

UNMASKING HIDDEN DEFICIENCIES: DETERMINANTS OF MICRONUTRIENT SHORTAGES IN CHILDREN WITH AUTISM

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ABSTRACT

Autism spectrum disorder is a complex neurodevelopmental condition characterized by difficulties in social interaction, and behavioral impairments. Globally, autism affects approximately one in every 100 children, with a higher prevalence in males. Children with autism are at heightened risk for micronutrient deficiencies due to various factors, including selective eating behaviors, sensory processing issues, and gastrointestinal problems. This review explores these determinants and their impacts, emphasizing the importance of adequate nutrition for children with autism. Selective eating habits and heightened sensory sensitivities often result in restricted diets, lacking essential nutrients such as vitamins D, calcium, iron, and zinc, which are crucial for physical and cognitive development. Gastrointestinal issues like chronic constipation and gastroesophageal reflux disease further exacerbate nutritional challenges, leading to poor appetite and food aversion. Behavioral and psychological factors, including anxiety and behavioral rigidity, complicate mealtime dynamics, limiting dietary variety. Additionally, socioeconomic constraints hinder access to nutrient-rich foods and specialized diets, increasing the risk of deficiencies. Parental knowledge and support are vital for managing these challenges, with education and training programs proving beneficial in improving dietary practices. A multidisciplinary approach combining medical, dietary, and behavioral interventions is essential to enhance the nutritional health and overall well-being of children with autism.

Keywords: Micronutrient Deficiency, Determinant, Children, Autism

INTRODUCTION

Autism spectrum disorder (ASD) is an extensive neurological disorder that has been thoroughly explored and studied for many years. Originally classified as an 'emotional disorder' linked to parenting practices, autism is now widely acknowledged as a neurobiological condition rooted from atypical brain development. ASD, as defined by the current Diagnostic and Statistical Manual of Mental Disorders (DSM-5), is a lifelong neurodevelopmental disease marked by persisting difficulties in social communication and interaction, along with limited and repetitive patterns of behaviour, interests, or activities (Centers for Disease Control and Prevention, 2023; Hirota & King, 2023; Hodges et al., 2020; Kassim & Mohamed, 2019; Kittana et al., 2023; Ministry of Health, 2014; Shohaimi et al., 2021; Zhu et al., 2020). The general traits typically include difficulty in starting or responding to social interactions, a lack of facial expressions, and unusual eye contact and body language. Additionally, behavioural impairments may appear as repetitive motor actions, rigid routines, and restricted interests with abnormal intensity.

Recent statistics indicate that approximately one in every 100 children globally is affected by ASD, with an estimated male-to-female ratio of 4.2:1 (Kassim & Mohamed, 2019; WHO, 2023). Nevertheless, there are no published studies on the prevalence of autism across Southeast Asia. Additionally, Malaysia lacks an official registry documenting the total number of children diagnosed with ASD (Neik et al., 2014; Sharudin N et al., 2021). Currently, the exact cause of the symptoms associated with ASD remains undefined. However, several factors are believed to contribute to the disorder, including genetic predispositions, familial autoimmune conditions, metabolic issues, and environmental influences (Kittana et al., 2023; Ministry of Health, 2014; Patil & Kaple, 2023; Shohaimi et al., 2021; Sobieski et al., 2022; Zhu et al., 2020). The absence of a clear aetiology often leads parents to develop their own interpretations of the disorder to manage their concerns, sometimes resulting in misguided interventions such as rejecting vaccinations and imposing inappropriate dietary restrictions on their children (Shohaimi et al., 2021).

Micronutrient deficiencies among children diagnosed with ASD have emerged as a significant issue in recent years, particularly as a result of their potential to exacerbate developmental delays and behavioural challenges (Dijkhuis et al., 2020). These deficiencies are often linked to protein-energy malnutrition, which contributes to underweight conditions in children with ASD. For example, a Malaysian study reported a prevalence of underweight among children with ASD at 9.3%, compared to 1.9% in the United States, 2.6% in China, 3.9% in Oman, 8.7% in Iran, and 11% in Turkey (Eow et al., 2021). These deficiencies can severely impair both brain function and physical health, underscoring the critical need for targeted interventions (Sweetman et al., 2019).

This narrative review aims to address the understudied determinants of micronutrient deficiencies in children with ASD and to explore how factors such as selective eating, socioeconomic constraints, and sensory sensitivities contribute to this issue. The objectives are to identify key determinants, evaluate their impacts, and propose interventions tailored to the Malaysian context. Addressing these gaps could not only improve nutritional outcomes for children with ASD but also inform region-specific policy interventions, fostering better health and developmental trajectories.

METHODS

We utilised PubMed, Scopus, and the Web of Science for data collection given their comprehensive coverage and rigorous peer-review processes for most of their included journals. These search engines were chosen to ensure the reliability and quality of the sources, focusing on publications from 2014 to 2024. The keywords used in the search were ‘autism’, ‘autism spectrum disorder’, ‘micronutrient deficiency’, ‘determinant’, ‘risk factor’, and ‘impact’.

NUTRITIONAL CHALLENGES AND MICRONUTRIENT DEFICIENCY IN CHILDREN WITH AUTISM SPECTRUM DISORDER

Child development is a complex and dynamic process encompassing physical, cognitive, and socio-emotional growth. Optimal development during early childhood relies heavily on proper nutrition, a phase marked by rapid increases in height, weight, and cognitive abilities (Wang et al., 2022). Adequate nutrition is crucial for supporting rapid growth, ensuring proper cellular activities, organ development, and overall bodily functions. It is especially important for brain development as the brain requires a continuous supply of energy and nutrients to function effectively (Jena et al., 2020).

Children with ASD face unique challenges, particularly with feeding and eating behaviours, which affect between 40.3% and 96% of this population (Sharudin N et al., 2021; Tsujiguchi et al., 2020; Wang et al., 2022). Children with ASD are at a higher risk of malnutrition because of their selective eating habits (Eow et al., 2021). Studies have revealed that they have a limited food range compared to their peers and exhibit a high frequency of single food intake, indicating restricted and repetitive eating behaviours. Additionally, they are more likely to refuse new foods and show more food refusal in general than typically developing children. This behaviour leads to a limited and restricted diet, which is a significant risk factor for micronutrient deficiency (Shohaimi et al., 2021; Tsujiguchi et al., 2020). A prior study suggests that children with severe autism face significantly greater feeding challenges compared to those with mild to moderate autism (Sharudin N et al., 2021). Severe feeding issues in children with ASD can meet the diagnostic criteria for avoidant/restrictive food intake disorder (ARFID), a psychiatric diagnosis that identifies ASD as a risk factor for nutritional problems related to food selectivity (Molina-Lopez et al., 2021).

Definition of Micronutrient Deficiency

Micronutrient deficiency refers to the lack of essential vitamins and minerals required in small quantities for the body’s proper functioning. In children with ASD, these deficiencies are particularly concerning because of the critical role that micronutrients play in neurological development, immune function, and overall health (Zhu et al., 2020). Common micronutrient deficiencies observed in children with ASD include deficiencies in vitamin D, calcium, iron, zinc, and omega-3 fatty acids (Bird et al., 2017; Ritchie & Roser, 2024; Zhu et al., 2020). These nutrients are crucial for various bodily functions, such as bone health, oxygen transport, immune response, and cognitive development. Deficiencies can lead to a range of health issues, including weakened immunity, anaemia, poor bone health, and exacerbated behavioural problems. Addressing these deficiencies through dietary adjustments and supplementation is vital for the holistic development and well-being of children with ASD.

Determinants of Micronutrient Deficiency among ASD Children

Food Selectivity and Eating Behaviours

One of the primary determinants of micronutrient deficiency in children with ASD is their pronounced food selectivity (Sharudin N et al., 2021). Many children with ASD display strong preferences for certain foods and aversions to others, leading to a limited and often unbalanced diet (da Silva & Gomes, 2024; Eow et al., 2021). This selective eating can result in the insufficient intake of essential vitamins and minerals for growth and development. Studies have shown that children with ASD often consume a restricted range of foods, frequently items high in carbohydrates and low in fruits, vegetables, and proteins (Eow et al., 2021; Tsujiguchi et al., 2020; Zhu et al., 2020). For instance, a study by Wang et al. (2022) found that children with ASD tend to have more rigid food preferences and are less likely to try new foods, contributing to a narrow diet. Another study by Alibrandi et al. (2023) reinforced these findings, showing that children with ASD are more likely to eat a limited variety of foods compared to their typically developing peers. Difficulty moving from paste to solid foods might be an early indicator of autism-related symptoms, such as restricted and stereotyped interests, which often appear as pervasive eating disorders (Alibrandi et al., 2023; Tsujiguchi et al., 2020; Wang et al., 2022). Additionally, food packaging and presentation can also influence eating behaviours.

Food selectivity extends beyond food refusal and lack of variety, encompassing a highly restricted diet of fewer than eight to twenty foods, indicating strong rigidity in food preferences and poor acceptance of new foods (Alibrandi et al., 2023). This limited dietary variety significantly increases the risk of deficiencies in key nutrients such as vitamin D, calcium, iron, and zinc. Vitamin D is essential for bone health and immune function, and deficiency in vitamin D can lead to conditions such as rickets in severe cases and may compromise the immune system, making children more susceptible to infections (Holick, 2017). Similarly, calcium is crucial for bone development, and a deficiency can result in poor bone health and an increased risk of fractures (Chang & Lee, 2019). Iron deficiency is another common issue in children with ASD given their selective eating habits. Iron is vital for oxygen transport in the blood and cognitive development, and deficiencies in iron can lead to anaemia, characterised by fatigue and developmental delays (Peretti et al., 2019). Zinc – important for immune function, cellular metabolism, and brain development – is also often deficient in children with ASD, further impacting their cognitive development and overall health (Sweetman et al., 2019). The health implications of these deficiencies are serious. Impaired immune function caused by a lack of essential vitamins and minerals can make children with ASD more prone to illnesses.

Sensory Processing Issues

Sensory processing difficulties are another significant risk factor contributing to micronutrient deficiencies in children with ASD. Many of these children experience heightened sensitivity to the taste, texture, smell, and appearance of food, making it challenging to accept a wide range of foods, particularly those that are nutritionally dense but have strong flavours or textures (Alibrandi et al., 2023; Bandini et al., 2017; Wang et al., 2022).

Children with ASD often exhibit extreme responses to sensory stimuli, which can cause children to avoid nutrient-rich foods such as vegetables, fruits, and proteins, opting instead for bland, processed foods that provide little nutritional value (Alibrandi et al., 2023). This avoidance of diverse and nutritious foods significantly limits their dietary variety, increasing the risk of deficiencies in key nutrients such as vitamins, minerals, and essential fatty acids. Furthermore, aversion to specific foods can be linked to smell, with heightened sensitivity to odours causing discomfort in environments such as school cafeterias, where the scents of other people's food are present (Alibrandi et al., 2023; Sharudin N et al., 2021). Studies comparing oral sensory processing between children with and without ASD have investigated the connections among unusual oral sensory processing, food selectivity, and the consumption of fruits and vegetables. These studies have shown that children with autism exhibit atypical sensory processing compared to their neurotypical peers (Molina-Lopez et al., 2021).

A study by Johnson et al. (2014) found that children with severe sensory sensitivities were more likely to have restrictive eating patterns and limited dietary diversity. The study highlighted that these children were more likely to consume processed and convenience foods, which are typically low in essential nutrients, thereby exacerbating the risk of micronutrient deficiencies. Moreover, sensory processing issues can lead to increased anxiety around mealtimes, further limiting dietary variety and nutritional intake. This anxiety can create a stressful eating environment, causing children to become more rigid in their food choices and more resistant to trying new foods. A study by Nadon et al. (2011) revealed that children with ASD who exhibited high levels of sensory sensitivity also experienced significant mealtime anxiety, which negatively impacted their nutritional status.

Additionally, sensory processing issues can interfere with the child's ability to tolerate different food textures, which is a common challenge in this population. For example, a child with ASD might refuse to eat foods that are mushy, are crunchy, or have a mixed texture. This can result in a diet that lacks variety and excludes many nutrient-dense foods. Field et al. (2003) noted that sensory-based food aversions are a major contributing factor to the limited diets observed in children with ASD, further emphasising the need for targeted interventions. Addressing these sensory challenges through occupational therapy, behavioural interventions, and creating a supportive mealtime environment is essential for improving the nutritional health and overall well-being of children with ASD.

Behavioural and Psychological Factors

Behavioural and psychological factors also significantly influence the nutritional challenges faced by children with ASD. Anxiety and stress around mealtimes can exacerbate selective eating behaviours and reduce overall food intake. For many children with ASD, mealtime can be a source of significant distress, which then impacts their willingness to try new foods or eat a balanced diet.

Anxiety and Mealtime Stress

Children with ASD often experience heightened anxiety during mealtimes, stemming from sensory sensitivities, negative food experiences, or the unpredictability of new items. Research by Kerzner et al. (2015) highlights that anxiety-related eating problems are prevalent, leading to a limited diet and the increased risk of nutritional deficiencies. Stress associated with trying new foods can heighten avoidance behaviours, further limiting dietary variety.

Behavioural Rigidity and Insistence on Sameness

Behavioural rigidity and a preference for sameness are hallmark characteristics of ASD. The study indicated that food refusals linked to factors such as colour, brand, and shape may not be connected to sensory processing difficulties but could instead be attributed to the 'need for sameness', a trait commonly observed in children with ASD (Eow et al., 2021; Sharudin N et al., 2021). These behaviours impact eating habits as children with ASD may insist on familiar foods, rejecting new or unfamiliar items. This insistence on sameness, reinforced by the comfort of routine, makes dietary expansion difficult (Wang et al., 2022). A study by Hubbard et al. (2014) found that children with ASD showed a strong preference for familiar foods and distress when presented with new ones, leading to a restricted, nutritionally inadequate diet.

Comorbid Conditions

Comorbidities such as attention-deficit hyperactivity disorder (ADHD) and anxiety disorders can complicate feeding behaviours and nutritional intake. ADHD contributes to impulsivity and inattention, making structured mealtimes challenging. Anxiety disorders can intensify selective eating behaviours as the fear of new foods can be overwhelming. Children with anxiety or ADHD are more likely to have severe feeding problems and a more limited diet compared to children with ASD alone (Emond et al., 2010).

Gastrointestinal Problems

Children with ASD frequently experience gastrointestinal (GI) issues such as chronic constipation, diarrhoea, and gastroesophageal reflux disease (GERD). These conditions can negatively affect appetite and food intake, leading to nutritional deficiencies. The underlying causes of GI problems in children with autism are not fully understood, but it is believed that the gut-brain axis plays

a crucial role. Research indicates that children with autism often have different gut microbiota compared to neurotypical children, which may contribute to GI symptoms (Alharthi et al., 2022). Chronic constipation, reported as one of the most frequent GI issues, causes discomfort, pain, and bloating, leading to reduced appetite and contributing to selective eating behaviours. McElhanon et al. (2014) found that children with ASD are four times more likely to experience constipation than their neurotypical peers. Conversely, diarrhoea can lead to nutrient malabsorption and worsening nutritional deficiencies. GERD, another common GI issue, involves acid reflux that irritates the oesophagus and causes discomfort that contributes to food aversion and selective eating (Mannion & Leader, 2013). GI discomfort often results in increased food refusal and selective eating behaviours, further restricting dietary variety and essential nutrient intake, which can lead to significant micronutrient deficiencies (Holingue et al., 2018).

Holingue et al. (2018) noted a strong association between GI symptoms and food selectivity in children with ASD. These combined issues lead to deficiencies in fibre, vitamins, and minerals such as iron, calcium, and zinc, resulting in health problems such as weakened immune function, poor bone health, and anaemia. GI problems can also exacerbate behavioural issues, creating a cycle of poor nutritional intake and worsening health outcomes. Chaidez et al. (2014) demonstrated a correlation between GI symptoms and severe behavioural problems in children with ASD.

Addressing GI issues involves a multidisciplinary approach, including medical management, dietary interventions, and behavioural strategies. Medical treatments such as laxatives for constipation and proton pump inhibitors for GERD can help alleviate symptoms. Dietary interventions, such as incorporating fibre-rich foods and probiotics, are beneficial, and behavioural interventions such as applied behaviour analysis (ABA) can assist in gradually introducing new foods. Parental education is crucial for effectively implementing these strategies and ensuring a supportive mealtime environment.

Parental Knowledge and Support

Parental knowledge and support are critical determinants of the nutritional status of children with ASD. Parents play a crucial role in shaping the dietary habits of their children, and their understanding of nutritional requirements is essential for ensuring balanced and adequate nutrient intake. Conversely, a lack of knowledge and support can lead to poor dietary choices and an increased risk of micronutrient deficiencies.

A study Shohaimi et al. (2021) in Kuala Lumpur found that only 37.9% of parents believed that their children's diets contained balanced nutrition. This low percentage underscores the need for improved educational initiatives to equip parents with the necessary knowledge and skills to manage their children's diets effectively. The study revealed that most parents knew about the negative effects of sugar, junk food, and gluten, but these foods were still common in their children's diets because of factors such as accessibility and convenience. This shows a gap between knowledge and practice, suggesting that parents might lack practical strategies to implement healthier dietary choices consistently. Additionally, while many parents knew about the benefits of vitamins and special diets for children with ASD, only 69.7% gave vitamins to their children. This gap suggests barriers such as cost, availability, and uncertainty about supplements. Educational programs tailored for parents of children with ASD could address these barriers by providing comprehensive guidance on the selection, administration, and benefits of dietary supplements. Educational programs and support networks can significantly improve parental knowledge and support, which are crucial for managing selective eating behaviours commonly observed in children with ASD. For instance, training sessions can teach parents how to introduce new foods gradually and create positive mealtime environments to reduce anxiety and resistance. Well-informed parents who employ these strategies can broaden their children's dietary variety, leading to better nutritional outcomes (Bultas et al., 2016).

Moreover, support networks offer parents a platform to share experiences and solutions, fostering a community of learning and mutual encouragement. These networks can be instrumental in helping parents stay informed about the latest research and recommendations on ASD nutrition, enabling them to make more informed decisions.

Socioeconomic Factors

Socioeconomic factors significantly influence the dietary patterns and nutritional status of children with ASD. Families with limited financial resources often face challenges in accessing a variety of fresh, nutrient-rich foods essential for their children's growth and development. This economic limitation can lead to a reliance on cheaper, processed foods that lack essential nutrients, thereby increasing the risk of nutritional deficiencies.

One of the primary issues faced by low-income families is the high cost of specialised diets and supplements that are often recommended for children with ASD. For instance, the financial burden of purchasing gluten-free or casein-free products, along with other dietary supplements, can be substantial (Reissmann, 2020). This financial strain can deter families from adhering to these specialised diets, which are crucial for managing the unique nutritional needs of children with ASD.

Access to healthcare professionals, such as dietitians and nutritionists, is another critical factor influenced by socioeconomic status. Families from lower socioeconomic backgrounds may have limited access to these professionals, who provide essential guidance on managing dietary challenges. Without professional support, parents may struggle to implement appropriate dietary interventions for their children, exacerbating the risk of micronutrient deficiencies.

Additionally, lower socioeconomic status is often associated with higher levels of stress and limited time for meal preparation. Parents in low-income families may work multiple jobs or long hours, leaving them with little time to prepare balanced meals. This time constraint can lead to a reliance on quick, easy-to-prepare processed foods that are typically low in essential nutrients ((APA), 2020).

Moreover, educational attainment and health literacy play a role in dietary practices. Parents with lower levels of education may have less knowledge about the importance of nutrition and how to prepare healthy meals. They may also be less aware of available resources and programs that could assist them in improving their children's diets. Improving health literacy through educational programs can help parents make better dietary choices, even within the constraints of a limited budget (Forray et al., 2023).

Interventions aimed at mitigating the impact of socioeconomic factors on the nutritional status of children with ASD should focus on increasing accessibility to nutrient-rich foods and providing financial support for specialised diets and

supplements. Programs that offer subsidies or vouchers for fresh produce and dietary supplements can alleviate some of the financial burdens faced by low-income families. Additionally, community-based programs that provide free or low-cost nutritional counselling and education can empower parents with the knowledge and skills needed to improve their children's diets.

CONCLUSION

Children with ASD face significant nutritional challenges because of selective eating behaviours, sensory processing issues, and GI problems. These factors lead to restricted diets often lacking essential nutrients such as vitamins D, calcium, iron, and zinc, crucial for health and development. Behavioural and psychological factors, such as anxiety around mealtimes and behavioural rigidity, further limit dietary variety. Comorbid conditions such as ADHD and anxiety disorders complicate feeding behaviours, worsening nutritional intake. GI issues, including chronic constipation and GERD, also impact appetite and food absorption, contributing to deficiencies. Parental knowledge and support are vital in managing these challenges. Educating parents about nutritional needs and providing practical strategies can improve dietary habits. Socioeconomic factors also play a crucial role, with financial constraints limiting access to nutrient-rich foods and specialised diets. Effective management requires a multidisciplinary approach, combining medical, dietary, and behavioural interventions, along with strong parental support and targeted educational programs, to improve the nutritional health of children with ASD. The findings from this study aim to raise awareness among autism stakeholders and lay the groundwork for future research to develop effective intervention programs. By gaining deeper insights into the feeding challenges faced by children with ASD, targeted strategies can be developed to support both children and their caregivers, improving nutritional outcomes and overall well-being.

However, this study has several limitations, as it relies on a narrative review methodology, which, while comprehensive, may lack the depth and rigor of systematic or meta-analytic approaches, and it does not account for other potentially influential variables, such as genetic predispositions, prenatal factors, or broader environmental determinants. Future research should address these gaps by incorporating a wider range of variables and employing more robust methodologies, to enhance the depth and reliability of findings and contribute to better strategies for managing the nutritional health of children with ASD.

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