et al., 2006). In another study, 25% of youth with subthreshold ADHD reported ever being treated with medication for ADHD, compared to 50% of youth with ADHD (Bussing, et al., 2010). While one would expect lower rates of medication treatment among individuals with diminished forms of ADHD compared to ADHD, some question the appropriateness of treating this group at all (Faraone, et al., 2006), while others reason that increasing medication rates among subthreshold cases may reduce the risk for negative functional outcomes (Bussing, et al., 2010).

Predictors of Service Use

Several studies have examined predictors of treatment utilization for youth with ADHD and only a few studies have examined predictors of treatment utilization for youth with subthreshold ADHD. Research shows service contact for ADHD is often made because of parent’s perception of problems (perceived burden) or parental strain rather than child factors such as comorbidity (Angold et al., 1998; Bussing et al., 2003; Sayal, 2006). Additional predictors of treatment seeking and service use for children with ADHD include male gender (Beuermeister, 2003; Gau et al., 2010; Bussing, 2005),
maternal education (college or higher) (Gau et al., 2010), parental mental health history, marital status (divorced) (Jensen, Bloedau, and Davis, 1990), and younger age (Leslie et al., 2005).

Of the few studies that have considered a subclinical ADHD group, two studies found subclinical ADHD (defined three different ways, and not including individuals who met impairment criteria) predicted stimulant medication use (Bauermeister et al., 2003; Leslie, et al., 2005). Reich et al. found that among comparison children, ADHD symptom counts and presence of impaired functioning were significant treatment correlates (Reich, Huang, & Todd, 2006). Similarly, Angold et al. found among the ADHD-NOS group, stimulant medication use was significantly related to number of symptoms and comorbid Oppositional Defiant Disorder (ODD) (Angold, Erkanli, Egger, & Costello, 2000). To our knowledge, no study has examined parent perceived burden as a predictor of medication use for youth with subthreshold ADHD.

**Study Purpose**

It is not clear from the literature if youth with subthreshold ADHD who are unmedicated fare particularly worse over time compared to individuals with subthreshold ADHD who are taking ADHD medication. To our knowledge, there are no published studies that have examined how medication use within the context of ADHD and subthreshold ADHD unfolds with regard to patterns of symptom and impairment change. The main purpose of this study is to discern prospective patterns of symptoms and functional impairment change in a community sample of youth with subthreshold ADHD and youth with ADHD, with regard to medication status (taking medication versus not taking medication). Additionally, this study evaluates predictors of ADHD medication
use for youth with subthreshold ADHD compared to youth with ADHD. This research adds to the existing understanding of subthreshold ADHD and explores symptom and functioning correspondence methodology that can be useful in identifying patterns that have important implications for conceptualizing treatment in research and practice for youth with subthreshold ADHD. It is also designed to identify more homogeneous subgroups with a higher likelihood of experiencing service utilization.

**METHODS**

**Recruitment and Sampling**

SCPLAY utilized a two-phase research design involving school district-wide, voluntary teacher and parent screenings (phase I) and in-person assessments (phase II). In person assessments involved (structured diagnostic interviews with youth and parents/caregivers at baseline and four follow-up points. Baseline interviews were conducted with consenting parents/caregivers and children 13 months (mean time) following the screening. Further explanation of the SCPLAY study population, design, sampling frame, and methods can be found elsewhere (M. L. Wolraich et al., 2012). SCPLAY study procedures were approved by the Institutional Review Board of the University of South Carolina and the Centers for Disease Control and Prevention and informed parental consent obtained for all interviews.

**Participants**

Data for these analyses were obtained from SCPLAY baseline (n=481; 9/03-1/06) and follow-up parent assessments (n=292; 9/07-2/09). Parent/caregiver [a biological parent in 426 out of 481 (89%) baseline families] provided family demographic and psychosocial information, mental health history, information about the selected child
related to ADHD symptoms and impairment, other psychiatric disorders, and treatment history via computer-based (interviewer administered) interview, and paper and pencil (self-administered) questionnaires.

Using the Diagnostic and Statistical Manual of Mental Disorders, 4th edition, (DSM-IV-TR) symptom criteria for ADHD, youth were categorized into two symptom groups: probable ADHD cases (≥ 6 Inattentive (IA) symptoms or ≥ 6 hyperactive/impulsive (HI) symptoms) and subthreshold ADHD cases (3-5 IA symptoms or 3-5 HI symptoms). After categorization, 69% (n=186) of the sample met inclusion criteria for probable ADHD and 31% (n=84) met inclusion criteria for subthreshold ADHD. These categories only consider symptoms counts and do not correspond to previously published prevalence estimates that used a strict DSM-IV-TR ADHD case definition (Wolraich et al., 2012). The final baseline sample for these analyses is 270 of the original 481, with 260 parents/caregivers completing the SDQ impact supplement at follow-up. The baseline samples are introduced in Table 4.2.1. Comparison of the retained sample versus those lost to attrition revealed no statistically significant differences related to baseline demographic and psychosocial variables.

Measures

The Diagnostic Interview Schedule for Children (DISC-IV; Shaffer et al., 2000). The DISC-IV, based on the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV-TR) (Association & DSM-IV., 2000), is a well-validated, fully-structured diagnostic interview developed to diagnosis psychopathology in youth (Shaffer, Fisher, Lucas, Dulcan, & Schwab-Stone, 2000). Parents were administered the DISC-IV by a trained interviewer during baseline and the first follow-up annual
assessments to obtain past year ADHD symptom counts and past year categorical probable diagnosis for ODD and CD. The test-retest reliability of the ADHD DISC-IV module (parent report) in a clinical sample and community sample (past year) among children aged 9-17 years was $k=.79$ and $k=.60$, respectively (Shaffer, et al.). The DISC showed moderate to good validity across a number of diagnoses, including ADHD (Schwab-Stone, Shaffer, Dulcan, & Jensen, 1996). Parent interview was used because research has shown low test-retest reliability in the child DISC interview (Schwab-Stone, et al., 1996).

**ADHD Medication Status.** One dichotomous medication status variable was created from the following item on the DISC-IV interview, “In the past twelve months, has your child taken any medicine for being overactive, being hyperactive, or having trouble paying attention?” Based on a subsample on whom we have detailed medication data ($n=458$), 14.6% of the subthreshold ADHD sample at baseline were taking stimulant medication and 4.3% were taking non-stimulant medication; 32.6% of the probable ADHD sample at baseline were taking stimulant medication and 13.6 were taking non-stimulant medication.

**The Strengths and Difficulties Questionnaire (extended version) (SDQ)** (Goodman, 2000). The SDQ (extended version) is a domain-specific behavioral screener consisting of 25 symptom items assessing five subscales: behavioral problems, emotional problems, hyperactivity, peer-problems, and prosocial behavior and seven “impact questions” assessing difficulties in functioning (i.e., school and classroom settings) associated with reported symptoms (Goodman, 1999). The SDQ is one of a few measures of functional impairment that was specifically developed to assess impairment in relation
to ADHD and other psychiatric symptomatology. For these analyses, only the parent version impact questions from the extended version of the SDQ were examined (baseline and follow-up assessments).

For the first impact question “Overall, do you think that (child’s name) has difficulties in any of the following areas: emotions, concentration, behavior, or being able to get along with other people?”, responses included ‘no,’ ‘minor,’ ‘severe,’ and ‘definite’; if respondents reported at least “minor” problems, then the following impact questions related to five domains of functioning were asked: Question 1. “Do the difficulties upset or distress the child?”; Questions 2.-5. “Do the difficulties interfere with the child’s life in the following areas: 2. home life?; 3. friendships?; 4. classroom learning?; 5. leisure activities? One additional impact supplement item asked if the reported difficulties put a burden on the family (response options are the same as for the five functional impairment questions). The five impairment items scores were summed to create a total impairment score. Individual domains of functioning and total impairment were used to assess reliable change in functioning from baseline to follow-up using a reliable change index (RCI; described below) (Jacobson & Truax, 1991).

The SDQ is well-validated, and reliability and validity data are summarized in two reports by the author (Goodman, 1999, 2001). For the impact supplement, the parent version has high internal consistency (Cronbach alpha coefficient = .85), good 4-6 month retest stability (Impact/impairment score; .57), and good validity (negative predictive value (NPV) = .95; positive predictive value (PPV) = .53)(Goodman, 2001).

Predictors of taking ADHD medication during the last year. Predictor

Variables: Several baseline factors were examined as predictors of ADHD medication
utilization. Child demographic and psychosocial variables included age, gender, race (Non-Hispanic white vs. Non-Hispanic Black vs. Other) (all three variables ascertained from parental reports on the demographic questionnaire); comorbidity (ODD/CD were coded as separate dichotomous variables) (ascertained form parent DISC-IV report); and, severe impairment (present if at least one of the five SDQ domain question responses was “a great deal” or if two or more question responses were “a medium amount”) (ascertained using parent SDQ report). Additionally, the following family factors were examined as predictors of ADHD medication utilization: marital status (dichotomized as married or unmarried), primary caregiver’s education level (dichotomized as less than a bachelor degree or a bachelor degree and higher), insurance (none vs. private insurance vs. Medicaid), (all three variables ascertained from parental reports on the demographic questionnaire); parental psychopathology (coded as a dichotomous variable) (ascertained from parent report on a mental health history questionnaire); and, parent-reported burden based on the SDQ question (treated dichotomously coded as “present” (“medium amount” or “great deal”) or “absent” (“not at all” or “a little”).

Procedures/Analysis:

All analyses were performed using SAS-callable SUDAAN version 10.0 software to adjust for the complex sampling design. Basic descriptive statistics were calculated and prevalence of treatment utilization reported. Raw frequencies and weighted percentages accounting for the sampling scheme are reported for all results. Procedures outlined in Jacobson and Traux’s (1991) methodology for creating a reliable change index (RCI) were used to determine which youth met criteria for reliable change in impairment (using the five functional domains from the SDQ data) in relation to
symptom category (subthreshold ADHD and probable ADHD) change from baseline to follow-up (considering ADHD medication status).

While other comparable statistical methods exist, researchers encourage use of this method for study comparison purposes (Karpenko, et al., 2009). The following formula for reliable change (RC) as outlined by Jacobson and Traux was used:

\[
RC = \frac{X_{post} - X_{pre}}{S_{diff}}; S_{diff} = \sqrt{2(S_E)^2}
\]

\[S_E = SD_1\sqrt{1 - r_{xx}}\]

The RCI method described by Jacobson and Traux (1991) was used to divide the baseline by follow-up differences for each participant by the standard error (SE) of the difference score for each domain of functioning. This allowed for the identification of individual change (significance level set to \(p \leq 0.05\)) that is greater than what would be attributed to chance or measurement error (Jacobson, Roberts, Berns, & McGlinchey, 1999).

Descriptive percentages were used to compare proportions of change (i.e., improvement, no change, and decline) in symptom categories and functional impairment measures (five domains and overall impairment) among symptom groups. SDQ scores \(\geq 1.96\) reflected positive change (i.e., impairment increased); scores \(\leq -1.96\) reflected negative change (e.g. impairment decreased); and, scores between 1.96 and -1.96 reflected no impairment change. Participants were then classified as “functionally improved” (i.e., significant positive change), “no change” (i.e., no significant change), and “functionally declined” (significant negative change). Further, chi-square tests were
used to determine if there was a significant association between improvement in symptoms and improvement in functioning.

A multivariable logistic regression analysis was used to examine which variables were independently predictive of ADHD medication use in multivariate models, using forward stepwise entry of variables of most interest to this study. Adjusted odds ratios and 95% confidence intervals (CIs) were computed to investigate the strength of the relationships.

**Results**

The sample was ethnically and gender diverse with non-Hispanic blacks and girls being well represented at baseline (38% and 31%) and follow-up (39% and 34%), respectively. At baseline, youth ranged in age from 5-13 (mean 9.4) and at follow-up youth ranged in age from 7-15 (mean 11.8). Thirty two percent of youth had comorbid ODD and/or CD at baseline and 30% of youth had comorbid ODD and/or CD at follow-up. Forty eight percent of youth were taking ADHD medication at baseline and 50% of the follow-up sample was taking ADHD medication. Among youth with subthreshold ADHD at baseline, 19% were taking ADHD medication the year prior to baseline compared to 42% of probable ADHD youth who were taking ADHD medication the year prior to baseline. At follow-up, 27% of youth with subthreshold ADHD and 41% of youth with probable ADHD were taking ADHD medication the year prior to follow-up.

After establishing medication status and symptom category change from baseline to follow-up, RCI was used to distinguish individuals who made a statistically reliable change in each domain of functioning (and overall impairment) from baseline to follow-up. The relation between symptom category change (decrease, no change, and increase)
for individuals with probable ADHD and subthreshold ADHD, and functional impairment change (individual domains and overall impairment) was analyzed through a series of chi-square tests. The percentage of children demonstrating patterns of symptom change (increased, no change, and decreased) (based on medication status) and impairment change (five domains of functioning and overall impairment) is shown in Tables 4.2.2 (functional decline/subthreshold at baseline), 4.2.3 (functional decline/probable ADHD at baseline), 4.2.4 (functional improvement/subthreshold at baseline), and 4.2.5 (functional improvement/probable ADHD at baseline).

Baseline youth with subthreshold ADHD who were not medicated the year prior to follow-up and who were probable ADHD cases at follow-up were significantly more likely to improve functionally than subthreshold ADHD at follow-up in classroom learning. Baseline youth with subthreshold ADHD who were not medicated the year prior to follow-up and who were subthreshold ADHD cases at follow-up were significantly more likely to improve functionally than probable ADHD at follow-up in total impairment. Baseline youth with subthreshold ADHD who were not medicated the year prior to follow-up and who were non-ADHD cases at follow-up were significantly more likely to decline functionally than probable ADHD cases and subthreshold cases at follow-up in distress/intrapersonal impairment. Baseline youth with probable ADHD who were not medicated the year prior to follow-up and who were non-ADHD cases at follow-up were significantly more likely to decline functionally than probable ADHD and subthreshold ADHD at follow-up in distress/intrapersonal impairment and friendships; they were also more likely to decline in leisure activities compared to youth with subthreshold ADHD and probable ADHD at follow-up.
PREDICTORS OF MEDICATION USE

Multivariable Models – Subthreshold ADHD and Probable ADHD

Multivariate regression models were used to identify whether any of the measured independent variables (overall impairment, parent perceived burden, conduct disorder and/or oppositional defiant disorder, gender, race/ethnicity, parent mental health history, age, primary parent education, and insurance) might predict ADHD medication use for youth with subthreshold ADHD and probable ADHD (Table 4.2.6). In the subthreshold ADHD model, parent perceived burden was positively associated with medication use. In the probable ADHD model, females were less likely than males to take medication. Overall impairment and comorbid CD/ODD were not significantly related to ADHD medication use. Race/ethnicity, parent mental health history, age, primary parent education, and insurance were also added to the models individually but were dropped due to lack of change in the point estimates of other variables before and after their addition to the models.

Discussion

In an attempt to consider ADHD dynamics in a more nuanced way, this study considered symptom and functioning change without using narrowly-defined DSM subtype, age of onset, and impairment (two or more settings) diagnostic criteria. This study is one of a relatively few prospective community-based studies following a diverse sample of youth with ADHD and subthreshold ADHD examining patterns of change in symptoms and functioning, considering ADHD medication status. Chi-square analyses showed that youth with subthreshold ADHD at baseline (and not medicated the year prior to follow-up) who were probable ADHD cases at follow-up were significantly more
likely to improve functionally in classroom learning compared to subthreshold ADHD cases at follow-up. Youth at baseline with subthreshold ADHD (and not medicated the year prior to follow-up who were subthreshold ADHD at follow-up were significantly more likely to improve functionally overall compared to youth with probable ADHD at follow-up. Considering medication status, one would expect individuals in the probable ADHD unmedicated group, who had increased symptoms from baseline subthreshold status) to show less improvement than individuals with unmedicated subthreshold ADHD at follow-up (no change from baseline); and this is evident in overall impairment (significant in chi square testing) and other measures of functioning (while not significant in chi-square testing), with more subthreshold youth (than probable ADHD youth) at follow-up showing greater positive change in improvement in the areas of home life and friendships.

A different trend was seen among youth with probable ADHD at baseline who were not medicated the year prior to follow-up and non-ADHD cases at follow-up. Those individuals were significantly more likely to decline functionally than probable ADHD at follow-up in distress/intrapersonal and friendships domains and more likely to decline in leisure activities compared to youth with subthreshold ADHD and probable ADHD at follow-up. These findings, that decreasing symptoms are associated with functional decline may be explained by research suggesting that although symptoms tend to diminish over time, symptom declines do not necessarily result in a return to normal function (Willoughby, 2003). Further, impairment may increase over time as demands increase and through an additive process; with impairment becoming more noticeable as children age and acquire more autonomy (Adler, Spencer, Stein, & Newcorn, 2008).
In line with the declining symptom with increasing impairment trend, baseline youth with subthreshold ADHD who were not medicated the year prior to follow-up and who decreased symptoms (i.e., were non-ADHD cases at follow-up) were significantly more likely to decline functionally than probable ADHD cases at follow-up in distress/intrapersonal impairment. This group (N=11) of youth with non-ADHD at follow-up showed some functional decline in the areas investigated (e.g. 75% in classroom learning and 34% in overall impairment) which is concerning. It may be that these individuals, while they no longer meet symptom criteria for subthreshold ADHD, are suffering from remaining ADHD symptoms and/or other impairing disorders or psychosocial circumstances.

Considering the medicated versus nonmedicated groups, the subthreshold baseline group who were probable ADHD at follow-up (and taking ADHD medication the year prior to follow-up) improved more functionally in the areas of intrapersonal, friendships, and classroom than those youth with probable ADHD at follow-up who were not medicated. The subthreshold baseline group who were subthreshold ADHD at follow-up and were taking medication the year prior to follow-up improved more functionally in the intrapersonal domain compared to those youth with subthreshold ADHD at follow-up who were not medicated. Youth who were probable ADHD at baseline and subthreshold ADHD at follow-up who were medicated the year prior to follow-up declined 14% in overall impairment at follow-up compared to those who were not medicated the year prior to follow-up (53% decline in overall impairment). This trend was similar for youth who were probable ADHD at baseline and remained probable ADHD at follow-up; 23%
of the medicated group declined in overall impairment compared to 44% of the unmedicated group.

While most ADHD medication treatment studies only consider symptom change, a review of the literature including studies assessing improvements in functioning found medication use versus no medication use is associated with greater rates of symptom remission and increased social and academic functioning (Steele, Jensen, & Quinn, 2006). While those findings show evidence of improvements in functioning with medication use, as described in the previous paragraph, this analysis showed youth with subthreshold ADHD at baseline and medicated the year prior to follow-up tended to decline functionally to a greater degree in four out of five domains of functioning and overall functioning compared to youth with subclinical ADHD at follow-up who were not medicated. Youth who were subthreshold ADHD who were probable ADHD at follow-up and medicated the year prior to follow-up also tended to decline functionally to a greater degree in three out of the five domains and overall functioning compared to youth with probable ADHD at follow-up who were not medicated. Individuals presenting with severe impairment may show less overall improvement in functional impairment measures over time. Additionally, medication treatment compliance may be as low as 50% in children with ADHD (Johnston & Fine, 1993) which may result in poor management of symptoms and functional impairment (Perwien et al., 2004).

In the present study we calculated a reliable change index (RCI) (Jacobson and Truax, 1991) to determine statistically significant functional impairment change. RCI has been applied to intervention and drug trial studies in the ADHD literature, and these data show the value of considering longitudinal community based symptom and functioning
trajectory data using the RCI method. RCI should not be confused with clinical significance which is often defined as a return to normal functioning (Jacobson, et al., 1999). With the understanding that ADHD is a persistent neurobiological disorder, we did not calculate clinical significance. If, in fact, remission should be the goal of ADHD medication treatment (Steele, et al., 2006), future research should evaluate if the Jacobson & Traux CS method would be too stringent a criterion to use with medicated and non-medicated youth with ADHD and subthreshold ADHD in community samples.

**Predictors of Medication Use**

The longitudinal data used here offered the opportunity to consider predictors of ADHD medication use among subthreshold ADHD and probable ADHD symptom categories. Self-referral in childhood is rare and only a small proportion of children with ADHD are receiving treatment, so having ADHD does not fully explain treatment seeking (Angold, et al., 1998). Most notable among the findings in this study was parent perceived burden was predictive of ADHD medication use for youth with probable ADHD but significantly so for youth with subthreshold ADHD. In these data, parent burden more so than youth clinical factors (i.e., comorbidity and overall impairment) predicted medication use. This finding for subthreshold ADHD is novel and in line with research showing parental strain or perceived burden more than symptoms (Angold, et al., 1998) or comorbid conditions (including ODD and CD) (Angold, et al., 1998; Bauermeister, et al., 2003) is a major reason for service contact for ADHD (Farmer, Stangl, Burns, Costello, & Angold, 1999). Additionally, the finding that overall impairment was not a significant predictor of medication use for either youth with
subthreshold ADHD or probable ADHD was surprising, and not in line with other research findings (Reich, et al., 2006; Zuvekas, Vitiello, & Norquist, 2006)

Similar to other studies, these data show being male significantly predicted ADHD medication use for youth with probable ADHD (Bauermeister, 2003; Gau et al., 2010; Bussing, 2005), however, while not significant, females with subthreshold ADHD were more likely to take ADHD medication than males with subthreshold ADHD. This finding was not expected as girls, especially those with inattention problems are more likely to be under-referred, and less likely to be treated than boys (Hinshaw & Blachman, 2005; Staller & Faraone, 2006).

**Study Limitations & Strengths**

As with any study, the current findings are not without limitations. The SDQ is a domain specific measure (assessing impairment in relation to symptoms of multiple disorders) (Canino, et al., 1999) so there is no way to know which symptoms, if any, are directly related to the reported impairment. However, using the DISC-IV (a symptom specific measure), was not possible because if the symptom criteria, duration criteria, or age of onset criteria for ADHD are not met, the functional impairment questions are never asked and subthreshold ADHD impairment could not be assessed. Symptom specific measures of impairment are needed that are not limited by those constraints. Additionally, domains of functioning were measured using a single SDQ item. While this does not allow for extensive detail, the SDQ is a well validated measure, is practical to administer, and captures multiple domains of functioning that can help inform developmental trajectory research as well as referral and service decisions.
The use of only parent/caregiver report is another limitation, as the DSM-IV recommends the use of multiple informants and the American Academy of Pediatrics recommends the need for both parent and teacher report of functional impairment (American Psychiatric Association, 2000; M. Wolraich, Brown, & Brown, 2011). Teacher reports of functional impairment were collected, but not used due to poor follow-up response rates. Parent subjectivity introduces bias (e.g., underreport due to social desirability, over-report due to help-seeking, endorse symptoms that affect them the most, and may be more reliable reporters for younger children) (Barkley, 2006). While there is often disagreement among multiple informants and subjective bias in parent report, parents are thought to be crucial for a valid assessment of ADHD (Barkley, Fischer, Smallish, & Fletcher, 2002; Cantwell, Lewinsohn, Rohde, & Seeley, 1997).

Symptom decreases over time might reflect true developmental changes, but also may be due to other things such as artifacts of repeated measurement (Hart, Lahey, Loeber, Applegate, & Frick, 1995) and diagnostic inadequacies (e.g., applying symptoms that are not developmentally sensitive) (Willoughby, 2003). Additionally, the relationship between symptom change and impairment in specific domains may be a function of the treatment or care that individuals were provided, comorbidity, or other factors. While the impact of such factors is not known, and the findings are constrained by unadjusted percents and small numbers, this study provides some of the only data available describing symptoms and functional impairment for youth in a community setting.

Another limitation of this study is the number of participants lost to follow-up. If those individuals were less or more likely to have ADHD symptoms or to take medication, the findings are less likely to be representative of the initial sample. Also,
due to the low prevalence rate of ADHD medication use in this sample the estimates of these predictor variables may not be precise. Finally, as the course of ADHD and subthreshold ADHD is continually changing, one’s symptom and impairment status at baseline and follow-up may not be static and future studies exploring changes in patterns of ADHD symptoms and functioning are needed that use repeated observations.

This study adds to an absence of population-based longitudinal impairment data of children with subthreshold ADHD who are identified in early childhood and followed into adolescence. While most ADHD trajectory studies consider only patterns of symptom change over time, this study considered patterns of change for both symptoms and functioning. It utilized well validated instruments, trained data collectors, and extensive data quality control measures. Study sampling design increased case finding and analysis accounted for sampling design to give unbiased estimates. It used a prospective design with a retention rate of 61% at follow-up. In addition to being cross sectional in nature, most studies focus on children, and this study followed youth up to age 15. This was a community-based rather than clinic-based study, which is a strength, as clinic-based youth are likely to have more severe symptom and functional impairments than youth in the community (Gau, et al., 2010) and may result in higher treatment seeking rates (Rowland, Lesesne, & Abramowitz, 2002). White boys account for the majority of research related to ADHD in youth (Hartung & Widiger, 1998) and girls and African American youth are well represented in this study.

Clinical Significance

Improved understanding of functional improvements and declines in the developmental characteristics related to symptom and impairment change in individuals
with ADHD and individuals with subthreshold ADHD will help clinicians who advise caregivers on matters related to treatment course and prognosis. Impairments are multidimensional in nature and not static. Assessing specific domains of functioning helps identify impaired areas to be used for referral, intervention starting points (Sayal, 2006) and modifications in ongoing treatment plans. Considering overall impairment provides a global assessment of functioning which can be clinically beneficial (Fabiano & Pelham, 2009), especially when considering overall degree of improvement or decline over time. In addition to helping define intervention needs and to show functional change over time, the SDQ impact supplement is a useful measure of difficulties prompting caregivers to seek help for their children and their impact (Ford, Hutchings, Bywater, Goodman, & Goodman, 2009). This study highlights the need for clinicians to consider diagnosis in a nuanced way, paying particular attention to unique individual changes in both symptom and functioning over time.

Logistic regression findings underscore the importance of understanding child and family factors associated with taking ADHD medication. Prior work has not included parent perception of burden when assessing risk factors of medication use for youth with subthreshold ADHD. Identifying parent burden provides an opportunity for clinicians to discuss parental perceptions of burden and address parent support needs alongside discussion and consideration regarding medication therapy need. Additionally the identified significant predictors of medication use are child and family factors that are not difficult for clinicians to ascertain and add to the small existing data available in the literature on this subject.
REFERENCES


Table 4.5 Demographics of Sample by Baseline ADHD Status; 
Raw Frequencies and Weighted Percents

<table>
<thead>
<tr>
<th>Subthreshold Cases</th>
<th>Probable cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
</tr>
<tr>
<td>Age in years (mean, range)</td>
<td>9.5 (5-12)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>59</td>
</tr>
<tr>
<td>Girls</td>
<td>25</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
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</tr>
<tr>
<td>Non-Hispanic White</td>
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</tr>
<tr>
<td>Non-Hispanic Black</td>
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<tr>
<td>Other</td>
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<tr>
<td>Insurance</td>
<td></td>
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<tr>
<td>None</td>
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<td>Private insurance</td>
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<td>Medicaid</td>
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<td>Yes</td>
<td>13</td>
</tr>
<tr>
<td>No</td>
<td>70</td>
</tr>
<tr>
<td>ADHD medication</td>
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<td>Yes</td>
<td>21</td>
</tr>
<tr>
<td>No</td>
<td>63</td>
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<td>Parent mental health history</td>
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<tr>
<td>Yes</td>
<td>14</td>
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<tr>
<td>No</td>
<td>69</td>
</tr>
<tr>
<td>Parent education level</td>
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<tr>
<td>Less than bachelors degree</td>
<td>54</td>
</tr>
<tr>
<td>At least bachelors degree</td>
<td>28</td>
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</table>
Table 4.6 Baseline to Follow-up Symptom Change and Corresponding SDQ Impairment Change (Functionally Improved) by Medication Status

<table>
<thead>
<tr>
<th>Subthreshold at Baseline (n=46)</th>
<th>Medicated year prior to follow-up (n=14)</th>
<th>Not Medicated year prior to follow-up (n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Decrease in sx (non-ADHD at follow-up)</td>
<td>No change in sx (subthreshold ADHD at follow-up)</td>
</tr>
<tr>
<td></td>
<td>(n=2)</td>
<td>(n=6)</td>
</tr>
<tr>
<td><strong>Baseline SDQ Impairment</strong></td>
<td>% who improved functionally (95% CI)</td>
<td>% who improved functionally (95% CI)</td>
</tr>
<tr>
<td>Distress/intrapersonal</td>
<td>14.2 (1.2, 68.5)</td>
<td>25.2 (6.3, 62.8)</td>
</tr>
<tr>
<td>Home life</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Friendships</td>
<td>14.2 (1.2, 68.5)</td>
<td>0.0</td>
</tr>
<tr>
<td>Classroom learning</td>
<td>0.0</td>
<td>12.9 (2.1, 51.0)</td>
</tr>
<tr>
<td>Leisure activities</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Total impairment</td>
<td>0.0</td>
<td>24.0 (6.0, 61.0)</td>
</tr>
</tbody>
</table>

** p < .01 for Chi-square analyses
* p < .05 for Chi-square analyses
Table 4.7 Baseline to Follow-up Symptom Change and Corresponding SDQ Impairment Change (Functionally Improved) by Medication Status

<table>
<thead>
<tr>
<th>ADHD at baseline (n=103)</th>
<th><strong>Medicated year prior to follow-up (n=58)</strong></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Decrease in sx</td>
<td>Decrease in sx</td>
<td>No change in sx</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(non-ADHD at follow-up)</td>
<td>(subthreshold ADHD at follow-up)</td>
<td>(probable ADHD cases at follow-up)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(n=4)</td>
<td>(n=11)</td>
<td>(n=43)</td>
<td></td>
</tr>
<tr>
<td>Baseline SDQ Impairment</td>
<td>% who improved functionally (95% CI)</td>
<td>% who improved functionally (95% CI)</td>
<td>% who improved functionally (95% CI)</td>
<td></td>
</tr>
<tr>
<td>Distress/intrapersonal</td>
<td>51.0 (15.5, 85.6)</td>
<td>17.6 (3.3, 57.3)</td>
<td>17.2 (9.1, 30.1)</td>
<td></td>
</tr>
<tr>
<td>Home life</td>
<td>31.1 (5.8, 76.7)</td>
<td>7.3 (1.3, 32.7)</td>
<td>19.5 (10.6, 32.9)</td>
<td></td>
</tr>
<tr>
<td>Friendships</td>
<td>31.1 (5.8, 76.7)</td>
<td>37.3 (14.7, 67.2)</td>
<td>21.9 (12.6, 35.2)</td>
<td></td>
</tr>
<tr>
<td>Classroom learning</td>
<td>0.0</td>
<td>7.0 (1.2, 32.1)</td>
<td>18.7 (8.4, 36.5)</td>
<td></td>
</tr>
<tr>
<td>Leisure activities</td>
<td>55.3 (17.9, 87.5)</td>
<td>32.5 (11.6, 63.7)</td>
<td>19.6, 10.8, 32.8)</td>
<td></td>
</tr>
<tr>
<td>Total impairment</td>
<td>0.0</td>
<td>0.0</td>
<td>18.8 (8.3, 37.0)</td>
<td></td>
</tr>
</tbody>
</table>

| Not Medicated year prior to follow-up (n=45) |  |  |  |
|--------------------------|-----------------------------------------------|---|---|---|
|  | Decrease in sx  | Decrease in sx  | No change in sx  |
|  | (non-ADHD at follow-up)  | (subthreshold ADHD at follow-up)  | (probable ADHD cases at follow-up)  |
|  | (n=9)  | (n=11)  | (n=25)  |
| Baseline SDQ Impairment | % who improved functionally (95% CI)  | % who improved functionally (95% CI)  | % who improved functionally (95% CI)  |
| Distress/intrapersonal | 14.3 (3.3, 44.8)  | 35.4 (10.4, 72.0)  | 8.0 (2.4, 23.0)  |
| Home life | 6.1 (0.9, 31.7)  | 4.3 (0.7, 22.4)  | 14.2 (2.6, 51.1)  |
| Friendships | 16.7 (4.3, 47.1)  | 16.0 (3.3, 51.1)  | 16.5 (6.9, 34.7)  |
| Classroom learning | 6.1 (0.9, 31.7)  | 0.0  | 16.0 (6.8, 33.4)  |
| Leisure activities | 14.3 (3.3, 44.8)  | 21.1 (5.7, 54.2)  | 7.7 (2.4, 22.1)  |
| Total impairment | 8.6 (1.8, 32.4)  | 0.0  | 11.1 (4.1, 27.0)  |

** p < .01 for Chi-square analyses
* p < .05 for Chi-square analyses
Table 4.8 Baseline to Follow-up Symptom Change and Corresponding SDQ Impairment Change (Functionally Declined) by Medication Status

<table>
<thead>
<tr>
<th>Subthreshold at Baseline (n=46)</th>
<th>Medicated year prior to follow-up (n=14)</th>
<th>Not Medicated year prior to follow-up (n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Decrease in sx (non-ADHD at follow-up)</td>
<td>Decrease in sx (non-ADHD at follow-up)</td>
</tr>
<tr>
<td></td>
<td>(n=2)</td>
<td>(n=11)</td>
</tr>
<tr>
<td>Baseline SDQ Impairment</td>
<td>% who declined functionally (95% CI)</td>
<td>% who declined functionally (95% CI)</td>
</tr>
<tr>
<td>Distress/intrapersonal</td>
<td>85.8 (31.5, 98.8)</td>
<td>69.5 (30.6, 92.1)</td>
</tr>
<tr>
<td>Home life</td>
<td>85.8 (31.5, 98.8)</td>
<td>47.1 (18.7, 77.5)</td>
</tr>
<tr>
<td>Friendships</td>
<td>85.8 (31.5, 98.8)</td>
<td>23.1 (8.0, 50.7)</td>
</tr>
<tr>
<td>Classroom learning</td>
<td>14.2 (1.2, 68.5)</td>
<td>74.6 (42.3, 92.2)</td>
</tr>
<tr>
<td>Leisure activities</td>
<td>0.0</td>
<td>25.3 (9.3, 53.0)</td>
</tr>
<tr>
<td>Total impairment</td>
<td>14.2 (1.2, 68.5)</td>
<td>33.6 (10.7, 68.0)</td>
</tr>
</tbody>
</table>

|                                 | Increase in sx (probable cases at follow-up) | Increase in sx (probable cases at follow-up) |
|                                 | (n=6)                                   | (n=12)                                  |
| Baseline SDQ Impairment         | % who declined functionally (95% CI)    | % who declined functionally (95% CI)    |
| Distress/intrapersonal          | 62.5 (25.9, 88.9)                      | 49.0 (17.4, 81.7)                      |
| Home life                       | 11.1 (1.7, 47.0)                       | 16.2 (3.6, 50.0)                       |
| Friendships                     | 74.8 (37.2, 93.7)                      | 49.3 (17.4, 81.7)                      |
| Classroom learning              | 64.3 (27.5, 89.5)                      | 43.3 (15.3, 76.4)                      |
| Leisure activities              | 53.2 (18.2, 85.3)                      | 57.6 (24.6, 85.0)                      |
| Total impairment                | 43.5 (15.5, 76.3)                      | 27.2 (7.4, 63.6)                       |

** p < .01 for Chi-square analyses
*p < .05 for Chi-square analyses
Table 4.9 Baseline to Follow-up Symptom Change and Corresponding SDQ Impairment Change (Functionally Declined) by Medication Status

<table>
<thead>
<tr>
<th></th>
<th>ADHD at baseline (n=103)</th>
<th>Medicated year prior to follow-up (n=58)</th>
<th>Not Medicated year prior to follow-up (n=45)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=4)</td>
<td>(n=11)</td>
<td>(n=25)</td>
</tr>
<tr>
<td>Baseline SDQ Impairment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distress/intrapersonal</td>
<td>49.0 (14.4, 84.5)</td>
<td>36.3 (15.5, 63.8)</td>
<td>38.6 (23.1, 56.7)</td>
</tr>
<tr>
<td>Home life</td>
<td>49.0 (14.4, 84.5)</td>
<td>43.2 (18.9, 71.4)</td>
<td>35.5 (21.0, 53.3)</td>
</tr>
<tr>
<td>Friendships</td>
<td>68.9 (23.3, 94.2)</td>
<td>26.3 (10.3, 52.7)</td>
<td>30.1 (16.5, 48.3)</td>
</tr>
<tr>
<td>Classroom learning</td>
<td>44.8 (12.5, 82.1)</td>
<td>57.9 (29.0, 82.2)</td>
<td>30.9 (17.4, 48.7)</td>
</tr>
<tr>
<td>Leisure activities</td>
<td>24.9 (4.3, 70.8)</td>
<td>24.1 (8.4, 52.5)</td>
<td>32.7 (20.2, 48.4)</td>
</tr>
<tr>
<td>Total impairment</td>
<td>24.9 (4.3, 70.8)</td>
<td>13.9 (3.9, 39.0)</td>
<td>23.4 (11.2, 42.3)</td>
</tr>
</tbody>
</table>

* p < .05 for Chi-square analyses
** p < .01 for Chi-square analyses
Table 4.10 Results of Multivariate Logistic Regression for Prediction of ADHD Medication Use

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Subthreshold ADHD cases</th>
<th>Probable ADHD cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall impairment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abnormal</td>
<td>0.5 (0.1, 2.2)</td>
<td>1.4 (0.5, 3.4)</td>
</tr>
<tr>
<td>Normal/borderline</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Parent perceived burden</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium amount/great deal</td>
<td>5.5 (1.3, 23.7)</td>
<td>1.8 (0.7, 4.6)</td>
</tr>
<tr>
<td>Not at all, a little</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>CD or ODD</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>2.5 (0.7, 9.9)</td>
<td>1.2 (0.5, 2.5)</td>
</tr>
<tr>
<td>No</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1.4 (0.5, 4.5)</td>
<td>0.4 (0.2, 0.8)</td>
</tr>
<tr>
<td>Male</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

CD, conduct disorder; ODD, oppositional defiant disorder
Chapter 5

DISCUSSION

This study considered patterns of symptom and functional impairment change and predictors of severe impairment and medication use among children in the community with probable ADHD, subthreshold ADHD, and children without ADHD transitioning from childhood to adolescence. This chapter revisits the study aims as a framework for providing a summary and discussion of the pertinent results and conclusions of this study. This chapter also covers a discussion of study implications, an acknowledgement of inherent study limitations, strengths, and implications for future research and practice.

RELATED PREVIOUS RESEARCH FINDINGS, MAIN RESULTS, IMPLICATIONS

Research Aims I & III: Aim I: To examine patterns of change between symptoms and functional among youth with ADHD, with subthreshold ADHD and without ADHD across two time-points; Research Aim III: To examine patterns of symptom and functional impairment change from baseline to follow-up for youth with subthreshold ADHD and youth with ADHD based on treatment status [taking ADHD medication versus not taking ADHD medication within the last year].

Striving to make meaningful sense of patterns of symptom and impairment trajectories is an important endeavor for the many reasons including: (1) ADHD and subthreshold ADHD are highly prevalent conditions; (2) The significant long-term functionally impairing nature of the disorder; (3) ADHD is under-diagnosed and undertreated; (4) Research shows impairment rather than symptoms are the main reason
for treatment referrals (Owens, Johannes, & Karpenko, 2009); and, (5) Federal agencies have adopted impairment criteria for access to treatment and services and individuals with subthreshold ADHD are unlikely to qualify for services (Bussing, Mason, Bell, Porter, & Garvan, 2010).

The analysis portion of the review of the literature revealed two studies which investigated whether function could normalize for youth, and found that the developmental trajectory of ADHD is often associated with inconsistent function (Biederman et al., 1996; Mick et al., 2011). These studies included subclinical groups with the ADHD groups and were unable to distinguish functional trajectories of youth with subclinical ADHD. Additionally, global assessment of impairment did not allow for domain specific assessment of functional impairment.

Young & Gudjonsson (2008) retrospectively demonstrated individuals continued to experience functional impairment even though they no longer meet full diagnostic symptom criteria. Using cross-sectional data, Scanhill found children with subthreshold ADHD were significantly less impaired than children with ADHD, but significantly more impaired than children without ADHD and demonstrated the usefulness of treating ADHD dimensionally rather than categorically (Scanhill et al., 1999). In line with both Young & Gudjonsson and Scanhill, all three studies that did meet inclusion criteria in the analysis review of the literature also demonstrated that youth with subclinical ADHD who no longer met symptom count criteria continued to suffer from impairment (Biederman, Mick, & Faraone, 2000; Bussing, et al., 2010; Faraone, et al., 2006).

The studies mentioned above, were constrained methodologically for at least one of the following reasons: not including a subclinical group; use of retrospective recall;
use of cross-sectional data; or not providing detailed information related to percentages of individuals who make reliable improvement in functioning but not symptoms and visa versa. Correspondence studies identified in the literature, while they did not meet all of the analysis review criteria, made a compelling case for using similar methodology to uncover symptom and functioning developmental trajectories (Karpenko, Owens, Evangelista, & Dodds, 2009; Owens, et al., 2009; Rosenblatt & Rosenblatt, 2002) among youth with subthreshold ADHD to compared to youth with and without ADHD in this study.

The Owens et al. study highlighted a need for research that considers profiles of children who show no change in symptoms or a reduction in symptoms (Owens, et al., 2009). The Karpenko study pinpointed a need to compare nontreated individuals with treated individuals when considering corresponding symptom and impairment, as they did not consider nontreated individuals (a limitation of using the MTA dataset) (Karpenko, et al., 2009). These studies also contributed to an understudied area in ADHD research; the relation between patterns of change in symptoms and change in function (Owens, et al., 2009). Given the potential importance of subthreshold ADHD and the almost complete absence of longitudinal research on this subcategory of ADHD, the literature review analysis helped identify gaps in the current literature that this study was designed to address.

Further, it is not clear from the literature if youth with subthreshold ADHD who are unmedicated fare particularly worse over time compared to individuals with subthreshold ADHD who are taking ADHD medication. To our knowledge, there are no published studies that have examined how medication use within the context of ADHD
and subthreshold ADHD unfolds with regard to patterns of symptom and impairment change. This study sought to discern prospective patterns of symptoms and functional impairment change in a community sample for youth with subthreshold ADHD and youth with ADHD depending on medication status (taking medication versus not taking medication).

This study is a novel extension to previous RCI studies examining the relationship between change in symptoms and reliable change in functioning and considered longitudinal data from the South Carolina Project to Learn about ADHD in Youth (SCPLAY). Findings from RCI and chi square analyses showed a trend among baseline youth with subthreshold ADHD or probable ADHD who were not medicated the year prior to follow-up and who were subthreshold ADHD or non-ADHD cases at follow-up; that decreasing symptoms are associated with functional decline. This may be explained by research suggesting that although symptoms tend to diminish over time, symptom declines do not necessarily result in a return to normal function (Willoughby, 2003). Further, impairment may increase over time as demands increase and through an additive process; with impairment becoming become more noticeable as children age and acquire more autonomy (Adler, et al., 2008).

While most ADHD medication treatment studies only consider symptom change, a review of the literature including studies assessing improvements in functioning found medication use versus no medication use is associated with greater rates of symptom remission and increased social and academic functioning (Steele, et al., 2006). While these study findings show evidence of improvements in functioning with medication use, findings here show youth with subthreshold ADHD at baseline and medicated the year
prior to follow-up tended to decline functionally to a greater degree in four out of five domains of functioning and overall functioning compared to youth with subthreshold ADHD at follow-up who were not medicated. Individuals presenting with severe impairment may be show less overall improvement in functional impairment measures over time. Additionally, medication treatment compliance may be as low as 50% in children with ADHD (Johnston & Fine, 1993) which may result in poor management of symptoms and functioning (Perwien, et al., 2004).

It should not be assumed that a reduction in symptoms equates with a reduction in impairment; nor should it be assumed that if a child continues to meet symptom criteria for ADHD that he/she is impaired by the disorder’s symptoms (Owens, et al., 2009). It is well documented that symptomatic remission does not equate with recovery of function (Biederman, 2011; Gordon et al., 2006; S.P. Hinshaw, Owens, Sami, & Fargeon, 2006; Mick, Faraone, & Biederman, 2004). Identifying children who make reliable change in both symptom and impairment change, as well as those who make change in one but not the other is an important distinction (Owens, et al., 2009). For research, referral, treatment, and intervention purposes it is important to identify children and adolescents who fail to meet symptom count criteria for ADHD or who fail to achieve full remission but continue to struggle with functional burden. Additionally, because subthreshold childhood ADHD symptoms predict the presentation of adolescent ADHD (Bussing, et al., 2010) a better understanding of the relationship between patterns between symptom and impairment change, especially among youth with subthreshold ADHD is warranted and is useful in identifying targets for early intervention.
Research Aim II: To examine baseline demographic and psychiatric variables (child factors: age, gender, comorbidity, medication; family factors: exposure to parental psychopathology, primary parents educational attainment, marital status) associated with severe levels of functional impairment at follow-up.

As discussed in Chapter 2, a review of the literature revealed few studies exploring predictors of impaired functioning among youth with ADHD. Though not well understood, a number of child and family risk factors have been explored. Child-related factors including (Gathje, Lewandowski, & Gordon, 2008), higher levels of comorbidity, increased impulsive symptoms (Biederman, Mick, & Faraone, 1998) and treatment use (Molina et al., 2009) were found to be associated with impaired functioning. Researchers analyzing ADHD symptoms most associated with impairment showed symptom prevalence or subtype distinctions are inadequate in predicting impairment (Mota & Schachar, 2000).

Family factors associated with functioning among ADHD youth cited in the ADHD literature include: maternal psychopathology (Biederman, et al., 1998), social advantage (Molina, et al., 2009), and marital status (Healey, Gopin, Grossman, Campbell, & Halperin, 2010). No study was found examining predictors of impairment for youth with subthreshold ADHD. Given that subthreshold ADHD may follow a very similar impairment trajectory as ADHD that is likely to persist, the current study address this gap in the literature and exploring predictors associated with more severe forms of ADHD impairment to see if they were similar for youth with ADHD and youth with subthreshold ADHD the current study.
Findings showed probable ADHD and subthreshold ADHD did not share any significant predictors in common. This was an expected finding based on the supposition that subthreshold youth would share a similar impairment predictor profile as ADHD youth. ADHD medication use and primary parent psychiatric history in the non-ADHD model; gender in the subthreshold model, and psychiatric comorbidity in the probable ADHD case model were all found to be predictors of severe impairment. These findings may be relevant to efforts to intervene earlier in childhood and to help identify high-risk individuals who may be good candidates for targeted interventions.

**Research Aim III:** To examine baseline demographic and psychiatric variables (child factors: impairment, gender, race, age, comorbidity; family factors: parent reported burden, insurance, parent educational level, exposure to parental psychopathology) that are associated with ADHD medication use at follow-up.

A review of the literature showed several studies that examined predictors of treatment utilization for youth with ADHD and only a few studies that examined predictors of treatment utilization for youth with subthreshold ADHD. Service contact for ADHD is often made because of parent’s perception of problems (perceived burden) or parental strain rather than child factors such as comorbidity (Angold et al., 1998; Bussing et al., 2003; Sayal, 2006). Additional predictors of treatment seeking and service use for children with ADHD include male gender (Beuermeister, 2003; Gau et al., 2010; Bussing, 2005), maternal education (college or higher) (Gau et al., 2010), parental mental health history, marital status (divorced) (Jensen, Bloedau, and Davis, 1990) and younger age (Leslie et al., 2005).
Among the few studies considering a subclinical ADHD group, two studies found subclinical ADHD predicted stimulant medication use (Bauermeister et al., 2003; Leslie, et al., 2005). Reich et al. found that among comparison children, ADHD symptom counts and presence of impaired functioning were significant treatment correlates (Reich, Huang, & Todd, 2006). Similarly, Angold et al. found among the subclinical group, stimulant medication use was significantly related to level of symptoms and was more common in individuals with a diagnosis of ODD (Angold, Erkanli, Egger, & Costello, 2000). No studies were found examining parent perceived burden as a predictor of medication use for youth with subthreshold ADHD.

The longitudinal data used here offered the opportunity to consider predictors of ADHD medication use among subthreshold ADHD and probable ADHD symptom categories. Most notable among the findings was that parent perceived burden was predictive of ADHD medication use for youth with probable ADHD but significantly so for youth with subthreshold ADHD. In these data, parent burden more so than youth clinical factors (i.e., comorbidity and overall impairment) predicted medication use. This finding for subthreshold ADHD is novel and in line with research showing parental strain or perceived burden more than symptoms (Angold, et al., 1998) or comorbid conditions (including ODD and CD) (Angold, et al., 1998; Bauermeister, et al., 2003) is a major reason for service contact for ADHD (Farmer, Stangl, Burns, Costello, & Angold, 1999).

Similar to other studies, these data show being male significantly predicted ADHD medication use for youth with probable ADHD (Bauermeister, 2003; Gau et al., 2010; Bussing, 2005), however, while not significant, females with subthreshold ADHD were more likely to take ADHD medication than males with subthreshold ADHD. This
finding was not expected as girls, especially those with inattention problems are more likely to be under-referred, and less likely to be treated than boys (Stephen P. Hinshaw & Blachman, 2005; Staller & Faraone, 2006).

Findings underscore the importance of understanding child and family factors associated with taking ADHD medication. Identifying parent burden provides an opportunity for clinicians to discuss parental perceptions of burden and address parent support needs alongside a discussion and consideration of medication therapy. Additionally the identified significant predictors of medication use are child and family factors that are not difficult for clinicians to ascertain and add to the small existing data available in the literature on this subject.

**Possible Areas of Future Research**

This study focused on five important domains of functioning (child distress, home life, friendships, classroom learning, and leisure activities) and used the first follow-up wave of four waves. Further investigation of these issues is warranted in teens transitioning into high school and young adulthood. A consideration of multiple time points using this same methodology is also warranted.

In the present study we calculated a reliable change index (RCI) (Jacobson and Truax, 1991) to determine statistically significant impairment change. RCI should not be confused with clinical significance which is often defined as a return to normal functioning (Jacobson, Roberts, Berns, & McGlinchey, 1999). With the understanding that ADHD is a persistent neurobiological disorder, further tests of clinical significance were not performed. Future research should consider if the two-method approach put
forth by Jacobson & Traux would be too stringent a criterion to use with ADHD and subthreshold ADHD populations.

**Study Strengths & Limitations**

This study adds to an absence of population-based longitudinal impairment data of children with subthreshold ADHD who are identified in early childhood and followed into adolescence. While most ADHD trajectory studies consider only patterns of symptom change over time, this study considered patterns of change for both symptoms and functioning. It utilized well validated instruments, trained data collectors, and extensive data quality control measures. Study sampling design increased case finding and analysis accounted for sampling design to give unbiased estimates. It used a prospective design with a retention rate of 61% at follow-up. In addition to being cross sectional in nature, most studies focus on children, and this study followed youth up to age 15. This was a community-based rather than clinic-based study, which is a strength, as clinic-based youth are likely to have more severe symptom and functional impairments than youth in the community (Gau, et al., 2010) and may result in higher treatment seeking rates (Rowland, Lesesne, & Abramowitz, 2002). White boys account for the majority of research related to ADHD in youth (Hartung & Widiger, 1998) and girls and African American youth are well represented in this study.

This study is not without limitations. The SDQ is not a symptom-specific measure (assessing impairment in relation to a specific symptom or diagnosis) (Canino, Costello, & Angold, 1999) so there is no way to know which symptoms, if any, are directly related to the reported impairment. However, using the DISC-IV (a symptom specific measure), was not possible because if the symptom criteria, duration criteria, or age of onset criteria
for ADHD are not met, the impairment questions are never asked and subthreshold impairment and control children’s impairment could not be assessed. Using the standardized diagnostic interview (DISC-IV) alone, would not have allowed for a consideration of subthreshold youth and youth without ADHD. Symptom specific measures are needed that are not constrained by this limitation.

The use of only parent/caregiver report is another limitation, as the DSM-IV recommends the use of multiple informants and the American Academy of Pediatrics recommends the need for both parent and teacher report of functional impairment (American Psychiatric Association, 2000; Wolraich, Brown, & Brown, 2011). Teacher reports of functional impairment were collected, but due to poor response rates, not used. Parent subjectivity may also be biased (e.g., underreport due to social desirability, over-report due to help-seeking, endorse symptoms that affect them the most, and may be more reliable reporters for younger children) (Barkley, 2006). While there is often disagreement among multiple informants and subjective bias in parent report, parents are thought to be crucial for a valid assessment of ADHD (Barkley, Fischer, Smallish, & Fletcher, 2002; Cantwell, Lewinsohn, Rohde, & Seeley, 1997).

Symptom decreases over time might reflect true developmental changes, but also may be due to other things such as artifacts of repeated measurement (Hart, et al., 1995) and diagnostic inadequacies (e.g., applying symptoms that are not developmentally sensitive (Willoughby, 2003). Additionally, the relationship between symptom change and impairment in specific domains may be a function of the treatment or care that individuals were provided, comorbidity, or other factors. While the impact of those things is not known, and the findings are constrained by unadjusted percents and small numbers,
this represents some of the only data available describing symptoms and functional impairment for youth in a community setting.

Another limitation of this study is the proportion of baseline participants lost to follow-up. If those individuals were less likely to have ADHD symptoms or more likely to have ADHD symptoms or to take medication or not take medication, for example, the findings are less likely to be representative of the initial sample. Also, due to the low prevalence rate of ADHD medication use in this sample the estimates of these predictor variables may not be precise. Finally, as the course of ADHD and subthreshold ADHD is continually changing, one’s symptom and impairment status at baseline and follow-up may not be static and future studies exploring changes in patterns of ADHD symptoms and impairment are needed that use repeated observations.

CONCLUSIONS

The overall results of this study speak to the importance of identifying individuals who may not experience chronically elevated symptom levels over time but who continue to experience significant impairments associated with ADHD diminished symptom counts. Applying the Jacobson & Traux method to these data demonstrates a useful method for identifying individuals who are at risk for poor developmental outcomes. For example, despite decreasing symptom counts among youth with ADHD at baseline, 20% of those who fell into the subthreshold category at follow-up were significantly impaired in at least one functional domain. This study also identified a minority of children with ADHD and subthreshold ADHD who despite elevated or increasing symptoms over time were not reported to have troublesome functional impairment. This investigation supports the argument for using an alternative to narrowly dichotomizing ADHD. It is hoped that
through a more careful consideration of symptom and impairment profiles resources can be targeted to help children and adolescents with ADHD and subthreshold ADHD lead less impaired lives.
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APPENDIX A – HUMAN SUBJECTS APPROVAL LETTER
Office of Research Compliance

November 27, 2012

Mrs. Lorie Geryk
Arnold School of Public Health
Epidemiology & Biostatistics
800 Sumter Street
Columbia, SC 29208

Re: Pro00021491
Study Title: Investigating Developmental Patterns of Symptom and Impairment Change Among Youth with ADHD, Subclinical ADHD and Youth Without ADHD

Dear Mrs. Geryk:

The Office of Research Compliance, an administrative office that supports the University of South Carolina Institutional Review Board (USC IRB), has completed an administrative review of the referenced study on behalf of the USC IRB, and has determined that the proposed activity is exempt from the Protection of Human Subjects Regulations (45 CFR 46.102). No further oversight by the IRB is required; however, the investigator should inform this office prior to making any substantive changes to the study, as this may alter the exempt status of the study.

If you have questions, please contact Arlene McWhorter at arlenem@sc.edu or (803) 777-7095.

Sincerely,

Lisa M. Johnson
IRB Manager

cc: Jim Hussey
APPENDIX B – STUDY CONCEPTUAL MODEL

Study Conceptual Model

Time

Current thinking: persistent developmental lag not outgrown

Differences in Clinical Expression

More Dimensional Consideration of ADHD

Symptoms tend to decrease; impairment tends to increase

Biology
e.g., genetic differences, brain structure and functioning, gender, comorbidity

Shape ADHD Symptom Expression

Dynamic interplay

Environment
e.g., individual, family, social experiences, family adversity, psychosocial variables, medication use, cultural norms, early identification

Impairment

Increase Decrease No change

ADHD

Subthreshold ADHD

Non-ADHD

Dynamic not static

Diminishing or increasing risk (biological and/or environmental) to functioning and eventual outcome

Time
APPENDIX C – DIAGNOSTIC CRITERIA FOR ADHD


A. Either 1 or 2
   1) Six (or more) of the following symptoms of inattention have persisted for at least 6 months to a degree that is maladaptive and inconsistent with developmental level:

   Inattention
   a) Often fails to give close attention to details or makes careless mistakes in schoolwork, work, or other activities
   b) Often has difficulty sustaining attention in tasks or play activities
   c) Often does not seem to listen when spoken to directly
   d) Often does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or failure to understand instructions)
   e) Often has difficulty organizing tasks and activities
   f) Often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (such as schoolwork or homework)
   g) Often loses things necessary for tasks or activities (eg, toys, school assignments, pencils, books, or tools)
   h) Is often easily distracted by extraneous stimuli
   i) Is often forgetful in daily activities

   2) Six (or more) of the following symptoms of hyperactivity-impulsivity have persisted for at least 6 months to a degree that is maladaptive and inconsistent with developmental level:

   Hyperactivity
   a) Often fidgets with hands or feet or squirms in seat
   b) Often leaves seat in classroom or in other situations in which remaining seated is expected
   c) Often runs about or climbs excessively in situations in which it is inappropriate (in adolescents or adults, may be limited to subjective feelings of restlessness)
   d) Often has difficulty playing or engaging in leisure activities quietly
   e) Is often "on the go" or often acts as if "driven by a motor"
   f) Often talks excessively

   Impulsivity
   g) Often blurts out answers before questions have been completed
   h) Often has difficulty awaiting turn
   i) Often interrupts or intrudes on others (eg, butts into conversations or games)

B. Some hyperactive-impulsive or inattentive symptoms that caused impairment were present before 7 years of age.
C. Some impairment from the symptoms is present in 2 or more settings (eg, at school [or work] or at home).
D. There must be clear evidence of clinically significant impairment in social, academic, or occupational functioning.
E. The symptoms do not occur exclusively during the course of a pervasive developmental disorder, schizophrenia, or other psychotic disorder and are not better accounted for by another mental disorder (eg, mood disorder, anxiety disorder, dissociative disorder, or personality disorder).

Code based on type:

**314.01 Attention-Deficit/Hyperactivity Disorder, Combined Type:** if both criteria A1 and A2 are met for the past 6 months

**314.00 Attention-Deficit/Hyperactivity Disorder, Predominantly Inattentive Type:** if criterion A1 is met but criterion A2 is not met for the past 6 months

**314.01 Attention-Deficit/Hyperactivity Disorder, Predominantly Hyperactive, Impulsive Type:** if criterion A2 is met but criterion A1 is not met for the past 6 months

**314.9 Attention-Deficit/Hyperactivity Disorder Not Otherwise Specified**
APPENDIX D – STUDY DESIGN PHASES

SCPLAY FLOWCHART

School District Screening Population 8487 → Parent and/or Teacher Screener → Interview Eligible → Recruited 630 (29%) → Parent Baseline Interview → Parent Follow-up Interview → Baseline 211 Non-ADHD 84 Subthreshold ADHD 186 Probable ADHD

Phase I: Screening

Parent Baseline Interview → Parent Follow-up Interview → Yes 481 (76%) → No 152 (24%)

Interview Eligible → Yes 2206 (48%) → Not Recruited 1573 (71%)

No 4606 (54%)

Recruited 630 (29%)

No 2400 (52%)

Phase II: Interviews

No 189 (39%)

Yes 292 (61%)

Follow-up 129 Non-ADHD 57 Subthreshold ADHD 106 Probable ADHD

(Modified from: Figure 1: Project to Learn about Attention-Deficit/Hyperactivity Disorder in Youth Screening and Case Ascertainment Flowchart)