ADHD AND HEARING LOSS: A STUDY EXAMINING THE CO-OCCURRENCE OF THE TWO DISORDERS

by

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Presented to the Faculty of the Graduate School of

The University of Texas at Arlington in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF SCIENCE IN SOCIAL WORK

THE UNIVERSITY OF TEXAS AT ARLINGTON

May 2015

Acknowledgements

I would like to acknowledge and thank my committee chairperson, Dr. Katherine Sanchez, along with my thesis committee members, Dr. Michael Killian and Dr. Catheleen Jordan. The support, honest feedback, and willingness to contribute your time for this thesis has been invaluable during this process. Thanks go to Professor Bruce Bower who provided valuable feedback and contributed to my decision to pursue a thesis. I would also like to thank my parents and my friends who have endured this process with me and have been beacons of support through the entire journey.

April 10, 2015

Abstract

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This paper will present information obtained from a nationwide dataset on the incidence of co-occurring Attention Deficit Hyperactivity Disorder and hearing loss. These disorders are frequently studied separately, but there is a lack of research on the co-occurrence of the disorders. A secondary data analysis was conducted in order to answer four primary research questions: 1) What are the demographic characteristics of children who have co-occurring HL and ADHD? 2) Is the incidence of ADHD co-occurring with HL higher than the expected incidence of ADHD for this population based on general U.S. prevalence? 3) Among those with past or current HL, what predicts a diagnosis of ADHD? 4) Does the severity of HL change the risk of co-occurring ADHD? The demographic characteristics of subjects with co-occurring ADHD are reported, along with odds ratios. The incidence of co-occurrence in this sample was 20.0%, which is higher than previously reported prevalence.

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Chapter 1

Review of the Literature

Attention Deficit Hyperactivity Disorder (ADHD) has a complex and controversial history (Smith, 2012). The past two centuries have seen an explosion of understanding surrounding the origin, prevalence, and diagnosis of ADHD; yet, much is still not fully understood (Smith, 2012). Hearing loss (HL) is better understood, as far as prevalence and diagnosis; however, there is a certain level of inconclusiveness in regards to etiology (Picard, 2004). Studies focusing on the incidence of children with HL who also have ADHD are relatively few with several studies on one disorder actively excluding the other (Dye & Hauser, 2013; Mitchell & Quittner, 1996; Schnoes, Reid, Wagner, & Marder, 2006).

Mental health professionals will likely encounter clients diagnosed with ADHD or displaying ADHD symptoms, especially in education or health settings (Brock, Jimerson, & Hansen, 2009). These professionals might also have clients with some degree of HL. Mental health professionals working with these clients need to understand the complexities involved in diagnosing ADHD in a client with HL, in order to ensure that all other potential attributions of the behavior are ruled out prior to the ADHD diagnosis. In a discussion about the overlap of two diagnoses, it is important to understand how each of these diagnoses exist separately and how they can exist together.

ADHD

Attention deficits and hyperactivity were first described in the literature in 1798 (Chandler, 2010; Smith, 2012). Recognition of these symptoms as disordered behavior came in 1902 with George Still's article in the journal, *Lancet* (Brock, Jimerson & Hansen, 2009; Millichap, 2010; Weyandt, 2001). After the encephalitis epidemic of 1917, a pattern of behavioral abnormalities was recognized in some patients as post-encephalitic disorder, which led to a realization that behavioral disorders were a condition of the brain and not a defect of the mind (Millichap, 2010; Smith, 2012). The understanding of post-encephalitic disorder developed over time leading to several name changes and improvements in diagnostic criteria (Brock et al., 2009; Chandler, 2010; Millichap, 2010; Weyandt, 2001). Now named ADHD, this disorder contains three subtypes in the Diagnostic and Statistical Manual (DSM), each with its own set of diagnostic criteria (American Psychiatric Association [APA], 2013).

A single, specific cause of ADHD has not been found (Brock et al., 2009; Chandler, 2010; Millichap, 2010; Weyandt, 2001). There has long been suspicion of a genetic component to ADHD, primarily because it was seen to run in families (Brock et al., 2009; Chandler, 2010; Millichap, 2010; Weyandt, 2001). Indeed, parental history of ADHD symptoms is a potential risk factor, along with having a sibling that has been diagnosed (Brock et al., 2009; Chandler, 2010; Millichap, 2010; Weyandt, 2001). Male gender and Caucasian race have also been linked to ADHD (Chandler, 2010; Galèra et al., 2011; Millichap, 2010).

Interest in understanding the risk factors of ADHD has grown over the years (Brock et al., 2009). During pregnancy, maternal substance abuse and viral infections have been linked to ADHD (Brock et al., 2009; Chandler, 2010; Galèra et al., 2011; Millichap, 2010; Silva, Colvin, Hagemann, & Bower, 2014; Weyandt, 2001). Birth complications, prematurity, and low birth weight are risk factors associated with the development of ADHD (Brock et al., 2009; Chandler, 2010; Galèra et al., 2011; Millichap, 2010; Silva et al., 2014). Viral infections during childhood, including encephalitis and meningitis, as well as chronic otitis media have also been linked to increased risk of ADHD (Brock et al., 2009; Millichap, 2010). Additionally, several syndromes have been found to be potential risk factors (i.e. Prader-Willi, Turner, and Williams syndromes) (Millichap, 2010). Differential diagnosis is critical when syndromes are present, as some syndromes are known to cause ADHD-like symptoms but are not ADHD (i.e. Fragile X and Klinefelter syndrome) (Chandler, 2010).

Considerable research has been done on the best method to diagnose and treat ADHD (Brock et al., 2009; Millichap, 2010; Weyandt, 2001). Many times, the first suspicion that the child might have ADHD comes from the classroom teacher, as this is the environment in which the child is most likely to show symptoms (Millichap, 2010). Diagnostic assessment is usually done by a mental health professional employed through the school district or the child's pediatrician

(Brock et al., 2009; Millichap, 2010). The American Academy of Pediatrics Clinical Practice Guidelines and current best practices utilize the DSM as a diagnostic tool and recommends interviews with the child's parents, teachers, and, if appropriate, the child (Anastopoulos & Shelton, 2001; Brock et al., 2009; Millichap, 2010; Munden & Arcelus, 1999; Weyandt, 2001). First line treatment for ADHD is a recommendation for medication (Millichap, 2010; O'Connell & Casale, 2004). Medication can be utilized along with psychoeducation, psychosocial interventions, and classroom accommodations according to what has the best results for the individual child (Anastopoulos & Shelton, 2001; Brock et al., 2009; Millichap, 2010).

Many studies have been conducted to try and gain a better picture of both domestic and international prevalence rates of ADHD (Anastopoulos, & Shelton, 2001; Brock et al., 2009; Millichap, 2010; Munden, & Arcelus, 1999; Weyandt, 2001). Diagnostic tools, such as the DSM and the International Classification of Diseases (ICD), have provided diagnostic criteria based on what was known about the disorder at the time of publication and some versions have been said to over or under estimate prevalence rates (Anastopoulos & Shelton, 2001; Munden & Arcelus, 1999). The continuing development of our understanding of the disorder has led to rapid changes in diagnostic criteria and, as a result, studies estimating prevalence rates have not utilized uniform measures leading to wide variation in reported prevalence, between 2- 43% (Anastopoulos & Shelton, 2001; Munden & Arcelus, 1999; Weyandt, 2001). As determined by the American Psychiatric Association (APA), the most widely accepted prevalence rate for ADHD among the United States school-age population is 3-5% (APA, 2013; Millichap, 2010; Weyandt, 2001).

HL

Man's difficulty or inability to hear did not become well documented until around the 17th century when several publications about HL were printed (Gannon, 1981). The first schools for deaf students opened in 1755, which started a movement towards a better understanding of HL and its impact on the individual (Gannon, 1981). Dr. Rudolph Pintner, in the 1900s, worked to develop an awareness of the psychology of HL (Gannon, 1981). Assistive technology for HL appeared in the 1960s as hearing aids and telecommunication devices for the deaf were introduced to the market (Gannon, 1981). In fact, the 1900s saw an explosion of interest in research surrounding the cause and complexities of HL (Dagan & Avraham, 2004; Nance, 2004).

No single defined cause for HL is known, much like for ADHD (Dagan & Avraham, 2004; Marschark, 1993; Nance, 2004; Picard, 2004). Causes of HL can be genetic or environmental in nature and can manifest either pre- or post-lingually (Dagan & Avraham, 2004; Gallaudet Research Institute, 2011; Marschark, 1993; Nance, 2004; Picard, 2004). The most common known cause of HL is linked to DNA and genetics, with genes being implicated in 50-60% of all cases (Dagan & Avraham, 2004; Gallaudet Research Institute, 2011; Marschark, 1993; Nance, 2004; Picard, 2004). Genetic causes can be categorized as syndromic or nonsyndromic (Dagan & Avraham, 2004; Nance, 2004; Picard, 2004). Syndromic causes are cases in which there is a genetic condition that causes a wide range of symptoms with HL being one possible, but not always present, symptom (Dagan & Avraham, 2004; Nance, 2004; Picard, 2004). There are currently around 400 known syndromes that can, but do not always, cause HL, including Down, Usher, and Treacher Collins syndromes (Beswick, Driscoll, Kei, & Glennon, 2012; Dagan & Avraham, 2004; Picard, 2004; Theunissen et al., 2014). Nonsyndromic causes include cases where mutations within the DNA have caused or have been linked to HL (Dagan & Avraham, 2004; Nance, 2004). There are approximately 17 autosomal dominant genes and 20 autosomal recessive genes linked to predominantly post- and pre-lingual HL, respectively (Dagan & Avraham, 2004; Nance, 2004).

Cases of HL caused by disease and illness have reduced significantly since the advent and wide dissemination of vaccines for diseases known to cause HL, such as: maternal rubella, mumps, and measles (Beswick et al., 2012; Biswas, Goswami, Baruah, & Tripathy, 2012; Kitsko, 2014; Marschark, 1993; Picard, 2004; Theunissen et al., 2014). Substance use and/or abuse during pregnancy has been found to be a risk factor for HL (Biswas et al., 2012; Kitsko, 2014). Birth complications, including prematurity and low birth weight, have also been linked to HL (Beswick et al., 2012; Biswas et al., 2012; Kitsko, 2014; Picard, 2004; Theunissen et al., 2014).

Childhood meningitis or encephalitis have been known to cause HL as a complication of the diseases (Beswick et al., 2012; Biswas et al., 2012; Dagan & Avraham, 2004; Kitsko, 2014; Marschark, 1993; Picard, 2004). Chronic otitis media is an additional known risk factor for developing HL (Picard, 2004).

A diagnosis of HL is made by evaluating the ability of the ears to receive and process sound (Audiometry, 2014). Sounds are measured by intensity with the unit decibel (dB) and tone is measured in Hertz (HZ) (Audiometry, 2014). The normal range of hearing for humans is approximately 20 – 20,000 HZ, and HL is determined by the amount of dB lost in each ear (Audiometry, 2014; Marschark, 1993). Diagnosis of HL is made when the ability to hear sounds above 25 dB is compromised (Audiometry, 2014; Marschark, 1993). The severity of the HL is also determined by a loss of dB with 26-40 dB being mild HL, 41-55 dB classified as moderate, 56-70 dB as moderately severe, 71-90 dB classified as severe, and any loss above 90 dB is considered profound HL (Marschark, 1993). Currently, children are tested for HL at birth and hearing tests are included in pediatric checkups as the child ages (Harlor & Bower, 2009).

Picard (2004) determined a decreased prevalence of HL at 0.07% of live births in the United States and a global prevalence of 0.14%. This prevalence likely includes only congenital hearing loss (Picard, 2004). Marschark (1993) estimates prevalence of deafness at around 0.2% for both adults and children. The difference in these rates reflects the addition of acquired and transient hearing loss that can occur as the child ages.

HL with ADHD

Individuals interacting with children with HL may erroneously attribute their behaviors as ADHD symptoms, however these children experience a number of difficulties including frustration and problems communicating. Language deficits can hinder a child’s ability to communicate effectively, thereby increasing their frustration with the world around them and increasing their “acting out” (Petersen, Bates, Lansford, Dodge, Pettit, & Van Hulle, 2013). The lack of natural language access that many children with pre-lingual HL experience might appear to be related to the impulsivity reported in these children (Dye & Hauser, 2013). Children with pre-lingual HL who have parents that use sign language to communicate have been shown to score lower on impulsivity scales and performed better at tasks of sustained attention (Dye & Hauser, 2013; Mitchell & Quittner, 1996). For these reasons, children with HL may be overly diagnosed as having comorbid ADHD.

Diagnosis of ADHD is made more difficult for a child with HL as the tests utilized in diagnosing ADHD are not normed for those with HL (Parasnis, Samar, & Berent, 2003). Behaviors that children with HL exhibit, such as looking around the room for visual cues, might also be considered symptoms of ADHD, further complicating diagnosis (Morgan & Vernon, 1994). The difficulty in diagnosing co-occurring ADHD in a child with HL comes with determining whether or not their language frustration and lack of communication skills are solely a result of their HL or if their behavior problems might be attributable to another cause (e.g. ADHD) (O'Connell & Casale, 2004). Proper accommodations and management of the HL are of critical importance when attempting to diagnose ADHD in a student with HL (O'Connell & Casale, 2004).

Many of the same risk factors for ADHD exist as risk factors for HL, as well (Morgan & Vernon, 1994; Parasnis et al., 2003). Maternal substance use and/or abuse and viral infections in pregnancy are linked to both ADHD and HL in children (Beswick et al., 2012; Biswas et al., 2012; Brock et al., 2009; Chandler, 2010; Galèra et al., 2011; Kitsko, 2014; Millichap, 2010; Picard, 2004; Silva et al., 2014; Theunissen et al., 2014; Weyandt, 2001). Birth complications, prematurity, and low birth weight are risk factors associated with both ADHD and HL (Beswick et al., 2012; Biswas et al., 2012; Brock et al., 2009; Chandler, 2010; Galèra et al., 2011; Kitsko, 2014; Millichap, 2010; Picard, 2004; Silva et al., 2014; Theunissen et al., 2014). Viral infections in children (i.e. meningitis, encephalitis, and chronic otitis media) increase the risk for development of ADHD, as well as HL (Beswick et al., 2012; Biswas et al., 2012; Brock et al., 2009; Kitsko, 2014; Millichap, 2010; Picard, 2004). Thus, it is possible that children who have HL might also present with ADHD (Morgan & Vernon, 1994).

Parasnis et al. (2003) estimate the incidence of HL co-occurring with ADHD ranges from 3.5% to 38.7%. The Gallaudet Research Institute's Annual Survey of Deaf and Hard of Hearing

Children and Youth reported a prevalence rate of 5.4%, while the Office of Special Education Programs' Special Education Elementary Longitudinal Study (SEELS) reported prevalence rates of 8.9-11.8% (Gallaudet Research Institute, 2011; Office of Special Education Programs, 2007a: Office of Special Education Programs, 2007b: Office of Special Education Programs, 2007c).

The APA's accepted prevalence rate for ADHD in the U.S. school age population is 3-5% and the reported co-occurrence of ADHD with HL in recent studies is between 5.4-11.8% (Gallaudet Research Institute, 2011; Office of Special Education Programs, 2007a; Office of Special Education Programs, 2007b; Office of Special Education Programs, 2007c; Parasnis et al., 2003; Weyandt, 2001). There is a need for a better understanding of how HL can contribute to ADHD-like symptoms and what factors might influence the presentation of ADHD in a child with HL. In order to contribute to this understanding, this study has four research questions:

1- What are the demographic characteristics of children who have co-occurring HL and ADHD?

2- Is the incidence of ADHD co-occurring with HL higher than the expected incidence of ADHD for this population based on general US population prevalence?

3- Among those with past or current HL, what predicts a diagnosis of ADHD?

4- Does the severity of HL change the risk of co-occurring ADHD?

Chapter 2

Methods

National Survey of Children's Health

The current study is a secondary data analysis conducted with data from the National Survey of Children's Health (NSCH). The NSCH is a quadrennial national phone survey with the most recent survey conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention (CDC) between February 28, 2011 and June 25, 2012 (Centers for Disease Control and Prevention [CDC], National Center for Health Statistics, State and Local Area Integrated Telephone Survey, 2013). Funding for the NSCH came from the United States Department of Health and Human Services (DHHS) Maternal and Child Health Bureau and the DHHS Office of the Assistant Secretary for Planning and Evaluation (CDC National Center for Health Statistics, State and Local Area Integrated Telephone Survey, 2013).

The survey was designed to last approximately 30 minutes and asked parents or caregivers questions regarding general physical, emotional, and mental well-being of one child in the home. Respondents for the study were selected from a cross-sectional sample of telephone numbers, both landline and cell-phones. The sample was then stratified by state and telephone type. Prior to April 2011, survey respondents using a cell-phone were eligible only if they did not have access to a land line (CDC National Center for Health Statistics, State and Local Area Integrated Telephone Survey, 2013).

Respondents were adults in the household who had the most knowledge of the children in the household's health and health care. Respondents were asked the ages of all children in the household and one child was randomly selected to be the subject of the interview. Only one child, between the ages of 0 – 17, per household was included in the study (CDC National Center for Health Statistics, State and Local Area Integrated Telephone Survey, 2013).

A total of 95,677 children were included in this study with a completion rate of 54.1% of landline users and 41.2% of cell-phone users (CDC National Center for Health Statistics, State and Local Area Integrated Telephone Survey, 2013). Incentives of up to $15 were utilized for

18,728 households in this sample (CDC National Center for Health Statistics, State and Local Area Integrated Telephone Survey, 2013).

NSCH Questionnaire

The NSCH is conducted to gain an understanding of the health and well-being of children across the United States (CDC National Center for Health Statistics, State and Local Area Integrated Telephone Survey, 2013).The NSCH questionnaire is divided into twelve sections; all respondents were asked questions from sections 1-5 and 8-11 (Child and Adolescent Health Measurement Initiative [CAHMI]; Data Resource Center for Child and Adolescent Health, 2012). Section six was asked for subjects between ages 0-5 (CAHMI; Data Resource Center for Child and Adolescent Health, 2012). Respondents with subjects between ages 6-17 answered section seven (CAHMI; Data Resource Center for Child and Adolescent Health, 2012). Respondents with subjects who did not have health insurance at the time of interview were asked section twelve (CAHMI; Data Resource Center for Child and Adolescent Health, 2012).

Current Sample- HL Sample

In answering the research questions, several procedures were used. The current study focused on a sample (*n*=3001) of subjects who were indicated to have a history of or a current HL. Of those subjects who had a HL, a subsample (*n*=601) was gathered for subjects who also had a history of or a current diagnosis of ADHD.

The demographic characteristics of children who have co-occurring HL and ADHD was gathered by obtaining demographic information for the subjects from the dataset. Several demographic variables were chosen along with variables relating to family composition and poverty level. Demographic variables were chosen based on what previous literature has linked to HL and ADHD, as well as the ability of the variables to provide a complete picture of the sample population. These variables included: age, gender, race, birth order, prematurity, birth weight, total number of adults in the household, total number of children in the household, number of parents in the home, mother’s education level, father’s education level, other respondent’s education level, health insurance status at the time of survey, consistency of health insurance coverage over the last year, type of health insurance held by subject, financial difficulty, home ownership, and poverty level.

In order to determine the prevalence of ADHD co-occurring with HL, information was gathered from the dataset about the number of subjects with history of or current HL and history of or current ADHD diagnosis. These variables were obtained from survey questions which asked if the subject currently has or has ever had hearing problems or ADHD. Respondents responding “Don’t know” or refusing to respond were excluded from the sample (Child and Adolescent Health Measurement Initiative [CAHMI], 2013).

To understand the influence of severity of HL on the risk of co-occurring ADHD, the numbers of subjects who have a history of or current diagnosis of ADHD, a history of or current diagnosis of HL, and the severity of the HL reported was examined. The first two variables were obtained in the same way as in research question number two. The third variable was obtained from a survey question which asked the respondent to describe the severity of the subject’s HL as ‘mild’, ‘moderate’, or ‘severe’ and was only answered if the respondent indicated that the subject did have a history of or current HL. Respondents responding ‘Don’t know’ or refusing to respond were excluded from the sample (Child and Adolescent Health Measurement Initiative [CAHMI], 2013).

Some variables necessitated recoding in SPSS to ensure integrity and clarity of the results obtained. The variables for history of or current HL and history of or current ADHD had three potential responses: ‘does not have condition’, ‘ever been told but does not currently have condition’, and ‘currently has condition’. For the purposes of this study, these response categories were condensed into ‘does not have condition’ and ‘past history or current condition’ and recoded variables were used.

In order to obtain demographic data on both the overall NSCH sample and the HL subsample, to obtain information about how each variable is distributed in both the sample and subsample, to observe any differences between the sample and the subsample, and to understand the association of each variable on the co-occurrence of ADHD and HL, t-tests or chi-square tests were performed for each variable. Logistic regression tests were performed for each demographic variable, as well, to determine the association between demographic characteristics and their association with the likelihood of being identified as ADHD among those already identified as HL. The statistical software package SPSS 22.0 was utilized for the analysis of data in this study.

Chapter 3

Results

Demographics

Overall

The NSCH collected data from a nationwide cross-section of subjects (*N*=95,677) (CDC National Center for Health Statistics, State and Local Area Integrated Telephone Survey, 2013). Subjects in the survey ranged in age from zero to seventeen with a mean age of 8.85 years and mode of 17 years. Male subjects comprise 51.5% (*n*=49129) of the survey sample. The majority of subjects were White, non-Hispanic (65.7%, *n*=61831). Hispanic subjects made up 13.6% (*n*=12682) of the NSCH sample. Other, non-Hispanic subjects made up 11.2% (*n*=10466) and Black subjects made up 9.5% (*n*=8875) of the NSCH sample. Primarily English speaking homes made up 92.2% (*n*=88163) of the NSCH sample.

Subjects in the survey were most frequently only children (41.3%, *n*=39550). Prematurity occurred for 11.3% (*n*=10750) of subjects and 9.1% (*n*=8277) of subjects were born with low birth weight. Multiple parent households made up 83.3% (*n*=75247) of the NSCH sample with 66.6% (*n*=63433) reporting two adults residing in the house. A majority of parents or caregivers had more than a high school education: 74.0% of mothers (*n*=64621), 70.2% of fathers (*n*=52496), and 54.0% of other caregivers (*n*=3610). The sample was primarily insured (95.8%, *n*=91471) with 91.4% (*n*=86929) reporting consistent coverage over the previous year. Most subjects held private health insurance (66.8%, *n*=63079).

When asked how often it had been difficult to survive on their family's income, 48.9% (*n*=45838) stated that it had never been difficult and 5.6% (*n*=5217) stated that it very often was difficult. Respondents owning their home comprised 74.6% (*n*=69996) of the survey sample. Department of Health and Human Services (DHHS) poverty level guidelines were used to determine poverty level for subjects (CDC National Center for Health Statistics, State and Local Area Integrated Telephone Survey, 2013). The greatest percentage of subjects (36.2%, *n*=34642) were included in the above 400% of the poverty level category, while 15.6% (*n*=14928) of subjects were included in the below 100% of the poverty level category.

The NSCH sample was divided into two groups in order to observe the difference between those subjects with HL and those subjects without HL. The mean age of subjects with HL was almost one year older than subjects without HL. Male subjects and White, non-Hispanic subjects make up the majority of both those with HL and without. A greater percentage of subjects with HL were reported to be premature or have low birth weight than those without HL. Single parent households and households with only one adult present have a higher representation for subjects with HL than those without. Subjects in both groups tend to be consistently insured; however, a larger percentage of subjects with HL have public insurance than those without HL. A greater percentage of subjects with HL report difficulty getting by on their family's income and income below 150% of the poverty level. Table 1, below, separates the overall survey data into two groups: NSCH sample who did not indicate a HL and HL subsample.

Table 1. NSCH sample demographics divided into those with HL and those without HL

Variable	HL Subsample, *n* (%) or mean (sd) *n*=3001	NSCH Sample without HL, *n* (%) or mean (sd) *n*=92676	Statistical test
Age	9.70 (4.436)	8.83 (5.259)	t=-10.599***
Gender			χ^2= 89.949***
Male	1800 (60.0%)	47419 (51.2%)	
Female	1199 (40.0%)	45150 (48.8%)	
Race			χ^2= 35.163***
Hispanic	343 (11.7%)	12339 (13.6%)	
White (non Hispanic)	2080 (70.7%)	59301 (65.6%)	
Black (non Hispanic)	222 (7.5%)	8653 (9.6%)	
Other (non Hispanic)	297 (10.1%)	10149 (11.2%)	
Primary Language			χ^2=47.745***
English	2867 (95.5%)	85296 (92.1%)	
Other	134 (4.5%)	7317 (7.9%)	
Birth Order			χ^2=17.829**
Only Child	1184 (39.5%)	38366 (41.4%)	
Oldest Child	740 (24.7%)	23305 (25.1%)	
2nd oldest child	842 (28.1%)	23125 (25.0%)	
3rd oldest child	187 (6.2%)	5927 (6.4%)	
4th oldest child	48 (1.6%)	1953 (2.1%)	
Born premature			χ^2=136.654***
No	2425 (82.0%)	81624 (88.9%)	
Yes	534 (18.0%)	10216 (11.1%)	
Birth weight			χ^2=93.923***

Table 1. *Continued*

Variable	HL Subsample, *n* (%) or mean (sd) *n*=3001	NSCH Sample without HL, *n* (%) or mean (sd) *n*=92676	Statistical test
Low (<2500g)	406 (14.2%)	7871 (8.9%)	
Normal	2448 (85.8%)	80306 (91.1%)	
Total adults in household			χ^2=25.695***
1	388 (13.0%)	9370 (10.2%)	
2	1913 (64.0%)	61520 (66.7%)	
3+	689 (23.0%)	21394 (23.2%)	
Total children in household			χ^2=5.866
1	1184 (39.5%)	38366 (41.4%)	
2	1175 (39.2%)	34689 (37.4%)	
3	450 (15.0%)	13420 (14.5%)	
4+	192 (6.4%)	6201 (6.7%)	
Parents in home			χ^2= 55.459***
Single parent	610 (21.9%)	14503 (16.6%)	
Multiple parents	2174 (78.1%)	73073 (83.4%)	
Mother's education level			χ^2= 2.474
Less than high school	216 (7.9%)	6689 (7.6%)	
High school graduate	470 (17.3%)	16060 (18.4%)	
More than high school	2037 (74.8%)	64621 (73.9%)	
Father's education level			χ^2=4.651
Less than high school	173 (8.0%)	5675 (7.8%)	
High school graduate	517 (23.8%)	15972 (22.0%)	
More than high school	1478 (68.2%)	51018 (70.2%)	
Other respondent's education level			χ^2=1.809
Less than high school	39 (15.4%)	994 (15.5%)	
High school graduate	68 (26.9%)	1972 (30.7%)	
More than high school	146 (57.7%)	3464 (53.9%)	
Health insurance status at time of survey			χ^2=4.016
Insured	2891 (96.5%)	88580 (95.7%)	
Not insured	105 (3.5%)	3935 (4.3%)	
Consistency of health care coverage past 12 months			χ^2=0.002
Consistently insured	2724 (91.3%)	84205 (91.4%)	
No coverage or inconsistent	258 (8.7%)	7954 (8.6%)	
Type of insurance			χ^2=93.668***
Public	1096 (36.9%)	26285 (28.7%)	
Private	1771 (59.6%)	61308 (67.0%)	
None	105 (3.5%)	3935 (4.3%)	
How often has it been hard to get by on your family's income?			χ^2=214.980***
Very often	298 (10.1%)	4919 (5.4%)	
Somewhat often	584 (19.8%)	14041 (15.5%)	
Not very often	934 (31.6%)	27196 (29.9%)	
Never	1140 (38.6%)	44698 (49.2%)	

Table 1. *Continued*

Variable	HL Subsample, *n* (%) or mean (sd) *n*=3001	NSCH Sample without HL, *n* (%) or mean (sd) *n*=92676	Statistical test
Own or rent			χ^2=3.230
Own	2166 (73.2%)	67830 (74.7%)	
Rent	793 (26.8%)	23020 (25.3%)	
Poverty level			χ^2=35.341***
At or below 100%	527 (17.6%)	14401 (15.5%)	
Above 100% - 133%	264 (8.8%)	7038 (7.6%)	
Above 133% - 150%	59 (2.0%)	1370 (1.5%)	
Above 150% - 185%	202 (6.7%)	5904 (6.4%)	
Above 185% - 200%	84 (2.8%)	2262 (2.4%)	
Above 200% - 300%	498 (16.6%)	14951 (16.1%)	
Above 300% - 400%	402 (13.4%)	13073 (14.1%)	
Above 400%	965 (32.2%)	33677 (36.3%)	

*$p < .05$. **$p < .01$. ***$p < .001$.

Subsample Demographics

Respondents were asked if the subject had a history of or current ADHD diagnosis, as well as, a history of or current HL. Subjects who reported a history of or current HL are indicated in Table 2 as sample *N*. The subjects who reported ADHD, in addition to HL, are indicated in Table 2 as subsample *n*. Each demographic variable was analyzed to determine the percentage of *n* out of *N.*

Of the male subjects with HL, 23.6% (*n*=425) reported ADHD and 14.7% of female subjects (*n*=176) also reported ADHD. Within each race category of those reporting HL, 16.9% of Hispanic subjects (*n*=58), 19.9% of White subjects (*n*=414), 22.5% of Black subjects (*n*=50) and 21.2% of subjects in the Other category (*n*=63) also reported ADHD. Five hundred eighty nine subjects (20.5%) who primarily spoke English also reported ADHD.

Households with one child present reported the highest occurrence of ADHD at 22.6% (*n*=268). Households with two, three, and four or more children reported 18.0% (*n*=212), 19.6% (*n*=88), and 17.2% (*n*=33), respectively. Single parent households reported 22.0% (*n*=134) occurrence of ADHD, while multiple parent households reported 17.6% (*n*=383) occurrence. Mother and father respondents for education level followed the same pattern, with those having not graduated from high school and high school graduates reporting higher percentages of children with ADHD than those who had more than a high school diploma. Respondents other than mother or father who were high school graduates or had more than a high school diploma had greater percentages of children with ADHD than those who had not graduated from high school.

Subjects who were insured at the time of the survey reported 20.4% (*n*=589) occurrence of ADHD. Uninsured subjects had an ADHD occurrence of 11.4% (*n*=12). Consistency of coverage for subjects demonstrated a 20.0% (*n*=545) occurrence of ADHD for those who were consistently insured, whereas those who did not have consistent health care coverage reported a 19.0% (*n*=49) occurrence. Subjects with public insurance reported 28.5% (*n*=312) ADHD occurrence and those with private insurance reported 15.4% (*n*=272) ADHD.

When asked how often it was difficult to get by on family income, 28.9% (*n*=86) with co-occurring ADHD reported very often. Almost 16% (*n*=180) of subjects with ADHD indicated that it had never been difficult to get by. Those who own their home reported 18.1% (*n*=393) occurrence of ADHD, whereas those who rent reported 24.6% (*n*=195) occurrence. Subjects reported higher occurrence of ADHD when they fell in the above 133% - 150% poverty level (30.5%; *n*=18). Subjects in the above 400% poverty level reported 15.4% (*n*=149) occurrence, the lowest of all eight categories.

Table 2 Association of HL and ADHD within sample demographic characteristics

Variable		Total with hearing problems	Hearing loss with ADHD
		N	*n* (%)
	Total	3001 (100%)	601 (0.7%)
Age		Mean=9.70 (sd=4.436)	Mean=11.39 (sd=3.803)
Gender			
	Male	1800	425 (23.6%)
	Female	1199	176 (14.7%)
Race			
	Hispanic	343	58 (16.9%)
	White (non-Hispanic)	2080	414 (19.9%)
	Black (non-Hispanic)	222	50 (22.5%)
	Other (non- Hispanic)	297	63 (21.2%)
Primary language			
	English	2867	589 (20.5%)
	Other	134	12 (9.0%)

Table 2. *Continued*

Variable		Total with hearing problems *N*	Hearing loss with ADHD *n* (%)
Birth order			
	Only child	1184	268 (22.6%)
	Oldest child	740	170 (23.0%)
	2nd oldest child	842	133 (15.8%)
	3rd oldest child	187	21 (11.2%)
	4th oldest child	48	9 (18.8%)
Born premature			
	No	2425	456 (18.8%)
	Yes	534	132 (24.7%)
Birth weight			
	Low (<2500g)	406	98 (24.1%)
	Normal	2448	463 (18.9%)
Total adults in household			
	1	388	92 (23.7%)
	2	1913	366 (19.1%)
	3+	689	139 (20.2%)
Total children in household			
	1	1184	268 (22.6%)
	2	1175	212 (18.0%)
	3	450	88 (19.6%)
	4+	192	33 (17.2%)
Parents in home			
	Single parent	610	134 (22.0%)
	Multiple parents	2174	383 (17.6%)
Mother's education level			
	Less than high school	216	55 (25.5%)
	High school graduate	470	109 (23.2%)
	More than high school	2037	343 (16.8%)
Father's education level			
	Less than high school	173	38 (22.0%)
	High school graduate	517	115 (22.2%)
	More than high school	1478	228 (15.4%)
Other respondent's education level			
	Less than high school	39	11 (28.8%)
	High school graduate	68	28 (41.2%)
	More than high school	146	51 (34.9%)
Health insurance status at time of survey			
	Insured	2891	589 (20.4%)
	Not insured	105	12 (11.4%)
Consistency of health care coverage past 12 months			
	Consistently insured	2724	545 (20.0%)

Table 2. *Continued*

Variable		Total with hearing problems *N*	Hearing loss with ADHD *n* (%)
	No coverage or inconsistent	258	49 (19.0%)
Type of insurance			
	Public	1096	312 (28.5%)
	Private	1771	272 (15.4%)
	None	105	12 (11.4%)
How often has it been hard to get by on your family's income?			
	Very often	298	86 (28.9%)
	Somewhat often	584	147 (25.2%)
	Not very often	934	178 (19.1%)
	Never	1140	180 (15.8%)
Own or Rent			
	Own	2166	393 (18.1%)
	Rent	793	195 (24.6%)
Poverty level			
	At or below 100%	527	143 (27.1%)
	Above 100% - 133%	264	63 (23.9%)
	Above 133% - 150%	59	18 (30.5%)
	Above 150% - 185%	202	46 (22.8%)
	Above 185% - 200%	84	16 (19.0%)
	Above 200% - 300%	498	101 (20.3%)
	Above 300% - 400%	402	65 (16.2%)
	Above 400%	965	149 (15.4%)

Incidence of HL Co-occurring with ADHD

The subjects with reported ADHD made up 9.8% of the survey sample (*n*=8344). Subjects with reported HL made up 3.3% of the survey sample (*n*=3001). The incidence of HL co-occurring with ADHD was calculated. The number of subjects reporting HL (*n*=3001) who also reported co-occurring ADHD was 601. A chi-square test examined the relation between HL and ADHD. The relation between these variables was significant, x^2 (1, N = 85256) = 370.63, p < .001. Subjects with co-occurring ADHD made up 20.0% (*n*=601) of those reporting a HL, as indicated in Table 3 below.

Table 3. Hearing loss co-occurrence with ADHD; crosstabs results

			Hearing Loss: Does not have condition	Hearing Loss: Current or past history of condition	Total
ADHD	Does not have condition	Count	74522	2400	76922
		% with HL	90.6%	80.0%	90.2%
	Current or past history of condition	Count	7733	601	8334
		% with HL	9.4%	20.0%	9.8%
Total		Count	82255	3001	85256
		% with HL	100.0%	100.0%	100.0%

Predictors of ADHD Diagnosis within HL Subsample

Logistic regression analysis was conducted for all subjects who reported HL to determine probability of co-occurring ADHD (*n* = 3001). The dependent variable is the concurrent diagnosis of HL and ADHD compared to those individuals with only HL. As illustrated in Table 4, the variables of race, total adults in the home, other respondent's education level, and consistency of health insurance coverage did not demonstrate statistical significance. The variables of age, gender, primary language, birth order, education levels of mother and father, type of insurance, financial difficulty, home ownership, and poverty level were statistically significant.

As age increased, the odds of being diagnosed with ADHD increase by 11.8% per year of age (OR=1.118, CI 95%, 1.094 – 1.142). Males were 44.3% more likely to be diagnosed with ADHD than females (OR=0.557, CI 95%, 0.459 – 0.675 for females). A primary language of English was associated with a 62.0% increase in the odds of an ADHD diagnosis (OR=0.380, CI 95%, 0.209 – 0.693 for language other than English). As the family grew and the birth order of the child changed, the odds of an ADHD diagnosis decrease by 81% per change in birth order (OR=0.813, CI 95%, 0.743 – 0.891). Children born premature were 41.8% more likely to be diagnosed with ADHD (OR=1.148, CI 95%, 1.316 – 1.769). Children with low birth weight(<2500g) are 26.7% more likely to be diagnosed with ADHD than those with normal birth weight (OR=0.733, CI 95%, 0.572 – 0.940 for normal weight).

Only children were 24.8% more likely to be diagnosed with ADHD than children with one sibling (OR=0.752, CI 95%, 0.615 – 0.920 for 2 children). Families with three or four children were not significantly associated with an increased risk of an ADHD diagnosis for a child in the home with prior hearing issues. Children in single parent homes were 24.0% more likely to be diagnosed with ADHD than those in multi-parent homes(OR=0.760, CI 95%, 0.609 – 0.948 for multi-parent). An education level greater than high school as compared to less than a high school education in mother and father respondents was associated with a 40.7% and 35.2% decrease in the likelihood of an ADHD diagnosis, respectively (OR=0.593, CI 95%, 0.427 – 0.822 for mother, OR=0.648, CI 95%, 0.440 – 0.954 for father).

Children who were insured are 49.6% more likely to be diagnosed with ADHD (OR=0.504, CI 95%, 0.275 – 0.926 for uninsured). Those families with public health insurance were 3.08 times more likely to be diagnosed with ADHD when compared to those with no insurance (OR=3.084, CI 95%, 1.667 – 5.707). When asked how difficult it was to survive on the family income, those who responded 'not very often' were 42.0% less likely to be diagnosed with ADHD and those who responded 'never' were 53.8% less likely to be diagnosed with ADHD than those who responded 'very often' (OR=0.580, CI 95%, 0.430 – 0.783 for not very often, OR=0.462, CI 95%, 0.343 – 0.622 for never). A response of 'somewhat often' was not statistically associated with the likelihood of an ADHD diagnosis when compared to a response of 'very often.' Children living in a rented home were 32.0% less likely to be diagnosed with ADHD than those living in owned homes (OR=0.680, CI 95%, 0.559 – 0.826 for rent). As poverty level increased, the likelihood of an ADHD diagnosis increased 9.6% per level (OR=0.904, CI 95%, 0.876 – 0.934). An increase in level of poverty is equivalent, in this case, to moving further toward, or below, the poverty line (i.e. a family moving from ‘above 150 – 185%’ to ‘above 133 – 150%’ poverty level).

Table 4. Logistic regression of demographic variables

					C.I. 95% of Exp(β)	
Variable	χ^2	β	Wald’s test	Exp(β) (odds ratio)	Lower Limit	Upper Limit
Age of Child	111.19***	0.111	105.01***	1.118	1.094	1.142
Gender (female)	36.94***	-0.586	35.25***	0.557	0.459	0.675
Race (NS)	3.25					

Table 4. *Continued*

Variable	X^2	β	Wald's test	Exp(β) (odds ratio)	C.I. 95% of Exp(β) Lower Limit	Upper Limit
Race[1] (Hispanic)		-0.200	1.68	0.819	0.509	1.108
Race[1] (Black)		0.157	0.17	1.170	0.839	1.632
Race[1] (Other)		0.080	0.28	1.083	0.804	1.460
Primary language (language other than English)	12.80***	- 0.966	9.97**	0.380	0.209	0.693
Birth Order	20.59***	-0.207	19.87***	0.813	0.743	0.891
Prematurity (premature)	9.21**	0.349	9.55**	1.418	1.136	1.769
Birth weight (normal)	5.76*	-0.311	5.98**	0.733	0.572	0.940
Total adults in home (NS)	4.12					
Total adults[2] (1)		0.207	4.42	1.230	.912	1.658
Total adults[2] (2)		-0.066	0.35	0.936	0.753	1.164
Total children in home	8.91*					
Total children[3] (2)		-0.284	7.65**	0.752	0.615	0.920
Total children[3] (3)		-0.185	1.18	0.831	0.634	1.088
Total children[3] (4+)		-0.343	2.85	0.709	0.476	1.057
Parents in home (multiple)	5.78*	-0.275	5.94*	0.760	0.609	0.948
Education level of mother	16.64***					
Education level[4] (HS)		-0.123	0.42	0.884	0.608	1.284
Education level[4] (>HS)		-0.523	9.81**	0.593	0.427	0.822
Education level of father	14.34***					
Education level[4] (HS)		0.016	0.01	1.016	0.671	1.540
Education level[4] (>HS)		-0.434	4.84*	0.648	0.440	0.954
Education level of other respondent (NS)	1.90					
Education level[4] (HS)		0.578	1.78	1.782	0.763	4.162
Education level[4] (>HS)		0.312	0.62	1.367	0.629	2.969
Health insurance status at time of survey (uninsured)	5.75*	-0.685	4.87*	0.504	0.275	0.926
Consistency of health insurance coverage (NS)	0.15	-0.065	0.15	0.937	0.677	1.297
Type of health insurance	75.80***					
Type of insurance[5] (Public)		1.126	12.87***	3.084	1.667	5.707
Type of insurance[5] (Private)		0.341	1.18	1.406	0.760	2.601
Financial difficulty	36.42***					
Difficult[6] (somewhat often)		-0.187	1.38	0.829	0.607	1.134
Difficult[6] (not very often)		-0.544	12.71***	0.580	0.430	0.783
Difficult[6] (never)		-0.722	25.96***	0.462	0.343	0.622
Home ownership (rent)	14.66***	-0.386	15.04***	0.680	0.559	0.826
Poverty level	36.51***	-0.100	36.88***	0.904	0.876	0.934

*$p < .05$. **$p < .01$. ***$p < .001$.

[1] vs White

[2] vs three or more adults

[3] vs one child

[4] vs <HS

[5] vs no insurance

[6] vs very often

ADHD and the Severity of HL

Subjects reporting a HL were asked to report the severity of the HL as 'mild', 'moderate', or 'severe' (*n*=1164). Of those who responded to the severity question, 280 subjects also reported a current or previous history of ADHD. An alpha level of .05 was used for all statistical tests. A chi-square test examined the relation between severity of HL and ADHD. The relation between these variables was not significant, x^2 (2, n = 1164) = 1.85, p = .396. A logistic regression analysis was subsequently performed and results are included in Table 5 below.

Table 5. ADHD and severity of hearing loss; logistic regression results

					C.I. 95% of Exp(β)	
Variable	χ^2	β	Wald's test	Exp(β) (odds ratio)	Lower Limit	Upper Limit
Severity of Hearing Loss (NS)	1.80					
Severity[1] (Moderate)		0.081	0.24	1.084	0.782	1.503
Severity[1] (Severe)		0.283	1.84	1.327	0.881	1.999

**p* < .05. ***p* < .01. ****p* < .001.
[1] vs Mild

Chapter 4

Discussion

Summary of Study

The present study sought to answer several questions about the co-occurrence of HL and ADHD. Data from the 2011-2012 NSCH quadrennial telephone study was analyzed in order to gain an understanding of the demographical characteristics of children with both HL and ADHD, to determine the prevalence of ADHD co-occurring in children with HL, and to determine if severity of HL had an impact on the odds of being diagnosed with ADHD.

The statistical software package SPSS 22.0 was used for analysis of the nationwide data sample (*N*=95,677). A study sample of subjects with a history of or current HL (*n*=3001) was gathered from the data, and those subjects also reporting a history of or current diagnosis of ADHD (*n*=601) were analyzed using t- tests, chi-square tests, and logistic regression tests for their demographics. The study sample was subsequently analyzed in order to determine the prevalence of ADHD in the sample. Logistical regression tests were performed for subjects who provided a severity level of HL (*N*= 1,164) to determine the odds of an ADHD diagnosis.

Summary of Results

The NSCH sample closely resembles the U.S. population in demographics. There are more females than males represented in the U.S. Census data; however, in the NSCH survey sample this is switched as males are more represented than females at 51.5% (*n*=49129) and 48.5% (*n*=46528), respectively (United States Census Bureau, 2015). White non-Hispanic subjects make up the majority of the sample at 65.7% (*n*=61831), closely matching the 63% represented in the U.S. Census (United States Census Bureau, 2015). Primarily English speaking homes make up 92.2% (*n*=88163) of the NSCH survey sample, whereas these homes make up 79% of the U.S. Census data (United States Census Bureau, 2015). The majority of families in the NSCH sample have only children (41.3%, *n*=39550), are multiple parent homes (83.3%, *n*=75247), and have 2 adults residing in the home (66.6%, *n*=63433). The CDC reports prematurity occurring in 11% of U.S. births and low birth weight occurring in 8% of U.S. Births

(Centers for Disease Control and Prevention [CDC], 2015). The NSCH sample closely resembles this data as prematurity is 11.3% (*n*=10750) and low birth weight is 9.1% (*n*=8277) of the sample. The NSCH survey sample has a higher representation of those who have health insurance (95.8%, *n*=91471) than U.S. Census data (87%) (United States Census Bureau, 2014). Subjects at less than poverty level for both the NSCH survey sample and U.S. Census data is approximately 15% (United States Census Bureau, 2015).

The NSCH sample was divided into two groups for further analysis: subjects with HL and subjects without HL. The differences between these two groups was observed and a few variables showed key differences: prematurity, low birth weight, single parent households, public insurance, and poverty level. The HL sample was older, contained a higher percentage of males, and had a greater percentage of white subjects than the non-HL sample. These differences are further explored in the discussion of results section of this chapter.

The demographic characteristics of subjects with diagnoses of HL and ADHD were examined and presented in relation to subjects with a diagnosis of HL. Ages of subjects in the sample range from 2 – 17 years of age with a majority of male subjects. Logistical regression tests with a confidence interval of 95% were run on the sample of subjects with HL to determine the probability of subjects with HL having a co-occurring ADHD diagnosis. Race, number of adults in the home, other respondent's education level, and consistency of health insurance coverage did not demonstrate statistical significance. Each of the other variables were statistically significant to at least, the $p < .05$ level.

Subjects reporting HL co-occurring with ADHD made up 20% of the sample (*N*). A chi-square test did produce a statistically significant result for this relationship. A logistic regression test to determine the relationship between severity of HL and an ADHD diagnosis did not produce statistically significant results.

Discussion of Results

Prevalence

The present study found an incidence of ADHD in children with HL to be 20.0%. This result is higher than previously reported prevalence rates for this population. A national study of children with hearing loss conducted from 2009 to 2010 by the Gallaudet Research Institute found prevalence rates of ADHD in the hearing impaired population to be 5.4% (Gallaudet Research Institute, 2011). The Special Education Elementary Longitudinal Study conducted with children who receive special education services in the U.S. found prevalence rates ranging from 8.9 – 11.8% (Office of Special Education Programs, 2007a: Office of Special Education Programs, 2007b: Office of Special Education Programs, 2007c). The American Psychiatric Association's reported prevalence rate is between 3 – 5% for the general U.S. school-age population (APA, 2013). Recent studies, however, have found higher prevalence rates at about 11.0% for school age children (Hesse, 2014; Schwarz & Cohen, 2013). In fact, in the current NSCH sample, the incidence of ADHD was 9.8%.

Higher prevalence rates could be related to a greater awareness of how ADHD manifests in children, improvements in diagnostic instruments, or potentially misdiagnosing other conditions as ADHD (Kendall, Leo, Perrin, & Hatton, 2005). ADHD is currently the most common mental health diagnosis in children which contributes to the increased awareness of the disorder, as well as an increase in research and understanding of the disorder (Kendall et al., 2005). The increase in research has improved treatment options for children with ADHD (Anastopoulos & Shelton, 2001). Increased awareness and the high prevalence rates of this disorder contribute to the possibility that a diagnosis of ADHD might be given to a child who is exhibiting symptoms of the disorder, but has a different underlying condition (Pozzi-Monzo, 2012; Weale, 2014).

Symptoms of ADHD can manifest in a child who has hearing loss or several other conditions (Chandler, 2010; Munden & Arcelus, 1999). ADHD symptoms are also linked to the environment the child is living in (Hesse, 2014; Pozzi-Monzo, 2012). Traumatic experiences in childhood or a tumultuous home life can contribute to a child exhibiting hyperactive or inattentive behavior in the classroom or other environment (Pozzi-Monzo, 2012). This highlights the importance of a thorough examination and biopsychosocial assessment prior to diagnosis (Bussing, Zima, Gary, & Garvan, 2003; Munden & Arcelus, 1999). Unfortunately, there are many situations in which the diagnosing professional might not be able to complete such a thorough examination, leading to potentially overlooking other explanations for the child's behavior (Hesse, 2014; Medellin, 2011; Weale, 2014). These situations will be further explored in a later section of this paper.

Hearing loss, as previously stated, can also demonstrate symptoms of ADHD. A child who has difficulty hearing might frequently ask for repetition of what is being said or might look around the room, seeking visual cues, which are both symptoms of a child with ADHD-inattentive type (Miller, 1980; Morgan & Vernon, 1994). Overlapping symptomatology demonstrates the importance of understanding how ADHD manifests in a child with HL. The prevalence of ADHD occurring with HL in this study could indicate that children with HL have a higher risk for ADHD or it could indicate that children with HL, exhibiting symptoms of ADHD, are assigned the ADHD diagnosis without a complete understanding of how HL affects the presentation of ADHD.

Miller (1980) recognized that children with hearing problems are frequently considered to have behavioral problems when the root of their disordered behavior is the HL. Children with HL have also been noted to be impulsive, which has been attributed to a lack of language access early in childhood (Marschark, 1993). Petersen et al. (2013) discovered a relationship between poor language skills and behavior problems that showed a pattern of direction where the lack of language ability is more likely to lead to behavior problems than the opposite occurring. Understanding the influence of HL on a child and how that can contribute to ADHD-like symptoms could help to improve diagnostic instruments for ADHD, service provision for children with HL who exhibit ADHD symptoms, and behavioral interventions for these children.

Severity of HL

The third research question of this study focused on the impact that severity of HL might have on the odds of an ADHD diagnosis. The logistic regression and chi-square tests did not find a statistically significant association between those two variables. Theunissen et al. (2014) support this finding that degree of HL does not influence the development of psychopathology. Other factors, such as age of diagnosis of HL and age of intervention for HL are listed as potentially more influential on the development of psychopathology (Theunissen et al., 2014). This is of particular importance when considering the lack of language access that a child with HL has. If severity of HL does not impact the odds for a diagnosis of ADHD, it can be thought that any loss of access to language can significantly impact the child and their potential for developing ADHD (Dye & Hauser, 2014; Mitchell & Quittner, 1996). Therefore, early intervention and management of the HL are tantamount to ensuring the child has the most language access possible. This allows caregivers, medical professionals, and educators to focus on other risk factors when considering a diagnosis of ADHD for a child with HL.

Environmental and demographic risk factors

This study found that prematurity increased risk of a dual diagnosis by 42% and low birth weight increased the risk by 27%. Picard (2004) found an increased risk of HL in premature infants and Beswick et al. (2012) found that infants with low birth weight are one-tenth more likely to develop HL. The development of ADHD has been similarly linked to both prematurity and low birth weight with increased odds ratios of 1.93 and 2.11, respectively (Galéra et al., 2011). Both risk factors being linked to HL and ADHD gives cause to believe that a child with HL and one, or both, of the risk factors may also develop ADHD. The mechanisms of the influence of prematurity and low birth weight on a diagnosis of ADHD are not fully understood. Future study could focus on developing this understanding along with understanding the combined influence of HL with either risk factor on a potential ADHD diagnosis.

The number of parents in the home demonstrated statistical significance; however, the total number of adults in the home did not. This is potentially related to the difference in the language of the questions. One question looks solely at the number of adults present in the home, whereas the other question discusses parental involvement. It is possible to see a scenario where a grandparent might also live in the home; therefore, there are two parents present and three adults. In this scenario, the number of adults does not statistically impact the risk of ADHD and HL co-occurring, but the fact that both parents are present would have a mitigating effect on the child's risk. Silva et al. (2014) did find that single mothers increased the risk for an ADHD diagnosis 1.5 times for boys and 1.6 times for girls. Galéra et al. (2011) found that the odds of being diagnosed with ADHD increased 1.9 times when in a non-intact family.

The number of children in the home provided some interesting results. There was significance when going from one child in the home to two, but no significance when growing to three or four children. This seems to show that a family growing from one child to two impacts the risk of dual diagnosis to a greater degree than a family growing from two children to three or four. Pinto, Rijsdik, Frazier-Wood, Asherson, & Kuntsi (2012) found that family size can moderate for comparison effect among children. This suggests that parents with more children have a larger base for comparison of disruptive behavior, whereas parents with fewer children have a limited point of reference for comparison (Pinto et al., 2012).

Families with single mothers and smaller families might have less of a reference for comparison, which could be heightened in the case of a child with HL. Most parents (92%) of children with HL do not, themselves, have a HL (Mitchell & Karchmer, 2002). In turn, the parent(s) of these children might have limited experience with HL which, when combined with the limited language access a child with HL has, could contribute to a suspicion of ADHD. This seems to be supported by the present study demonstrating that single parent homes and smaller families both increase the risk of dual diagnosis, 24.0% and 24.8%, respectively. Further study could seek to clarify the influence of family size on the risk for diagnosis of ADHD in a child with HL.

As age of the child increases, the odds of a dual diagnosis increase 11.8% per year of age. This seems to be corroborated by studies showing the numbers of children on ADHD medication in high school to be greater than then at younger ages (Schwarz & Cohen, 2013). A recent New York Times article cites that one in five high school age boys are diagnosed with ADHD and one in ten are on medication for the disorder (Schwarz & Cohen, 2013). In fact, the gender split in diagnosis is seen to be consistent across age groups (Schwarz & Cohen, 2013). The prevalence of ADHD in school age is 15% for boys and 7% for girls (Schwarz & Cohen, 2013). Upon reaching high school, the prevalence rates rise to 19% for boys and 10% for girls (Schwarz & Cohen, 2013). However, there is a current trend toward diagnosing and medicating preschool age children with ADHD (Hesse, 2014). While the numbers still show that older children are more likely to be diagnosed, it would be interesting to see if the direction of risk changes in the coming years.

The fact that risk of a dual diagnosis is consistent with the increased risk for ADHD as the child ages gives cause to believe that children with HL are being accurately diagnosed with ADHD. If the number of preschool age children with ADHD begins to rise, future study could look to see if the risk of dual diagnosis remains consistent with that pattern.

Race was not a significant risk factor in this study. This is a surprising result as race is frequently implicated in ADHD (Bussing et al., 2003; Howie, Pastor, & Lukacs, 2014; Morgan, Staff, Hillemeir, Farkas & Maczuga, 2013). There is some contradiction between ADHD and HL as Caucasian race is more frequently implicated in ADHD and those with minority race more frequently are diagnosed with HL (Bussing et al., 2003; Howie et al., 2014; Marschark, 1993; Picard, 2004). This contradiction in racial makeup of both disorders could be the reason that race was not a significant variable for dual diagnosis. Kendall & Hatton (2002), however, posit that the rate of ADHD for each racial group is proportional to the group's size in the region. This implies that race is not as significant a factor in the presence of ADHD rather that it is more difficult for a child of a minority race to be diagnosed with ADHD (Kendall & Hatton, 2002).

Health insurance coverage is a significant variable in dual diagnosis, however, the consistency of coverage did not demonstrate statistical significance. The type of insurance coverage a child has was a significant factor for dual diagnosis. A child with public health insurance has 3 times the risk for dual diagnosis compared to a child with no health insurance. This aligns with other studies reporting similar results for non-hearing impaired children (Kendall et al., 2005; Schwarz & Cohen, 2013). Kendall et al. (2005) found a large discrepancy between the numbers of toddlers with public insurance receiving ADHD medication and those with private insurance (10,000 vs 4,000).

A potential reason for the high increased risk with public insurance could be the type of medical care typically received with public insurance. Medellin (2011) found that only 54% of pediatricians in the U.S. fully participated in Medicaid. Access to pediatric care is difficult for those in rural and inner-city areas who are on Medicaid or Children's Health Insurance Program (CHIP) (Ku, Jones, Shin, Bruen & Hayes, 2011). In fact, a study by Dr. Karin V. Rhodes of the Leonard Davis Institute of Health Economics found that 66% of children with Medicaid or CHIP in Cook County, Illinois were denied appointments with specialists, whereas only 11% of those with private insurance were denied (Grady, 2011). The patients who were able to secure appointments tended to have long wait times before their appointment; an average of 22 days longer than those with private insurance (Grady, 2011).

Not only is access to doctors who accept Medicaid difficult for some children, those physicians accepting Medicaid also likely have high caseloads and limited time to spend with each patient (Medellin, 2011). Recent changes in health care policy have increased the Medicaid threshold which could potentially increase the demand for physicians who accept Medicaid and CHIP (Ku et al., 2011). Practices currently accepting Medicaid, which typically pays less than private insurance, must decide whether to accept a decrease in income or make up for the difference by increasing their caseloads (Medellin, 2011).

As previously stated, the evaluation of a child for ADHD includes interviewing the parents, the teachers, and the child (Anastopoulos & Shelton, 2001; Munden & Arcelus, 1999). Physicians with high caseloads and limited time might not be able to conduct a thorough, in-depth evaluation that can rule out other potential diagnoses which can mimic ADHD. Family environment can also have an effect on the presentation of ADHD symptoms (Millichap, 2010). Hesse (2014) suggests that doctors evaluating a child for ADHD are less likely to "attempt to unravel the complex issues of a difficult home environment" and, in that situation, would be more willing to prescribe ADHD medication for the child. Weale (2014) highlights the importance of working with the family as a whole when treating ADHD rather than simply prescribing medication which is meant to be a short-term solution to a long-term condition.

A complicating factor for children with HL who are being evaluated for ADHD is the HL itself. An accurate evaluation of ADHD in a child with HL means ensuring that the HL is well controlled prior to making a diagnosis of ADHD (O'Connell & Casale, 2004). The majority of newborns in the U.S. have their hearing screened at birth (Limb, McManus, Fox, White, & Forsman, 2010). However, only about 64% of children who are found to have permanent HL receive follow up care (Limb et al., 2010). Furthermore, children with HL require a pediatrician who understands how HL impacts the child and the family, as well as care from an Audiologist experienced with pediatric patients (Limb et al., 2010).

The limited access to pediatric care for children on Medicaid without HL becomes even more limited when seeking a pediatrician who is experienced in working with HL and accepts Medicaid (Limb et al., 2010). This difficulty is not limited to those with Medicaid; private insurance does not always cover hearing aids for children (Limb et al., 2010). A child with public health insurance who has HL that is not fully managed because of insurance limitations and who is unable to find a pediatrician experienced in working with this population could potentially be at greater risk for being diagnosed with ADHD. While this study does not focus specifically on these aspects of care, future study could look at the impact of health care access, type of insurance, and availability of specialists to see the influence they have on risk of ADHD diagnosis.

Limitations

This study does face certain limitations for generalizing the data. The two main variables for inclusion in the study were a current diagnosis or history of HL and/or ADHD. The present study did not differentiate between current diagnosis and previous history of the diagnosis, meaning that a child with a previous history of HL and a current diagnosis of ADHD might be included in the results. The impact of any HL on the child's language development and subsequent risk for ADHD was taken into consideration when determining the categories for variables. The decision was made that any previous history of either diagnosis could have impact on the current diagnosis and was better served to be included in the study than to be included with those who had never been diagnosed with either condition.

As a secondary data analysis, this researcher did not have the ability to create follow up questions for the sample. The responses to the questions are all based on parent or caregiver report with no way to verify the accuracy of the information provided. No questions were asked about which diagnosis came first, how the HL is managed, if sign language is used in the home, or if there are any other comorbid conditions or syndromes. Future studies could seek to answer these questions with a sample of children with HL.

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