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Multifactorial Influences on ADHD in Children: The Roles of Biological and Enviromental Factors

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ABSTRACT

Attention-Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder characterized by inattention, disorganization, and/or hyperactivity-impulsivity, which interferes with daily functioning, and has multifactorial causes involving biological, psychosocial, and environmental factors. This study aimed to examine genetic, prenatal, perinatal, and environmental/parenting influences on ADHD in two children. A qualitative multiple case study design was employed, with data collected through semi-structured interviews with mothers and participatory observations during five therapy sessions for each subject. Thematic analysis revealed that subject MN's symptoms were primarily linked to genetic predisposition, supported by a family history of ADHD, as well as prenatal maternal stress and pregnancy complications. Subject HA's symptoms were more strongly associated with prenatal risks, including maternal smoking and economic stress. Both subjects shared perinatal factors—premature birth, low birth weight, and NICU care. Environmental influences differed, with MN receiving consistent parenting and limited gadget exposure, while HA experienced inconsistent parenting and early gadget use. These findings underscore the complex interplay of genetic vulnerability, prenatal and perinatal conditions, and environmental factors in shaping individual ADHD profiles.

Keywords: Attention-Deficit/Hyperactivity Disorder; Case Study; Genetic; Prenatal-Perinatal; Parenting

ABSTRAK

Attention-Deficit/Hyperactivity Disorder (ADHD) merupakan gangguan perkembangan saraf yang ditandai oleh gejala kurangnya perhatian (inatensi), disorganisasi, dan/atau hiperaktivitas-impulsivitas, yang mengganggu fungsi sehari-hari. ADHD memiliki penyebab multifaktorial yang melibatkan faktor biologis, psikososial, dan lingkungan. Penelitian ini bertujuan untuk mengkaji pengaruh faktor genetik, prenatal, perinatal, serta lingkungan/pola asuh terhadap ADHD pada dua anak. Desain penelitian menggunakan studi kasus jamak kualitatif, dengan pengumpulan data melalui wawancara semi-terstruktur kepada ibu dan observasi partisipatif selama lima sesi terapi pada masing-masing subjek. Analisis tematik menunjukkan bahwa gejala pada subjek MN terutama berkaitan dengan predisposisi genetik, didukung oleh riwayat keluarga ADHD, serta stres maternal selama kehamilan dan komplikasi kehamilan. Sementara itu, gejala pada subjek HA lebih kuat berasosiasi dengan risiko prenatal, termasuk kebiasaan merokok ibu selama kehamilan dan tekanan ekonomi. Kedua subjek memiliki faktor perinatal yang serupa, yaitu kelahiran prematur, berat badan lahir rendah, serta perawatan di NICU. Pengaruh lingkungan menunjukkan perbedaan: MN memperoleh pola asuh yang konsisten dan paparan gawai yang terbatas, sedangkan HA mengalami pola asuh yang tidak konsisten dan penggunaan gawai sejak dini. Temuan ini menegaskan adanya interaksi yang kompleks antara kerentanan genetik, kondisi prenatal dan perinatal, serta faktor lingkungan dalam membentuk profil ADHD yang spesifik pada tiap individu.

Kata Kunci: *Attention-Deficit/Hyperactivity Disorder (ADHD), studi kasus, genetik, prenatal-perinatal, pola asuh*

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Introduction

According to the American Psychiatric Association, Attention-Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder characterized by persistent patterns of inattention, hyperactivity, and impulsivity that interfere with an individual's cognitive, psychomotor, language, and social development (Jacob & Watini, 2022). Barkley (2022) further explains that ADHD involves difficulties primarily related to attention, impulsivity, and activity regulation, which significantly impact time management, self-control, planning, and problem-solving abilities. Similarly, Coghill et al. (2023) define ADHD as a condition marked by ongoing behaviors of inattention, disorganization, and/or hyperactivity- impulsivity that disrupt daily functioning and deviate from typical developmental norms, often lying at the extreme end of human behavioral patterns.

These characteristics have real implications in everyday life. Previous research shows that ADHD significantly affects children's executive functioning, including self-regulation, emotional control, and social skills (Fitriyani et al., 2023). Children with ADHD often struggle to follow instructions, complete tasks, and maintain positive peer relationships (Julianingsih et al., 2023). They also face difficulties in academic settings, tend to have lower self-esteem, frequently experience emotional dysregulation, and may encounter family conflicts (Maharani, 2023). If left untreated, ADHD may persist into adolescence and adulthood, increasing the risk of comorbidities such as behavioral disorders, mood disorders, anxiety, language impairments, and substance abuse (Cerrillo-Urbina et al., 2018; Gunawan, 2021; Maharani, 2023). Motor coordination problems are also common, as children with ADHD often show clumsy movements or underdeveloped motor skills due to a lack of focus on body awareness (Jacob & Watini, 2022). The manifestation of symptoms can differ by gender: girls are more likely to develop emotional and internalizing problems, while boys tend to display oppositional and externalizing behaviors (Chronis-Tuscano, 2022; De Rossi et al., 2022).

While the symptoms and consequences of ADHD are widely recognized, its exact causes remain unclear. However, researchers agree that ADHD is a multifactorial condition resulting from the interaction of genetic, biological, environmental, and psychosocial factors. Genetically, ADHD is not attributed to a single gene but rather to the cumulative influence of multiple genes. A study in the United States found that approximately 30% of children with ADHD have at least one parent who also exhibits the disorder (Pranata et al., 2024). Biologically, ADHD is associated with imbalances in neurotransmitters such as dopamine and norepinephrine, which are essential for attention regulation and impulse control (Cervantes-Henríquez et al., 2021). Environmental and psychosocial risk factors also play a critical role in the development of ADHD. Children raised in dysfunctional family environments—such as those with parents experiencing mental health problems, substance abuse, or inconsistent parenting—are at higher risk (Ginting et al., 2023). In addition, perinatal factors like low birth weight, premature delivery, cesarean section, and low Apgar scores have been linked to increased ADHD risk (Bala et al., 2023). Given the widespread impact and complex causes of ADHD, it is essential for parents, educators, and healthcare professionals to develop a comprehensive understanding of the disorder. Early diagnosis and timely intervention can help reduce the long-term effects of ADHD and support more optimal developmental outcomes for affected children.

Material and Method

This study employed a qualitative approach using a multiple case study method conducted at a child therapy center in Sidoarjo. The case study method was chosen to explore in depth the contributing factors and possible causes influencing the development of ADHD in the subjects within the context of their daily lives and therapeutic environment. According to Assyakurrohim et al. (2022), the case study approach is suitable for gaining a detailed understanding of complex and multifaceted phenomena in their natural settings, which aligns with the objective of investigating the underlying factors of ADHD in this research.

Participants

The participants were selected using purposive sampling based on specific characteristics relevant to the research objectives, namely children diagnosed with ADHD. Selection criteria included children of the same age but different genders to allow comparison across developmental stages. Additionally, participants were chosen based on the availability and willingness of their parents to be interviewed and to permit observation of their children during therapy sessions. This approach ensured that the study could effectively explore the contributing factors of ADHD within a comparable age group while considering gender differences. This study examined two subjects who met the inclusion criteria specified by the researcher.

Name	: MN
Place, Date of Birth	: Jombang, 18 April 2020
Age	: 5
Sex	: Female
Order in Family	: 1 of 1
Last Education	: Kindergarten
Hobbies	: Playhouse, dolls
Name	: HA
Place, Date of Birth:	: Sidoarjo, 12 Desember 2019
Age	: 5
Sex	: Male
Order in Family	: 2 of 2
Last Education	: Kindergarten
Hobbies	: Playing with cars, leggo

Data Collection

Data were collected using two primary techniques: semi-structured interviews and participatory observation. Semi-structured alloanamnesis interviews were conducted individually with each subject's mother. This approach was chosen because the children had not yet developed sufficient communication skills or self-reflective capacity to provide valid information independently. The interview questions explored key domains related to potential contributing factors of ADHD, including prenatal and birth history, developmental milestones, environmental conditions, and daily behavioral patterns.

Participatory observations were conducted during five therapy sessions for each subject over a period of approximately three weeks. The researcher assumed the role of a moderate participant, allowing for direct observation of the children's behavior in a naturalistic therapeutic setting while maintaining enough interaction to build rapport and capture authentic responses (Romdona et al., 2025).

Data Analysis

The collected data were analyzed using thematic analysis to identify and compare contributing factors to ADHD and the current developmental profiles of both subjects. The analysis process followed the six steps of thematic analysis (Bryne, 2021): (1) familiarization with the data through repeated readings of interview transcripts and observation notes, (2) generating initial codes related to potential causal factors and developmental characteristics, (3) searching for themes that captured patterns within and between subjects, (4) reviewing and refining themes to ensure accuracy and coherence, (5) defining and naming each theme, and (6) producing the final comparative report.

To enhance the credibility of the findings, data triangulation was applied by cross- verifying information from interviews with mothers, and observational records. The analysis aimed not only to identify individual characteristics but also to highlight similarities and differences between the two subjects in terms of possible causal factors and their present developmental outcomes.

Result

Aloanamnesis Interview

MN's Mother

The subject's mother reported that her pregnancy was marked by both physical and emotional challenges. During the pregnancy, she had to manage everything on her own, as her husband was studying veterinary medicine as a clinical co-assistant on another island and could only return home once a month. Despite the circumstances, she continued working as a high school teacher and commuted long distances by motorcycle each day, which contributed to the vulnerability of the pregnancy. She experienced several instances of bleeding, was required to undergo bed rest, and was prescribed various medications to maintain the pregnancy. At 33 weeks of gestation, the mother experienced a sudden rupture of membranes and underwent a cesarean section. The subject was born prematurely with a birth weight of 2.2 kilograms and required intensive care in the Neonatal Intensive Care Unit (NICU) for three weeks. The mother also reported a family history of ADHD, specifically in one of the subject's cousins, who had exhibited impulsive behavior and difficulty following rules since early childhood.

In terms of developmental milestones, the subject showed age-appropriate progress in certain areas, such as beginning to speak at around 10 months and being able to identify colors and shapes by the age of four. However, she often failed to respond when called, and her speech remained difficult to understand. She frequently became frustrated when her mother could not comprehend what she was trying to express. Socially, the subject tended to play alone, as she had a habit of teasing her peers—for example, by pinching them or hiding their toys. At school, she often received warnings due to her inability to sit still, low tolerance for boredom, and frequent disruptive behavior during learning activities. In public settings such as restaurants or supermarkets, she also had difficulty waiting her turn and displayed impatience by whining or complaining persistently.

HA's Mother

The subject is a five-year-old boy who was born prematurely at 31 weeks of gestation via cesarean section following sudden premature rupture of membranes. He had a birth weight of 1.9 kg and required neonatal intensive care for four weeks in an incubator to support his physiological stability. The pregnancy was marked by significant physical and emotional stress experienced by the mother, particularly after the father lost his job during her early pregnancy. Both parents had been active smokers prior to marriage; although the mother ceased smoking during her first pregnancy, she resumed during the pregnancy with the subject, consuming up to four cigarettes per day. The subject was exclusively breastfed until the age of three months, after which he was switched to formula feeding due to cessation of lactation. Complementary feeding began at eight months of age. He lives with his nuclear family and maternal grandmother. From the age of two, he was frequently given a gadget to reduce fussiness, a practice introduced by his father despite maternal reservations. The mother applies a relatively firm parenting approach, though consistency is challenged by differing practices from the grandmother, who tends to indulge the child.

Speech and language development has been notably delayed. At age three, the subject had not yet achieved fluent speech and could only produce isolated words. Vocabulary expansion began after entering kindergarten at age four; however, at the present time, he is still unable to speak in complete sentences and requires substantial assistance to communicate effectively during conversations. In terms of self-help skills, the subject can perform simple tasks such as tidying toys, placing clothes and shoes in their designated places, and fetching eating utensils. Nevertheless, he still requires support with more complex daily activities, including bathing, personal hygiene, and organizing school materials. Socially, he tends to avoid peer interaction, prefers solitary play, and exhibits limited sharing behaviors. He may cry or throw toys when his demands are unmet. The

subject also demonstrates difficulty waiting his turn in both school and public settings, often displaying impatience through crying, whining, or aggressive behaviors such as pushing others in line.

Observation

MN's Observation

Based on observations conducted over five therapy sessions, the subject had difficulty sustaining focus, was easily distracted, frequently switched between activities without completing them, and was reluctant to engage in tasks requiring sustained cognitive effort. Hyperactivity was evident through excessive motor behavior and an inability to remain still, while impulsivity was observed in spontaneous actions such as hugging or pinching peers without self-control.

Emotionally, the subject appeared labile and reactive, often crying or having tantrums when her desires were unmet. She demonstrated resistance to rules but was able to cooperate when provided with clear structure and positive reinforcement. In social interactions, the subject initiated communication but often lacked an accurate understanding of social boundaries. Nonetheless, she showed the ability to learn from experience and demonstrated more adaptive behaviors after receiving guidance.

HA's Observation

The subject, a male child, usually arrived at the therapy center accompanied by his mother and initially often resisted interacting, such as greeting or praying. However, with the therapist's guidance, he began to participate, although his responses were frequently imitative or echoed the therapist's words rather than being spontaneous. His language skills were delayed, and he often repeated what the therapist said. The subject had difficulty focusing and was easily distracted by noisy environments, exhibiting impulsive behaviors such as throwing balls and grabbing toys from others. In fine motor skills, he required assistance to use utensils, color, and string buttons but was able to complete tasks with guidance. The subject also frequently cried or threw tantrums when faced with rules, yet he was able to calm down with the therapist's support.

Cognitively, the subject showed progress in following simple instructions, recognizing the functions of body parts, and sequencing pictures, although he still needed some help. In social interactions, the subject learned to share and ask permission before taking toys after being guided by the therapist. Over several therapy sessions, he demonstrated improvements in spontaneous responses, focus, and task completion abilities.

Based on the results of the interviews and observations of both subjects, the following key points can be identified:

Causes Factors	MN (female)	HA (male)
Genetis	✓	-
Prenatal	✓	✓
Perinatal	✓	✓
Parenting	-	✓

Discussion

The present study demonstrates that the ADHD symptoms observed in subjects MN and HA arise from a multifactorial interplay of genetic, prenatal, perinatal, and environmental influences. This supports the assertion by Abidin (2023) that ADHD cannot be explained by a single etiology but is instead the product of cumulative biological, psychosocial, and environmental risk factors. Importantly, the two cases illustrate how different constellations of risks can converge toward similar symptomatic expressions, underscoring the heterogeneity of ADHD and the need for individualized interpretation. In MN's case, the contribution of genetic vulnerability is evident, given a family history of ADHD in a maternal cousin who displayed hyperactivity, impulsivity, and difficulty following rules since childhood. This is consistent with previous findings showing that children with

close relatives diagnosed with ADHD face a significantly increased risk of developing the disorder themselves (Kian et al., 2022; Pranata et al., 2024). By contrast, HA did not present with a documented familial predisposition, yet the literature suggests that ADHD is often polygenic and shaped by the cumulative effect of multiple interacting alleles (Klein et al., 2019; Cervantes-Henríquez et al., 2021). This highlights that genetic contributions may not always be explicitly traceable within family histories but can nonetheless predispose children to attentional and behavioral dysregulation. Thus, the two subjects together illustrate the dual nature of genetic influences: direct and observable in some cases, latent or subtle in others, yet still exerting a meaningful role in the emergence of ADHD symptoms.

Beyond genetic factors, prenatal adversities provided another layer of risk that shaped the developmental outcomes of both subjects. MN's mother experienced chronic psychological stress during pregnancy due to her husband's absence, demanding work responsibilities, and long-distance commuting, compounded by repeated instances of bleeding requiring intensive medical care and bed rest. Maternal stress of this nature has been linked to interactions with specific child genotypes, such as DRD4 or LPHN3, which can amplify ADHD risk (Hamida et al., 2022; Choudhury et al., 2024). Mechanistic studies have further shown that maternal stress may alter DNA methylation and reduce the expression of neurotransmitter receptors critical for regulating attention and impulse control (Jeon et al., 2021). In contrast, HA's prenatal profile was marked by both psychosocial and toxicological risks. His mother reported stress due to the father's job loss, while also engaging in daily cigarette smoking during pregnancy. Prenatal nicotine exposure is widely recognized as a teratogenic factor that impairs dopamine-producing neuronal activity, with lasting consequences for attention and behavioral regulation (Ginting et al., 2023). Previous research has also documented how prenatal smoking interacts with genes such as DAT1 and DRD4 to intensify hyperactive-impulsive symptomatology (Barkley et al., 2019; Kessi et al., 2022). Taken together, these findings emphasize that while both subjects experienced prenatal risk factors, the mechanisms involved were distinct: psychosocial stress in MN, and nicotine exposure in HA. This contrast reflects the multiple developmental pathways that may contribute to ADHD, reaffirming its multifactorial etiology.

Perinatal complications emerged as a shared vulnerability in both cases, further compounding the subjects' risk profiles. MN was born at 33 weeks and HA at 31 weeks, both with low birth weights (2.2 kg and 1.9 kg, respectively), delivered via cesarean section, and requiring extended NICU care. These complications align with extensive literature linking prematurity, low birth weight, and cesarean delivery to heightened ADHD risk (Adiputra et al., 2021; Bala et al., 2023). Moreover, both subjects presented with low Apgar scores, which may suggest compromised neonatal function and possible hypoxia at birth, a condition known to interfere with brain development and to be associated with long-term neurocognitive impairments (Grizenko et al., 2016; Ma et al., 2020). Although both children shared these perinatal risk factors, the severity of ADHD symptoms in their daily functioning suggests that such biological vulnerabilities interact with later environmental conditions, magnifying their impact rather than operating in isolation. This illustrates that perinatal factors, while important, are best understood as part of a broader constellation of risks that continue to shape outcomes across development.

Perhaps the most striking differences between the two subjects emerged in their postnatal environmental and parenting contexts. MN grew up under consistent and structured parenting, with both parents providing clear rules and strict limits on gadget use. Such an environment is known to foster the development of self-regulation and attention skills in children with ADHD (Siron et al., 2021). In contrast, HA experienced inconsistent caregiving due to divergent approaches between his mother, who enforced stricter rules, and his grandmother, who was more permissive. When his mother imposed boundaries, HA often sought comfort from his grandmother, who accommodated his demands, thereby reinforcing oppositional and impulsive behaviors. Additionally, HA had regular and prolonged gadget exposure from the age of two, a factor associated with poorer attention span and emotional regulation (Ginting et al., 2023). These differences support the argument that structured, warm, and responsive parenting can mitigate ADHD symptoms, while inconsistent or permissive caregiving may exacerbate them, particularly in children already biologically vulnerable. Importantly, this suggests that parenting practices function not only as risk or protective factors but

also as moderators that can either buffer or intensify the expression of ADHD traits depending on their consistency and quality.

In summary, the comparison between MN and HA illustrates how ADHD emerges from unique but overlapping pathways shaped by biological vulnerabilities, prenatal exposures, perinatal complications, and environmental contexts. MN's risk profile was primarily marked by genetic predisposition and maternal stress, while HA's was driven more by prenatal nicotine exposure and inconsistent caregiving. Yet both children exhibited ADHD symptoms, supporting the position of Agnew-Blais et al. (2022) that biological and environmental risks interact synergistically, leading to the manifestation and intensification of ADHD. These findings underscore the heterogeneity of ADHD etiology and highlight the need for individualized assessment and intervention strategies that consider each child's unique developmental history and risk profile. Future research should build on these insights by examining how combinations of risks, rather than isolated factors, predict symptom severity and treatment outcomes, thereby advancing a more nuanced understanding of ADHD as a multifactorial and contextually embedded disorder.

Conclusion

The findings of this study indicate that ADHD symptoms in MN and HA are influenced by a combination of genetic, prenatal, perinatal, and environmental/parenting factors. In MN's case, genetic factors are dominant, with a family history of ADHD, reinforced by maternal emotional stress and pregnancy complications. In HA's case, prenatal factors are more prominent, including stress due to economic hardship and maternal smoking during pregnancy. Both subjects share perinatal factors, namely premature birth, low birth weight, and NICU care. Environmentally, MN experienced consistent parenting with restricted gadget use, while HA was raised with inconsistent parenting and early gadget exposure. These findings reaffirm that ADHD is multifactorial, and its prevention and management should comprehensively address all contributing factors.

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