Effects of Fetal Exposure to Drugs: Systematic Review

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Abstract

This paper explores the long-term effects of fetal drug exposure on individuals, examining the implications for cognitive, physical, and social development. This paper reviews existing literature to consolidate an understanding of the effects of in-utero drug exposure. Prenatal exposure to substances such as opioids, alcohol, tobacco, and illicit drugs adversely affects neurodevelopment creating cognitive challenges and behavioral disorders. The paper also discusses the stages of fetal development, the types of substances commonly involved, and the physiological mechanisms by which these drugs impact fetal growth. The findings underscore the importance of informed interventions and holistic treatment approaches for mothers and infants affected by drug exposure, aiming to enhance developmental outcomes and reduce societal stigma. This paper ultimately calls for further research into effective care strategies and the development of supportive frameworks for affected families.

Keywords: Neonatal Abstinence Syndrome, Drug withdrawal, fetal development

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Introduction

Drugs of addiction have been used for thousands of years, many used before the long-term consequences of them have been fully understood. With modern technology and better understanding of the human body people understand the effects of these addictive drugs now more then ever. A new aspect of this understanding is the investigation of addictive drug use while pregnant. Women who use addictive drugs often are unable to stop use during pregnancy, which can lead to short- and long-term effects on their children (Strahan, 2019). This led to the investigation of the short- and long-term effects of drug exposure during fetal development throughout the lifespan. As the understanding of the effects of drugs continues to develop it is important to understand the lifelong effects that fetal drug exposure can have on individuals who are incorporated into society. This paper investigates the short- and long-term effects of fetal drug exposure in the scope of biology effects, physical health effects, mental health effects and social implications for the individual and those around them. This paper will cover generalized background information, the stages of fetal development and how they can become impacted by drug exposure, long term developmental effects, physical and mental health effects, social effects and stigma as well as future points of research.

Background Information

Fetal Exposure to Drugs

According to *Stanford Medicine Children's Health* fetal exposure to drugs is defined as, "…when babies are exposed to drugs in the womb before birth" (2024, p. 2). This is generally understood as when a pregnant woman consumes a substance that can affect the fetus during

fetal development and most often happens with the consumption of opioids and alcohol The use of opioids during pregnancy is common because of the highly abdicative nature creating challenges for quitting during pregnancy (Stanford Medicine, 2024). The use of alcohol is also common due to the mass use and commonality of alcohol consumption in many societies around the world (Stanford Medicine, 2024). In general, the use of illegal drugs puts a massive stain on the larger society, according to the *U.S. Department of Justice* in 2010 the use of illegal drugs cost an estimated $215 billion, and is said to overburden the justice and healthcare systems daily (2010, p. 5). This strain on the greater society follows through to children born addicted to drugs. The average cost for a child born addicted to drugs is $22,552 during the first year of life and is the largest category of birth expenses covered by Medicaid in 2019 (Strahan, 2019). Alone the cost effects of children born addicted to drugs is a concern for the greater society. This paper aims to develop a better understanding and awareness for fetal exposure to drugs and how individuals and society are affected throughout their lives.

Fetal Development Stages

Fetal development is a period of approximately 40 weeks that can be broken down into three stages and three trimesters (Dziuk, 1992). The first stage is the germinal stage, which starts at conception and continues for approximately the first three weeks of pregnancy. This stage starts at conception when the egg is fertilized by sperm within the fallopian tube, creating a zygote (Dziuk, 1992). This zygote travels through the remaining fallopian tube over about a week's time, until reaching the uterus. While traveling the zygote goes from a singular cell to multiple cells containing one structure that will become the fetus and another that will form the placenta (Dziuk, 1992). Once these two structures form the zygote has now become a blastocyst.

By the end of this period the blastocyst is 2 millimeters long (Cleveland Clinic, 2024). This stage is generally unaffected by maternal drug consumption as a placental exchange of product has not been established.

Following the germinal stage is the embryonic stage of fetal development. During the previous stage the blastocyst traveled to the uterus. After this the blastocyst implants into the lining of the uterus. At this point the next stage, embryonic stage, begins. The embryonic stage starts after the third week of pregnancy and lasts until the eighth week. This stage begins with the blastocyst continuing to develop and becomes a fetus with differentiated cells and a heartbeat. During this time the mother experiences intense hormonal changes to support the pregnancy and the fetus develops the neural tube, limbs develop, bones, eyes and the umbilical develop (Dziuk, 1992). The now fetus measures approximately 1 inch in length at the end of this stage. This stage also allows for the development of the placenta, which will allow for drug exchange and fetal drug exposure.

Once the embryo becomes a fetus, at the end of the eighth week the fetal stage starts. The fetal stage starts at the ninth week of pregnancy and continues until birth. At the start of this stage the fetus undergoes sex differentiation, organs fully develop and the fetus growth substantially (Dziuk, 1992). This stage encompasses week three through week forty. By the end of week 12 most critical development of the fetus is complete, most of the rest of the pregnancy is for growth and brain development. This stage of fetal development is centered around development and preparation for life outside of the whomp (Cleveland Clinic, 2024). During this stage the fetus has can build up substantial levels of drug, which will have an impact on the developing brain.

Types of Drug Exposure Covered

There is a large variety of substances that fetuses are exposed to during development and that expecting mothers are instructed to avoid. These range from reduced caffeine intake to controlled substances. For the scope of this paper, the focus will be on illegal drugs such as opiates, cocaine, methamphetamine, and commonly used drugs including alcohol tobacco use. These drugs will be examined due to the high prevalence of use during pregnancy and a strong understanding of how the drugs affect individuals in both the short and long term.

Mechanisms of Transfer

During fetal development, the ingestion of drugs by the mother can often have effects on development through the transfer across the placenta. During fetal development, there are stages of critical development, during the embryotic and fetal stanges, that can be disrupted due to exposure to different chemical substances. Drug exposure is least impactful during the germinal stage and most impactful during the fetal stage of development. The exposure can be chronic or acute, but it is most likely that all drugs consumed by the mother during pregnancy can affect fetal development, many changes go unnoticed while others may have positive effects or detrimental consequences (Garland, 1998). The movement of substances across the placenta has many cofactors including diet, environment, and maternal health. Most drugs reach a developing fetus through the process of simple diffusing across membranes. However, drug characteristics such as molecular weight, lipid solubility, and pH affect the quantity of drug exposure a fetus will experience (Garland, 1998). The strongest determinant of the quantity of fetal drug exposure is maternal drug exposure, showing a linear relationship between maternal drug quantity and fetal exposure quantity (Garland, 1998). Measuring the exact amount of exposure is difficult

during all stages of fetal development, but often times maternal urine screening, maternal drug use history, and retroactive analysis are used to determine exposure amount (Garland, 1998).

For drugs to reach and affect the fetus they have to be in the maternal circulation and be transferred across the placenta. Most drugs move across the placenta through passive diffusion (Garland, 1998). The drugs that pass through the placenta with ease are lipid soluble and have a small molecular weight. Large and polar molecules have a more difficult time passively diffusing across the placenta due to placenta pore size and thickness (Garland, 1998). Throughout the gestational process the placenta changes to accompany the growth and development of the fetus. The placenta allows drug exposure into the fetus, but it is also used for fetal clearing of drugs. When the placenta increases in surface area and reduces is thickness, such as in the fetal stage of pregnancy there is more permeability in both directions, allowing for greater fetal clearing of drugs (Garland, 1998). During this time the fetus is primary in growth and brain development phases, which are the two most effected systems of fetal drug exposure. During the germinal stage development the placenta has restricted surface area and greater thickness, meaning that the drugs that are able to cross the placental barrier have a harder time being cleared by the fetus making the fetal drug exposure higher.

In addition, there are some mechanisms that can decrease the amount of drug diffusion across the placenta. Some drugs within the maternal circulation bind to proteins which impairs their ability to diffuse across the placenta (Garland, 1998). This creates a ratio of bound drugs versus free drugs. When there is a drug that has a high affinity for binding to a protein it can reduce the amount of drug that can cross the placenta and cause fetal development abnormalities.

Types of Drugs and Their Effects

Illegal Drugs

During pregnancy, there is a growing rate of individuals who use illegal drugs during the time of pregnancy. In 2015 approximately 5.9% of pregnant people participated in the use of illegal drugs in the United States. The majority of illegal drug use affects the placental function, however, problems with fetal growth restriction, preeclampsia, prematurity, premature rupture of membranes, or fetal defects can also occur.

Within recent years the use of methamphetamines and methylenedioxy-N-methamphetamine (MDMA) has become more popular than many other illegal drugs including opioids, with close to 5% of newborns testing positive for these drugs in 2014 (Fitzgerald, 2023). When methamphetamine is ingested by a pregnant woman it is metabolized by the maternal liver into amphetamine and 4-hydroxymethamphetamine. These two substances can easily cross the placental barrier due to the lipophilic nature of the substances. Once across the placenta the substances accumulate in higher quantities within the fetus due to the extended half-life of methamphetamines (Fitzgerald, 2023). Once in contact with a developing fetus the substances cause an increase of neurotransmitters in the intervillous space, the exchange area between the placenta and fetus. This upregulation causes vasoconstriction in the placenta, uterine contractions, platelet activation, and accumulation within the fetal lungs. Within two hours of maternal ingestion of methamphetamines, the fetus had a 37% increase in blood pressure, a decrease in arterial blood pH, and a decrease in arterial blood oxygen saturation (Fitzgerald, 2023). These results are caused by the vasoconstrictive nature of methamphetamines restricting the blood flow of the placenta and inadequate oxygenation of the fetus. The main complication

of maternal use of methamphetamines is reduced blood flow to the fetus because of increased neurotransmitters.

In developed nations such as the United States, Western Europe, and Central Europe cocaine is one of the top consumed illegal drugs (Fitzgerald, 2023). Cocaine that enters into the maternal system enters in a lipophilic nature allowing it to cross the placental barrier as well as the fetal blood-brain barrier. There is not a specific set of symptoms observed in infants born to mothers who ingested cocaine despite the high prevalence. In general, however, infants are observed to have smaller head circumference, and behavioral disorders observed in infancy (implying cognitive impairments) most likely caused by placental complications (Fitzgerald, 2023). In all individuals when cocaine is ingested it blocks norepinephrine reuptake in synaptic neurons, this results in higher levels of synaptic cleft dopamine, serotonin and norepinephrine (Fitzgerald, 2023). These substances increase the maternal blood pressure and impair placental blood flow resulting in placental complications (Fitzgerald, 2023). These complications are often worsened with lowering of amino acid transport and human chorionic gonadotropin synthesis all contributing to preeclampsia.

While opiates can be used as legal painkillers, the use of them without a prescription is considered an illegal drug and can lead to opioid use disorder. Approximately 2.7 million people in the United States over the age of 12 have developed opioid use disorder in 2020 (NIDA, 2021). The use of opioids is associated with alcohol or cocaine abuse in about 22% of instances in 2014 (Fitzgerald, 2023). Opiates encompass a large category of drugs making the route of transfer vary across opiate types, either lipophilic pass quickly through the placenta or polar opiates diffuse slowly and build up within the intestine of a fetus. The most common opioids are morphine, fentanyl, and sufentanyl and are all drugs that quickly pass across the placenta and

reach maternal fetus equilibrium within five minutes of maternal ingestion, meaning that the amount of detectable opiate in the maternal blood is equivalent to the detectable amount of opiate in fetal cord blood (Fitzgerald, 2023). The use of opioids has the highest association of placental complications of any other illegal drug. These complications can include preeclampsia, premature rupture of membranes, placental insufficiency, placental abruption, fetal growth restriction, and intrauterine fetal death (Fitzgerald, 2023). These placental complications all come with different outcomes for fetal and maternal health.

Tobacco and Alcohol

The harms of tobacco have been known for a significant amount of time and negative effects on a fetus have been correlated since the negative impacts of tobacco have been known. Tobacco has several different ingredients, nicotine, carbon monoxide, cadmium and benzopyrene, that all affect a developing fetus differently. Nicotine crosses the placenta easily and with chronic use fetal blood levels will reach equilibrium with maternal blood levels. Cotinine easily passes the placental barrier and can accumulate very quickly within the fetal circulation, almost double the concentration of maternal blood dose due to extended half life (Fitzgerald, 2023). Benzopyrenes, which are found only in cigarette smoke, is inhaled and reach equilibrium in maternal and fetal blood while also have a strong effect on placental metabolism. Carbon monoxide can accumulate in the placental barrier and form carboxyhemoglobin ultimately leading to fetal and placenta hypoxia. The combination of these chemicals results in pregnant people experiencing smaller placentas with thick membranes and possible necrosis (Fitzgerald, 2023). The damage caused to the maternal body when tobacco is used often upregulates the inflammatory process within the body, this is reflected in the fetus. In both

maternal systems and fetal systems xenobiotic genes, involved with the detoxification of carcinogens are upregulated, and genes of cell adhesion, wound healing, and apoptosis are damaged (Fitzgerald, 2023). Many of the maternal effects of tobacco are reflected in the developing fetus and infant, which can cause major problems with breathing development.

Alcohol is by far the most consumed damaging substance during pregnancy. In a self-report survey in 2012, approximately 20% of pregnant women reported moderate alcohol consumption and 8% reported risky alcohol consumption, under-reporting is assumed due to the nature of the survey (Fitzgerald, 2023). Alcohol use during pregnancy can lead to low placental birth weight, reduced placental vasculature, fetal vasoconstriction, and increased fetal and maternal blood pressure. The placenta is heavily affected by dose-dependent alcohol consumption, with higher and more regular use leading to greater effects of increased permeability, reduced vasculature, higher vascular resistance, and reduced amino acid transfer (Fitzgerald, 2023). As alcohol is commonly consumed during pregnancy, the effect of the consumption can vary greatly depending on several factors, one of the biggest being how the placenta reacts to maternal alcohol consumption. Infants born after fetal exposure to alcohol often present with postnatal growth restriction, facial dysmorphology, central nervous system dysfunction, and neurobehavioral disabilities (Denny, 2017). Individuals can display a spectrum of these symptoms, which often leads to a spectrum of lifelong effects from alcohol exposure.

Long-Term Effects on Development

Cognitive Development

Children who are exposed prenatally to drugs can show signs of cognitive impairment from a very early age that persists throughout their lifespan. The cognitive effects of drug

exposure are observed as early as a few months of age (Alessandri, 1998). In a conjoined study between the University of New Jersey and the Medical College of Pennsylvania to observe the cognitive effects of cocaine exposure on infants 18 months and younger. The study evaluated the cognitive abilities of 236 infants at 8 months and then again at 18 months. These children ranged from being heavily exposed to cocaine, lightly exposed to cocaine or not exposed at all. The children's cognitive development was evaluated based on Bayley Scales of Infant Development. Using this developmental scale at both ages the study was able to conclude that children that were heavily exposed to cocaine scored significantly lower on cognitive ability than children that were not exposed to any cocaine. This study was also able to conclude that children who were only moderately exposed to cocaine had not significant difference in cognitive scores then children who were not exposed at all (Alessandri, 1998). This study provides evidence that even from a very early age the cognitive discrepancies between drug-exposed children and nonexposed children become significant.

Cognitive development is one of the longest-lasting and most detrimental effects of fetal drug exposure. As described above most drugs that are consumed during pregnancy can easily pass through the placenta, especially during the ladder parts of fetal and brain development, and interact with the fetus to cause long-lasting effects. Some of the longest-lasting effects are experienced by cognitive development impacts. In 2007 a comparative study was completed between children at the age of 5 who had been exposed to drugs during the development and children who were not exposed to drugs. This study overall concluded that children who were exposed to drugs during development scored lower on language skills, school readiness skills, impulse control, and attention span than when compared to baseline skills for five-year-olds (Pulsifer, 2007). This study was able to determine key differences in children's ability to succeed

in school once these children reached school age. It was concluded that children who experienced … "prenatal drug exposure are at increased risk for learning and attention problems and are in need of close development surveillance…" (Pulsifer, 2007, pg. 10). This study looked primarily at school readiness skills and reflects that cognitive skills are affected long-term when prenatal drug exposure occurs.

Cognitive development is not simply based on the fetal environment but is fostered by a child's environment and access to resources. Cognitive development happens rapidly during the young childhood years. These developments can be supported by stability in the environment, access to resources, and other factors that all compound to determining a child's cognitive development scores (Oei, 2018). There are strong trends in children that are exposed to drugs during development and often have less cognitively supportive environments which could lower cognitive scores.

Emotional and Behavioral Outcomes

Since the start of the investigation into the effects of drug and alcohol exposure in utero, it is known that impaired brain development was a common occurrence, more recently people have started to look at the long-term effects into adolescence and adulthood. Looking specifically at children aged 11 years and up it was observed across 17 different studies that children exposed to alcohol in utero developed some degree of an emotional or behavioral abnormality (Irner, 2011). These disorders include attention deficits, autistic spectrum problems, difficulties in short-term memory, obsessive-compulsive disorder, anxiety, depressive disorders, antisocial behaviors, mania spectrum disorders and generalized impairment (Irner, 2011). Every study that was

conducted found to some degree that children who were exposed to alcohol during development had long-lasting developmental effects to their brains.

While these studies can speak to the lifelong disorders and challenges many children face when exposed to alcohol a more holistic view of developmental drug exposure can be found when looking at more substance types. In a consolidation of studies, it was observed that children who are exposed to drugs (mostly opioids and cocaine) are more likely to maintain behavioral issues and lower academic and social success than peers during their teenage years (Irner, 2011). In eight studies looking at individuals aged five to 17 who were exposed to cocaine, nicotine, heroine or methamphetamines all studies found at least one significant behavioral deviation from the standard. These behavioral issues included lower ability to communicate, lower ability to interoperate social cues, delinquent behavior, attention problems, hyperactivity, attention-defecate disorder and emotional underdevelopment (Irner, 2011). Most of the individuals reviewed in these studies suffered from attention problems or attention deficit disorder closely followed by the number of children who struggled with long-term mental health issues such as anxiety and depressive behavior. These studies cannot avoid confounding variables due to the nature of human-only observation and evaluation studies (Irner, 2011). However, even with confounding variables, it is evident that children who are exposed to alcohol, tobacco, or other drugs during development experience long-lasting emotional and behavioral challenges into teenage and adult living.

Physical Development

Drugs that can pass the placenta can have a magnitude of effects on a developing fetus, including brain development as well as physical development issues, often determined by when a

developing fetus was exposed to drugs. A major issue with fetal drug exposure is spontaneous abortions and fetal demise, which are typically about ten times higher in drug-abusing mothers when compared to non-using mothers (Bandstra, 1992). While most pregnancies can produce a viable fetus prematurity and pregnancy complications remain abnormally high in drug-abusing mothers. Most drugs cause vasoconstriction of the placenta leading to hypoxia and restricted blood flow of the fetus which is often credited with causing most on the physical malformations. Physical abnormalities that are most often seen at higher than typical rates are genitourinary tract abnormalities, cardiomegaly, atrial septal defects, and ventricular septal defects (Bandstra, 1992). These abnormalities happen in high quantities of drug-exposed children and are screened for soon after birth in children that meet exposure criteria. These abnormalities are well known to healthcare professionals allowing them to be addressed soon after birth and hopefully results in repair.

During in-utero development, there can be complications such as growth restriction and low birth weight that can lead to problems during early infancy and childhood. Birth weight is classified into several different groups, low birth weight (less then 2,500 grams), very low birth weight (less then 1,500 grams), and extremely low birth rate (under 1000 grams). These categories allow for a general understanding of size restriction during development but do not allow for gestational age to be considered as a factor (Bandstra, 1992). To gather a more holistic look at newborn size children can be determined by growth parameters, infants that fall in the lower 10^{th} percentile for gestational age are considered growth restricted. Infants that are exposed to drugs during development are consistently considered small for gestational age and growth-restricted (Bandstra, 1992). This is generally thought to be due to the lowered blood flow to the placenta during pregnancy which does not allow sufficient fetal support and growth. The

restricted in-utero growth is often able to be compensated for after birth through supportive care and alternative processes such as tube feedings and milk fortification. Children that are considered growth-restricted at the time of birth are often able to return to on-target growth percentiles by the age of two with proper supportive care (Bandstra, 1992). Due to the progression of knowledge and healthcare, many of the physical abnormalities that often develop due to fetal drug exposure can be reduced soon after the time of birth.

Neonatal Abstinence Syndrome

There is one overarching term that can be used in the short term for newborns that experienced in utero exposure to drugs, neonatal abstinence syndrome (NAS). The National Institute of Health defines Neonatal Abstinence Syndrome as "… a spectrum of clinical manifestations seen in neonates due to withdraw secondary to intrauterine drug exposure" (Anbalagan, 2024). In 2016 there were more than 10,000 births that resulted in NAS. Newborns tend to start withdrawing from drugs within he first 24 to 48 hours after birth, with the most dramatic withdraw symptoms happening between 34 and 50 hours of life (Maguire, 2016). The signs of withdrawal in an infant are very similar to the signs of withdrawal in an adult due to nervous system irritability, autonomic overactivity, and gastrointestinal distress. The outward display of symptoms includes tremors, increased muscle tone, excoriation, sweating, fever, mottling, nasal stiffness, regurgitation, projectile vomiting, tachypnea, poor feeding, extensive high-pitched crying, sleeplessness, hyperactive reflexes, and seizures (Maguire, 2016). To lessen the severity and damage of withdrawal external stimuli is minimized and many are giving opioid pain medication, morphine is most common, that is slowly tapered off to allow for a more gradual withdrawal process.

Infants can be immediately treated for NAS, but there are longer-lasting effects. Many of the effects have been described earlier in this paper, as NAS is a blanket term that is used to cover all withdrawing infants regardless of what substance they are withdrawing from. The most common long-term ailments found in infants who are determined to have NAS are vision development abnormalities, motor control problems, slow or inadequate behavioral and cognitive development, and hearing deficits (Maguire, 2016). These developmental issues can cause problems for the lifespan of an individual who experienced NAS. In addition, children who experience withdrawal are at higher risk for sudden infant death syndrome (SIDS). This is a deadly complication that is not fully understood, and NAS could play a role in who is susceptible, however, there is a magnitude of confounding variables and a lack of understanding (Maguire, 2016). Due to the frequency of withdrawal cases, it has become treatable, however, the long-lasting effects are still detrimental and variable among individuals.

Social Perceptions and Stigmatization

Public Perception of Drug-Exposed Infants

The stigma surrounding the use of illegal drugs is a strong deterrent for many people to seek help, this stigma only compounds when an individual is pregnant. Stigma is considered "…an attribute that is deeply discrediting, reducing someone from a whole and usual person to a tainted, discounted one…" according to the National Library of Medicine. Neonates that are born and experiencing withdrawal symptoms are immediately faced with stigmatization during care. Many of the healthcare workers taking care of children with NAS have preconceived notions about who should determine care, the healthcare team or parents, and what the child's custody should be (Recto, 2020). Infants experiencing withdrawal are often marked within hospital care

units and there is restricted visitation access. These circumstances can create altered care of the child due to preconceived ideas about the challenges of caring for withdrawn infants. Many individuals who experienced NAS grow up to be healthy adults, however, when information about their infancy is known many people apply stereotypes to them.

Stigmatization of Mothers

Mothers who use drugs are often stigmatized by the public as well as through self-stigmatizing often leading to a worsening situation and avoidance of assistance and healthcare. Women are more stigmatized than men who use illegal drugs, especially once pregnancy or early motherhood becomes more obvious to the public (Recto, 2020). Mothers who use drugs often experience public and self-stigma in the form of stereotypes, prejudices, and discrimination. Common thoughts surrounding pregnant women from the public are that many of these mothers "are criminals" "unfit mothers" or "unworthy to keep their children" (Recto, 2020). These thoughts can inhibit the care that mothers receive or the care that these mothers seek. Many mothers who are drug abusers experience large amounts of fear and anxiety about the custody and visitation of their infants. This can often lead mothers attempting to improve their addiction to lean closer to relapse. Mothers who have a child in long-term hospital care often feel an immense amount of guilt, whether it was the mother's fault or not. These emotions combined with heightened sensitivity due to postpartum changes can often overwhelm new mothers and create a positive feedback loop of stigmatization.

Developing Treatments and New Research

Specialized nurseries and intensive care units are becoming more common around the world, due to the increasing number of in-need infants as well as the increasing knowledge base that can be utilized to treat these infants. While drug-exposed infants are considered to have routine treatment plan when admitted to an intensive care unit, the majority of the support, care and understanding of the condition stops at date of discharge. After the initial symptoms of withdraw have subsided there is not much research about how to care and minimize cognitive and behavioral outcomes of these children. There is also little to no research in what the best environment for development and reduction of risk factors is for children, young adults or adults. Many of these children often have social services involved while they are admitted to the hospital. These social service workers attempt to place these children in the best environments with very little research into what those environments should look like.

While much is understood and known about neonatal abstinence syndrome the treatment is often time-consuming, restrictive, requires long-term hospitalization, and can only treat short-term symptoms with harsh pharmaceuticals such as morphine. Researchers are attempting to discover better and more holistic treatments for drug-exposed children. Most of the advances are to use alternative drugs to morphine to treat withdrawing infants, by using pharmaceuticals such as methadone, sedatives naltrexone or nonpharmaceutical alternatives (MediFind, 2024). These alternatives just described are practices that are currently being used in treatment plans around the country and case management is being compared to the standardized treatment for withdrawing infants.

To expand the knowledge base, treatment, and care for drug-exposed infants and drug-addicted mothers there are numerous clinical trials currently being conducted. Within the past

year, clinical trials stressing alternative treatments and quicker identification have been implemented. Some of these include a trial assessing the benefits of auricular neurostimulation, which is stimulation of the vagus and trigeminal nerve, in conjunction with oral morphine to reduce the length of hospital stay for withdrawing newborns (Benner, 2024). In an attempt to limit the negative impacts of opioid use during pregnancy Boston Medical Center is conducting a clinical trial to ensure the safety and effectiveness of naltrexone, a medication used to treat addiction, in pregnant women (2024). Some researchers, such as those at the University of Alberta are attempting alternative methods of treatment to reduce intensive care admission or length of stay by creating a system that keeps new mother and infant living together in the hospital, creating knowledge and supportive care and enrollment in support programs for mother and baby at the time of discharge (2024). There are also extensive genetic testing clinical trials attempting to identify at risk populations, prediction of severity of withdraw, and customized treatment plans of both mother and infant. Diet is being investigated to better understand the benefits and support for withdraw symptoms resulting in abnormalities in gastrointestinal actions. One study is evaluating infants on a caloric supplementation via fortification of breast milk to identify how weight gain rates and benefits to digestive health (Yale, 2024). In contrast, a different clinical study is investigating the benefits of feeding an infant with NAS only human milk and human milk fortifiers to decrease length of hospital stay (Blanco, 2024). Some of the most popular clinical trials for infants experiencing withdraw is the use of consoling practices, usually with cuddler programs, and the use of different types of music therapy to reduce nervous system stimulation (Loewy, 2024). As the rate of drug usage and therefore rate of withdrawing infants increases there is a large demand to care and help both mother and baby to minimize effects.

Conclusions

Fetal drug exposure has long-term effects on individuals, including biological, physical, mental, and social implications. The use of methamphetamines, MDMA, cocaine, opioids, tobacco, and alcohol during pregnancy can have severe effects on fetal development, including placental complications, cognitive impairments, and behavioral disorders that persist throughout a lifetime. Fetal drug exposure can have long-lasting effects on cognitive development, including lower language skills, shortened attention span and mental health diseases. Physical development can be affected by spontaneous abortions, low birth weight, and growth restriction. There is a significant amount of stigma that surrounds the use of drugs, which is often heightened during pregnancy. Researchers are investigating alternative treatments and supportive environments to minimize the effects of in-utero drug exposure on infants and mothers. While much is being done, there is much more to investigate about in-utero drug exposure.

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