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Maternal Smoking Contributes to the Development of Childhood ADHD

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ABSTRACT

A review of the literature was undertaken concerning maternal cigarette smoking during pregnancy. A link between this behavior and an increased incidence of behavioral disorders, specifically Attention Deficit/Hyperactivity Disorder (ADHD) was explored. The review was performed using Medline, CINAHL, and Pubmed. Search terms used were maternal smoking, ADHD, and behavioral disorders. Maternal smoking during pregnancy appears to be associated with an increased incidence of ADHD in childhood. A direct causative relationship has not been established. However, after controlling for other potential variables such as maternal age, education and socioeconomic status, it can be concluded that smoking during pregnancy is associated with an increased risk for the development of ADHD in childhood. The development of childhood behavior disorders is likely a lesser-known effect of maternal smoking. This information can be used to alert physician assistants and other clinicians to a potentially preventable common childhood cognitive disorder.

INTRODUCTION

It is estimated that 46.5 million adults in the United States smoke cigarettes on a daily basis.¹ This common behavior will result in death or disability for one half of these individuals. According to the Center for Disease Control, tobacco use is the number one preventable cause of death and disability in the United States. Nationally, smoking results in more than 5.6 million years of potential life lost each year.¹ Even more disturbing are the statistics involving pregnant women. A study conducted by Colman and Joyce indicated that quit rates during pregnancy have remained relatively constant over the preceding decade.² Between 1993 and 1999 quit rates during pregnancy rose only from 37%-40%.² In 1990 approximately 18.0% of pregnant women in the 25-29 age group reported smoking. In 2001 the National Vital Statistics Report estimated that 14% of pregnant women in this age group reported smoking.¹

Smoking has been demonstrated to have an undeniably harmful effect on a developing fetus. Maternal smoking during pregnancy has been linked to low birth weight, higher rates of spontaneous abortion and an increased need for neonatal ICU care following birth. There are some commonly known effects of maternal smoking such as an increased incidence of sudden infant death syndrome (SIDS), increased incidence of asthma in childhood, and a predisposition to respiratory infections and acute otitis media. Research has noted that children of smoking mothers are at an increased risk for pneumonia, bronchitis, tracheitis and laryngitis.³ Additionally, there are emerging data that indicate children exposed to tobacco smoke in utero have an increased incidence of behavioral problems, particularly ADHD, later in childhood.⁴

METHODOLOGY

The framework for this project was a detailed literature review to summarize and discuss maternal smoking as a risk factor for developing behavioral problems in childhood. This was accomplished through a literature review utilizing Medline, Pub Med and CINAHL. Key search terms included maternal smoking, ADHD, behavioral disorders, nicotine exposure and prenatal risk. In addition to articles and research pertaining to maternal smoking as it relates to behavioral disorders, diagnoses of ADHD was also thoroughly explored.

MATERNAL SMOKING DURING PREGNANCY

The percentage of smoking in the general population is declining according to many recent studies. However, the rate of decline is slowest among women of childbearing age.⁵ The rates of smoking during pregnancy have been trending downward over the preceding several decades. However, rates have remained fairly stable in the last several years. In 1999 an estimated 13% of U.S. women reported smoking during pregnancy.²

According to data from the Pregnancy Risk Assessment Monitoring System (PRAMS) the percentage of women who report smoking cessation during pregnancy varies by age, parity and education. Pregnant teens were more likely to quit than older women. Women delivering a first child were more likely to quit than women who had previously delivered at least one other child. As expected, education was also a significant predictor of quitting. College-educated women were significantly more likely to quit smoking during pregnancy. Of note is that this group of women also exhibited significantly lower rates of smoking prior to pregnancy. Additionally, the intensity of smoking prior to pregnancy proved to be a major predictor of quitting. Approximately 62% of women who smoked ten or fewer cigarettes per day prior to pregnancy quit before delivery. This compares to approximately 30% of women who smoked more than ten cigarettes per day prior to pregnancy.²

The harmful effects of maternal smoking begin almost immediately upon conception when nicotine begins to pass across the placenta rapidly. Fetal concentrations of nicotine are often 15% above maternal levels.⁶ Women who smoke during pregnancy have alarmingly higher incidences of spontaneous abortion and placenta previa, lower birth weight babies and a greater need for neonatal ICU care after delivery. Annually, five percent of perinatal deaths and fourteen percent of preterm deliveries in the United States have been attributed to maternal smoking.³

In addition to these commonly known effects of maternal smoking, new evidence is emerging implicating smoking during pregnancy in one of the most common behavioral disorders of childhood. Attention Deficit / Hyperactivity Disorder has been substantially linked to maternal smoking in a variety of studies. This is troublesome as it indicates that smoking during pregnancy has an effect not only on a child's physical health, but on his or her cognitive functioning as well.

Extensive studies have documented the effects of maternal smoking on the developing fetus. These effects are thought to be due to three distinct pathways. First, cigarette-smoking compromises maternal-fetal blood flow which negatively effects perfusion to the fetus. This decreased perfusion could lead to abnormalities in the neural development of the fetus. Second, nicotine has been shown to facilitate apoptosis leading to an overall reduction in cell number in the fetus. Third, exposure to nicotine leads to long-term effects on monoamine systems. Monoamine systems have been shown to play a role in many psychiatric disorders, most notably ADHD and other neuro-behavioral disorders.⁴

ATTENTION DEFICIT / HYPERACTIVITY DISORDER

Childhood behavioral disorders have become increasingly prevalent over the past decade. ADHD has become the most common mental health disorder of childhood, affecting approximately 3-5% of the population with onset in early childhood. Although the disorder is more prevalent in males, it affects both genders. Many young children display deficits in the areas of patience, thinking ahead and concentration. However, most of these children will show improvement in these areas as they grow. Children with ADHD continue to struggle with inattention and impulsivity throughout childhood and often into adulthood.⁹ Due to wide variations in the rate of growth and development of children, it is often difficult for parents and teachers to distinguish normal age-appropriate behavior from ADHD. This has led to difficulties in diagnosing ADHD at a young age and often these children go undiagnosed until later in childhood when it becomes apparent that they are not showing improvement and the behaviors begin to negatively affect the child's school performance.

ADHD is a chronic disorder and typically includes symptoms of inattention and overactivity.⁹ The DSM-IV requires that these symptoms be present in at least two settings and must be present for at least 6 months to carry the diagnosis of ADHD.¹⁰ The symptoms of this disorder result in serious impairment in multiple areas of functioning. Children afflicted with ADHD often exhibit

dysfunction in school, family and peer relations. Children with ADHD seem to display an increased risk for developing cognitive deficits and learning disabilities.¹¹ This along with a difficulty in concentrating on some aspects of schoolwork leads to a high rate of academic failure. These children are almost always of normal intelligence and have little to no difficulty comprehending schoolwork. However, deficits in areas such as concentration and impulse control can lead to an inability to focus long enough to finish assignments, a tendency to misplace homework, and often difficulty in sitting in class due to overactivity.⁹ These academic challenges can lead to disruptions in interpersonal relationships. The child may have difficulty interacting with peers, teachers and caregivers. A recent study revealed that 35-50% of children currently detained in the juvenile justice system have identifiable behavioral disorders, most commonly ADHD or conduct disorder.¹² In addition to criminal behavior and academic failure, children with ADHD may be at an increased risk for a variety of mood and anxiety disorders as well. Approximately 50% of children diagnosed with ADHD will develop one of these co-morbidities during their lifetime.¹¹

Symptoms of ADHD can vary greatly between the genders. Girls may not demonstrate the same disruptive and hyperactive symptoms as boys. Many girls will show predominately signs of inattention such as taking a longer time to finish schoolwork. Many of these girls will show a tendency to daydream and fidget and may talk excessively.¹³ Boys with ADHD will typically display high levels of overactivity and impulsivity. These children will often be very disruptive in class and have a difficult time following rules. Boys may have a difficult time interacting with other children and may be very aggressive.¹¹

Children with ADHD often show an increased severity of the disorder as they move into adolescence. As hormones change during puberty, these children often suffer consequences of ADHD that go beyond academic difficulties. Adolescent girls with ADHD show poor impulse control and consequently often engage in high-risk sexual behavior. These girls are likely to have their first sexual experience at a younger age than girls without ADHD. They are also five times more likely to become pregnant.¹³ Driving also poses a problem for adolescents with ADHD. Girls and boys with the disorder are up to four times as likely to have an accident while driving and four times more likely to be at fault in the accident than adolescents without ADHD.¹³

Although ADHD is a childhood disorder, recent studies have indicated that these impairments often persist into adulthood. Adults and adolescents with ADHD are at an increased risk for a variety of serious co-morbidities. Among these are academic and professional failure, dysfunctional interpersonal relationships, criminal behavior and alcohol and substance abuse (Pelham 1999). Follow-up studies of children diagnosed with ADHD have indicated that they are at an increased risk to develop antisocial disorders.¹¹ These adults have a high level of comorbidity with anxiety disorder; conduct disorder, and substance abuse. Retrospective studies have typically shown that these adults have struggled with a lifetime of underachievement, both academically and occupationally.¹¹

NICOTINE USE AND BEHAVIORAL CONSEQUENCES

It is an undisputable fact that maternal smoking during pregnancy has a harmful effect on the developing child. Many of these commonly known effects have been researched extensively and a causative link has been established. These effects include a higher incidence of Sudden Infant Death Syndrome (SIDS), increased incidences of childhood asthma, acute otitis media, and upper respiratory infections in childhood.. However, the link between maternal smoking and ADHD remains less well-known.

Over the last decade many studies have been conducted and data collected documenting the substantial link between ADHD and fetal nicotine exposure. These studies, both prospective and retrospective, have revealed similar findings. Children of mothers who smoked during pregnancy generally displayed more signs of attention deficit and were more likely to exhibit learning problems in school⁶. The majority of these studies also revealed that children of smoking mothers performed worse on spelling and math tasks.⁶

Many studies categorize behavioral problems into externalizing or internalizing behavior problems. Externalizing problems generally include descriptors such as oppositional, aggressive and overactive. Children with internalizing behavior disorders are described as being withdrawn and anxious or nervous. In general it seems that maternal smoking during pregnancy has as a negative effect on children in that it seems to increase the incidence of externalizing behavior problems. Maternal smoking does not seem to exert any type of effect on internalizing behavior disorders.¹⁴

It has been proposed that there may be other confounding factors associated with ADHD. Many of these factors such as single parent households, low socioeconomic status and limited maternal education have been linked to higher rates of maternal smoking during pregnancy. It has been argued that the link between maternal smoking and ADHD is not as direct as most researchers believe. However, many of the more recent studies have adjusted for these variables and have nonetheless arrived

at a similar conclusion. It appears that mothers of hyperactive children were more likely to have smoked during pregnancy than mothers of non-hyperactive children, regardless of socioeconomic status and maternal education.¹⁵

CAUSE OF BEHAVIORAL DISORDERS AND LINK TO NICOTINE EXPOSURE

The recent attention given to behavioral disorders, and ADHD specifically, has led to extensive research on possible causes. In searching for a possible mechanism, many variables have been considered. Among these variables were maternal age, socioeconomic status, birthweight, and lead exposure during infancy.⁴ According to this particular study, high lead concentrations were related to small increases in the delinquency category of the rating tool. However, smoking was associated with worse scores in all categories (aggressive, delinquent, attention problems, and social problems).

Given that social factors do not seem to entirely explain the development of childhood ADHD, great attention has been given to finding a biological cause. In general, most researchers have focused on specific brain regions and deficits in these regions. It has been proposed that any damage to these regions, including defects during fetal development, may lead to behavioral problems. For example, the ventral-prefrontal cortex interacts with the striatum and is thought to be responsible in part for impulse control. Any defect or deficit in this area could produce impulsive behavior.⁴ The functioning and development of the prefrontal-striatal circuits are partially under the control of monoamine projections. It has been proven that cigarette smoking has a profound effect on brain monoamine systems. Therefore, maternal smoking could negatively effect the development and functioning of prefrontal-striatal circuits through effects on monoamines.⁴

Additionally, other regions of the brain have been implicated in behavioral disorders. The amygdala is also involved in behavioral inhibition. The ventral-prefrontal cortex receives input from the amygdala. The amygdala is influence by monoamine projections. The effects of smoking on monoamine projections could lead to defects in the amygdala. This would interfere with its input to the prefrontal cortex. This defect would result in behavioral problems and lower levels of inhibition.⁴

Studies in animals have indicated an overall reduction in cerebral blood flow. Also, an association has been made between nicotine exposures and decreased total brain weight. This corresponds with a finding of smaller head circumference in infants exposed to tobacco in utero.⁶ However, it is unclear if this reduction in head circumference or brain weight correlates with any specific behavioral disorder.

IMPLICATIONS FOR CLINICAL PRACTICE

Those who come in contact with pregnant women in clinical practice are in a unique position to intervene and educate these women on making healthy lifestyle choices. Many expectant mothers see their clinicians on a regular basis for prenatal visits. This allows time for the clinician to build a rapport with the mother and assess her motivation for changing her lifestyle during pregnancy. Although the best choice is intervention and smoking cessation during the first weeks of pregnancy, this is not always realistic. Encouraging an expectant mother to quit smoking at any time during her pregnancy is beneficial to the baby. Smoking cessation before 16 weeks gestation has been shown to reverse any negative effect on birth weight. Even smoking cessation before 30 weeks gestation has been shown to improve birth weight of the baby.³

Adequate research has not been done at this time to determine at what point in gestation smoking begins to effect specific brain areas. However, it is suspected that any exposure to nicotine in utero can inflict damage on the developing brain. Many clinicians can use this information along with a new expectant mother's concern for the baby as an opportunity to intervene. Often, frequent nausea associated with the first trimester of pregnancy may provide an additional opportunity to encourage at least temporary smoking cessation.³

LIMITATIONS

Through careful evaluation of the literature pertaining to ADHD and possible etiologies of the disorder, an adequate amount of research has been conducted to indicate a strong causative link between maternal smoking and the development of childhood ADHD. However, some limitations do exist in many of the studies.

One possible confounding variable is the possibility of a genetic link. Many studies have explored the possibility of a genetic component to ADHD. Research also indicates that teenagers and adults with ADHD have a higher incidence of cigarette smoking. This fact could weaken the argument that maternal smoking contributes to the development of ADHD. What appears to be a strong causative link could possibly be more attributable to genetics. However, recent studies have controlled for this possible genetic component and have arrived at similar conclusions regarding smoking during pregnancy and ADHD.

Another limitation involves socioeconomic status of the mother. Frequently, mothers of lower socioeconomic status have higher than average rates of smoking. Also, these mothers tend to have a greater chance of raising a child with ADHD. This fact could possibly be misinterpreted as a causative link. However, in the vast majority of studies, this was recognized and controlled for.

CONCLUSIONS AND RECOMMENDATIONS

The area of childhood behavior disorders is one that has gotten much attention recently. However, more research needs to be done on the subject of ADHD and possible etiologies of the disorder. Studying a large sample of the current research, it seems reasonable to conclude there is a link between maternal cigarette smoking and the development of ADHD in childhood. Although there are several limitations to many of these studies, the fact that these variables have been controlled for in various other studies indicates a fairly solid link between maternal smoking and ADHD.

This link between ADHD and maternal smoking could prove very useful in clinical practice. Most mothers are aware of many of the harmful effects of smoking on an infant. Many are also aware that smoking during pregnancy can have a harmful effect of the developing fetus. However, few mothers are aware that smoking during pregnancy could cause a lifelong cognitive disorder that would affect multiple areas of the child's functioning. ADHD has become very well known to the majority of parents. Knowing that this is a chronic disorder that can affect a child's academic, social and career performance is often enough to encourage mothers make an attempt to prevent this disorder. Often an attentive and persistent clinician is all that is necessary to encourage an expectant mother to quit smoking.

In many primary care practices it is standard of care that smoking status be assessed at every routine office visit. The clinician should examine the patient's motivation to quit and offer possible cessation techniques. This should also be standard of care at every prenatal visit. Many mothers simply do not have knowledge of the harmful effects smoking has on the fetus or she does not have the motivation to approach the clinician. Smoking status should be assessed at each prenatal visit and the mother should be educated about harmful effects to the fetus. At each visit, an attempt should be made to offer cessation techniques to the mother and support and guidance should be given.

Additionally, this new information should be used to educate clinicians, physician assistants in particular, about a less familiar effect of maternal smoking. Many PA programs have built into the curriculum a prevention course. This course typically is very complete concerning obesity, heart disease, diabetes and other common conditions with modifiable risk factors. However, little attention is given to prenatal risk factors. A physician assistant who is educated in this area is more likely to extend this knowledge to his or her patients in clinical practice. The more knowledge a clinician has on the topic the more likely he or she will be to approach the topic with an expectant mother. This developing information on maternal smoking and ADHD should be presented to physician assistant students as another harmful effect of cigarette smoking.

A great amount of research has been done indicating a link between maternal smoking during pregnancy and ADHD. However, more research needs to be conducted examining the exact mechanism of this link.

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