



Impact of Malnutrition and Poor Water on Children Ages Six to Twelve Years

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Abstract

This study investigates the combined impacts of malnutrition and unsafe drinking water on the cognitive and physical development of children aged six to twelve. A comprehensive literature review was conducted to examine studies on nutrition, hydration, waterborne diseases, and their effect on middle childhood development. Findings in this literature review indicate that chronic malnutrition impairs physical growth, weakens the immune system, and disrupts cognitive processes such as memory, attention, and emotional regulation. Constant exposure to contaminated water exacerbates these effects by increasing susceptibility to infections, reducing nutrient absorption in children's bodies, and contributing to conditions such as environmental enteric dysfunction. The interaction between malnutrition and unsafe water forms a cycle that diminishes academic performance, limits cognitive functions, and affects long-term health. Intervention strategies such as school meal programs, micronutrient supplements, safe water infrastructure, and hygiene education are possible ways to mitigate these risks and improve developmental outcomes. This study underscores the importance of access to clean water and how adequate nutrition is crucial for human development, positive educational outcomes, and future economic productivity. Addressing these challenges through integrated public health initiatives is essential to breaking the cycle of malnutrition and waterborne disease, promoting resilience, and reducing global inequalities among vulnerable children.

Keywords: malnutrition, development, children, water

Introduction

Childhood, defined as the period from birth to age 12, is a crucial period for body development. Thus, access to proper nutrients, clean water, and a safe environment is critical throughout childhood. However, in many parts of our world today, these needs are not fully met. Limited safe drinking water and malnutrition continue to threaten children's health and development (Shinwari, 2022).

Access to safe drinking water is not only essential for hydration, but it is also vital for preventing diseases, absorbing nutrients, and maintaining your overall health (WHO, 2023; Shinwari et al., 2022). Yet, approximately 2 billion people reside in low-income and rural regions with contaminated water (Daba et al., 2025). Poor drinking water sources contribute to dehydration, diarrhea, infections, and other health issues, all of which weaken a child's immune system over time (Morales, 2023).

Although the effects of malnutrition on children have been widely studied among children under the age of five, there is limited research on the effect of malnutrition and limited safe water on the latter part of childhood, extending to age twelve (Zerga, 2022). It is particularly in this age group where there is rapid brain development and increasing educational demands, which is an overall very critical period of growth (Georgieff, 2018). Unlike younger children, children between the ages of six and twelve rely greatly on consistent nutrition and hydration to sustain energy for learning and physical activity, making malnutrition and poor water more likely to affect their overall health (Maria Elena Capra, 2024). Therefore, this paper focuses on how prolonged exposure to poor water quality and malnutrition impacts the cognitive and physical development of children aged six and twelve.

Findings from this literature review contribute to the development and improvement of intervention strategies aimed at improving the health and development of children aged six to twelve. This research can further inform public health officials in designing and implementing targeted nutrition and safe water initiatives, assist policymakers in integrating child head considerations into national and regional development, and guide educators in implementing school-based programs that address the cognitive and physical effects of malnutrition and poor

water quality. All of which seek to enhance the well-being and resilience of vulnerable children around the world.

Background Knowledge

Malnutrition is a strong predictor of poorer cognitive function and brain development (Liu et al., 2014). For example, prior research has revealed that malnutrition compromises memory, decreases attention span, and undermines academic performance (Kenney et al., 2015). Additional research demonstrates that unsafe drinking water leads to various infections and diseases, such as typhoid fever, Cholera, Shigellosis, etc. (Lauer et al., 2018). Moreover, exposure to both malnutrition and unsafe drinking water at a young age can cause developmental delays in children, which may be irreversible (Soliman et al., 2021).

Literature Review

Causes of Malnutrition

Malnutrition is an issue that arises from a combination of social, economic, educational, and environmental factors. Malnutrition is not merely the lack of food, but rather, it's a lack of proper access to a balanced diet, which provides the necessary nutrients for development.

Malnutrition has many interconnected causes: One of the highest contributors to malnutrition is poverty. Low-income families can struggle to afford and access nutritious food for themselves, often resorting to cheaper, unhealthier food (Yin et al., 2025). They are also less likely to eat well-balanced meals every day, which prevents them from meeting their daily dietary needs (Diaz et al., 2021). A well-balanced meal for middle-aged children should consist of a balance of nutrient-dense foods, such as lean protein, whole grains, fruits and vegetables, and low-fat dairy products. While it can also include added sugars, saturated fats, and salt, these should be limited when obtaining a fresh, well-balanced meal (Mayo Clinic, 2025).

Second, a lack of proper knowledge about nutrition, hygiene, and food safety contributes to malnutrition (Prasetyo et al., 2023). In many areas, older individuals might be well-educated to understand the importance of proper nutrients and daily dietary needs (Institute of Medicine (US) Food Forum, 2010). However, children ages six to twelve can be less likely to understand

the importance of proper hygiene due to the environment and area in which they grow up (Save the Children Somalia Study, 2019).

Lastly, geographic and environmental factors also play a role in child malnutrition. This is because in remote, rural, and underserved areas, there is often food insecurity (the condition of not having access to sufficient food, or food of an adequate quality to meet one's dietary needs). Such as poor infrastructure, food shortages, and limited access to transportation (Benassai-Dalmau et al., 2025). This causes many children to have limited access to safe drinking water and to have to walk long distances to obtain proper food and water.

Effects of Malnutrition

Limited access to nutrients can impact children's health, including suppression of the immune response (Silbergeld, 2016). Over time, children face delayed physical development, stunted growth, and greater vulnerability to illness as previously mentioned (Lauer et al., 2018). These are not the only outcomes since having chronic malnutrition can also disrupt brain development, impair memory, attention, and emotional challenges (Kenney et al., 2015).

Additionally, another commonly found consequence of malnutrition in children ages six to twelve is stunted growth. This occurs when children do not receive adequate calories, proteins, and micronutrients, which are essential for bone development and cell growth (de Onis et al., 2016). Specifically, protein-energy malnutrition, which is a serious nutritional deficiency caused by insufficient intake of proteins and calories, and the lack of insulin-like growth factor 1 (IGF-1), which reduces bone growth in children, resulting in slower growth and weaker bones (Laron, 2001). Therefore, protein-energy malnutrition aids in impairing skeletal development during middle childhood (Prendergast et al., 2014). Deficiencies in micronutrients, such as zinc, have been found to result in decreased cartilage formation and bone mineralization, further slowing height progression in children (Ramakrishnana et al., 2004). As a result, children with stunted growth not only remain shorter than others but also face long-term consequences.

Children who do not receive proper nutrition can experience delayed physical development, making it harder for them to build strength, stamina, and coordination during the

important years when their bodies are still growing (Prendergast et al., 2014). Furthermore, malnourished children are increasingly prone to fatigue and low energy expenditure, which restricts their physical activity, playtime, and exercise (Black et al., 2013). Furthermore, recurrent infection, more common in malnourished people, diverts nutrients away from growth processes and towards immune defense (Victoria et al., 2008). Over time, this delayed physical development has long-term consequences, such as poor muscle coordination and limited physical productivity during adulthood.

There are also cognitive consequences of malnutrition. Children are at risk of impaired brain development, which can lead to lasting cognitive delays for a lifetime (Khan, 2023). Obtaining proper nutrition during middle childhood is essential for synapse formation and myelination (Grantham-McGregor et al., 2007). Specifically, deprivation of iron reduced oxygen delivery to the brain, impaired attention, memory, and the learning capacity of children (Lozoff et al., 2006). Similarly, insufficient iodine intake can interfere with thyroid hormone production, which is critical for neuronal growth and cognitive performance (Zimmermann, 2012). As a result, malnourished children frequently struggle with lower academic achievement, reduced problem-solving skills, and long-term deficits in intellectual potential.

Impaired memory and reduced attention span are both critical for academic success. However, malnutrition can cause deficiencies in processes vital for attention and consolidating memory, including fatty acids, especially docosahexaenoic acid (DHA), interfering with neuronal membrane fluidity and neurotransmission (Innis, 2007). Moreover, malnutrition can also contribute to lapses in concentration, which is the failure to maintain focus, attention, or mental clarity (Pollitt, 1997). Therefore, when combined with malnutrition and micronutrient deficiencies, these factors create cumulative cognitive challenges, making it difficult for malnourished children to maintain focus, retain knowledge, and process new information (Grantham-McGregor et al., 2007).

Many micronutrients, such as iron, zinc, and vitamin B, can disrupt neurotransmitter synthesis, which plays a role in mood regulation and emotional stability (Benton, 2008). Therefore, children who are undernourished are more susceptible to irritability, anxiety, and

depressive symptoms (Walker et al., 2011). Furthermore, stress about malnourishment and food insecurity can cause an increase in cortisol levels, which weakens the immune system and increases emotional reactivity and behavioral issues (Lupien et al., 2009). Gradually, these combined effects of malnutrition and psychosocial stress cause long-term mental health difficulties, making behavioral and emotional regulation a challenge for malnourished children.

Drinking Water Quality in relation to Children's Health

Beyond malnutrition, unsafe drinking water poses an additional threat to child development. For example, in Ethiopia, a meta-analysis found that 50% of drinking water samples contained bacterial contamination with fecal coliform, which was present in about 45% of the cases (Daba et al., 2025). The risk of contamination remains high today, largely due to the increased use of unsafe storage products and areas without water treatment (UN-Water, 2021).

Similarly, in Uganda, environmental enteric dysfunction was strongly linked with unsafe drinking water (Lauer et al., 2018). Environmental enteric dysfunction is a condition that causes damage to the small intestine lining due to exposure to poor sanitation and hygiene conditions. It is also linked to nutrient malabsorption and poor growth among children (Lauer et al., 2018). These findings show that access to unsafe drinking water contributes to short-term illnesses, but also has long-term consequences on development.

Safe Water and Its Role in Children's Health

Safe water is defined as water that is free of contaminants, such as pathogens, chemicals, and other impurities, and is suitable for drinking, cooking, and personal hygiene without posing a risk to human health (WHO). Safe water contributes to overall well-being by promoting hydration, hygiene, and sanitation, which are vital predictors of growth, cognitive development, and disease prevention in children (Pruss-Ustun et al., 2014).

Unsafe drinking water is linked to several negative outcomes for health and development. Waterborne diseases, such as cholera and diarrhea, are major health threats for children ages six to twelve in communities without reliable, safe water access (WHO). Contaminated water often contains pathogens like *Vibrio cholerae* and *Escherichia coli*, which cause gastrointestinal

infections leading to dehydration, nutrient loss, diarrhea, and other major health effects (WHO). Constantly suffering from diarrhea weakens a child's immune system and impairs the body's ability to absorb nutrients, impacting their physical and cognitive development (Guerrant et al., 2013). Children who are exposed to multiple waterborne diseases in a short period of time are also 2.3% likely to experience fatigue, stunting, and difficulty concentrating since their bodies start to divert their energy to constantly thinking about various things and their recovery rather than growth and learning at their young ages (Pruss-Ustun et al., 2014). Access to safe water plays a crucial role in preventing waterborne diseases in children and ensures they are able to thrive both mentally and physically.

Dehydration is very common in children ages 6-12, with studies showing that over 60% of children in this age group may be inadequately hydrated. Dehydration is often caused by limited access to safe water and has direct impacts on cognitive performance in children ages six to twelve (Kenney, 2015). These impacts can start from mild dehydration, defined as “a loss of 1-2% of body weight in fluids, causing short-term memory loss, decreased attention, and executive functioning” (Bar-David et al., 2005). An investigation conducted by Roberta Fadda, in 168 children aged between nine and eleven years living in Sardinia, Italy, shows that children who were not adequately hydrated struggled with tasks that required concentration and problem-solving, resulting in lower test scores and lower participation in school (Fadda et al., 2012). Therefore, for school-aged children, it is crucial to ensure proper hydration as it can support and improve children's learning, memory, and overall academic success.

Unsafe Water Results in Cognitive Consequences

In contrast, unsafe drinking water, along with short-term and long-term effects on children's health, unsafe drinking water also impacts the cognitive function of children. Notably, a study in Afghanistan found that children, ages seven to fifteen, who consume tap water that is contaminated with toxic trace metals, bacteria, and other chemicals, have significantly lower IQ levels compared to children who have been drinking safe water. The study compared children who used different water sources, and it found that children who used tap water had lower IQ scores than those who used other sources. (Shinwari et al., 2022). Likewise, research has shown that children who have inadequate hydration have lower levels of pass rates on school

assignments. 16.3% of the 245 children were in the low IQ group. (Drozdowska et al., 2020). This is because the children perform worse on memory tasks, attention tasks, and their overall attention span also decreases, underscoring the connection between proper hydration and cognition (Chard et al., 2019).

More specifically, studies highlight how neurotoxic elements in water, such as lead, have impaired brain function. For instance, early exposure to lead has been linked with long-term lower cognitive performance (Lee et al., 2022). Illnesses caused by unsafe drinking water significantly impair the body's ability to absorb essential nutrients, increasing the risk of malnutrition in children ages six to twelve. Moreover, frequently experiencing diarrheal episodes can damage the intestinal lining, leading to a condition called environmental enteric dysfunction (EED). EED reduces the ability of the gut to absorb vitamins, minerals, and macronutrients from food, which is essential to prevent malnutrition (Humphrey et al., 2009). Furthermore, waterborne infections like *Giardia lamblia* or *Cryptosporidium* further increase the rate of malabsorption by causing inflammation of the intestines, leaving children malnourished (Checkley et al., 1998). Ensuring safe drinking water is therefore essential to preventing diseases and enabling proper nutrient utilization, growth, and long-term cognitive and physical development during middle childhood.

The combination of poor nutrients and waterborne diseases can create a life-threatening cycle of effects in children ages six to twelve. Malnutrition begins by weakening the immune system, leaving children susceptible to repeated waterborne infections, which can in turn damage the intestinal lining and reduce nutrient absorption (Humphrey et al., 2009). Over time, the repeated cycles of illness and malnutrition start to produce long-term deficits in educational achievements, social development, and cognitive development (Pruss-Usten et al., 2014). This interplay between malnutrition and unsafe water demonstrates why child health requires both proper nutrition and access to safe water to break the cycle of malnutrition and waterborne diseases in children ages six to twelve.

The combined effects of malnutrition and unsafe water create immediate health problems and lead to long-term consequences that shape a child's future. Due to children suffering from

chronic undernutrition and frequent waterborne illnesses during the ages of six to twelve, they often experience lower academic performance due to impaired memory, reduced attention span, and frequent school absences (Walker et al., 2007). Besides individual outcomes, there are also economic and societal impacts. This is because with a lower number of individuals receiving higher education and retaining information, there will be lower productivity, which will hinder national development (Black et al., 2013). Furthermore, the effects of malnutrition and unsafe water are very likely to grow into bigger consequences, with the malnourished children growing into malnourished adults, who may face consequences such as complications in pregnancy and pass on poor health outcomes to their own children (Grantham-McGregor et al., 2007). Breaking this cycle and its consequences will require nutrition adequacy and safe water access, which safeguard not only child development but also future generations.

Advances

To combat malnutrition in children, there could be nutrition programs, such as school meal initiatives and micronutrient supplementation. These programs have proven to be effective strategies in addressing malnutrition and reducing children's reliance on unsafe water (Alan, 2021). School meal programs ensure that their students, encompassing the age range from six to twelve, receive at least one balanced meal per day, to support their physical growth and improve concentration in class (Kristjansson et al., 2015). Another possible solution to combat malnutrition and unsafe drinking water is fortified foods and targeted supplements, such as vitamin A, iron, and zinc, which can impair immunity and cognitive development (Bhutta et al., 2013). Beyond only providing direct nutritional benefits for children, these programs will also promote the use of safe drinking water within schools, reducing children's vulnerability to waterborne diseases (Jukes et al., 2008). By integrating both food security and safe water access, these nutrition programs break the cycle of malnutrition and illness but also strengthen long-term educational outcomes and community health.

To improve water quality, we can also implement safe water initiatives in areas that do not have access to safe water. The construction of community wells and implementation of purification systems will play a vital role in protecting children ages six to twelve from the health and development risks that come with unsafe water. Moreover, in areas where piped water

infrastructure is unavailable, these community wells will provide a sustainable source of groundwater, reducing exposure to contaminated surface water (Howard et al., 2003).

Pairing these initiatives with low-cost purification technologies will significantly lower the risk of waterborne diseases that impair nutrient absorption and hinder child development (Clasen et al., 2015). Through the construction of these initiatives, these programs can reduce the time children spend having to fetch water, allowing them to attend school more regularly and benefit from educational opportunities (UNICEF, 2022). Most importantly, integrating safe water access with hygiene education will maximize health outcomes as children can learn about the consumption of clean water along with safe practices that protect the long-term well-being of individuals (Pruss-Ustun et al., 2014). Together, the community wells and purification system will form a critical foundation for breaking the cycle of unsafe water, malnutrition, and lost potential in vulnerable communities.

Discussion

Research consistently shows that malnutrition and unsafe drinking water each pose serious threats to children's health and development. Malnutrition in middle childhood impairs physical growth, resulting in stunted height, weakening muscle and bone development, and disrupts cognitive functions such as memory, attention, and emotional regulation (Grantham-McGregor et al., 2007). Similarly, exposure to contaminated water leads to infections and intestinal damage, including environmental enteric dysfunction, which further impairs brain function and academic performance. (Lauer et al., 2018)

The interaction between malnutrition and unsafe water creates a compounding cycle of harm. Nutrient deficiencies weaken immune defenses, increasing susceptibility to waterborne illnesses (Humphrey et al., 2009). This cycle exacerbates deficits in physical growth, cognitive development, and school performance, ultimately affecting lifetime productivity and economic potential (Prüss-Ustün et al., 2014).

Children exposed to these dual risks during middle childhood face long-term disadvantages. These early deficits contribute to persistent inequalities, reinforcing cycles of poverty and limiting human capital development (Walker et al., 2011). The literature underscores

that access to clean water and adequate nutrition is not only a health issue but a foundational requirement for equitable development.

Outlook

Several studies advocate for integrated approaches to break this cycle. Effective strategies include combining safe water infrastructure, hygiene education, and school nutrition programs (Piper et al., 2024; Kumar et al., 2021). Evidence suggests that such interventions yield long-term benefits in cognitive performance, reduced healthcare costs, and improved societal outcomes (Humphrey et al., 2009).

Early nutritional and environmental disadvantages can become lifelong inequalities for children who experience chronic malnutrition and consume unsafe drinking water during middle childhood. Children exposed to chronic malnutrition and unsafe water face reduced economic potential and perpetuate cycles of poverty into adulthood (Walker et al., 2011). Thus, access to clean water and nutritious food is not just a health issue; it's a human development imperative.

Conclusion

Malnutrition and unsafe drinking water during middle childhood have profound and lasting effects on physical and cognitive development. Together, they form a destructive cycle that undermines health, learning, and future economic potential. Addressing these issues requires coordinated efforts from governments, NGOs, educators, and public health officials to implement integrated interventions that ensure access to clean water and nutritious food (Kumar et al., 2021).

The literature highlights the urgent need for interdisciplinary, longitudinal research focused on children ages 6–12 to better understand the long-term consequences of early nutritional and environmental disadvantages. Bridging these gaps will not only improve child health but also strengthen human capital and reduce global inequalities (Humphrey et al., 2009).

Access to clean water and adequate nutrition is a fundamental human right. Investing in these areas during childhood offers one of the most effective strategies for improving global

health and development (Zavala., 2021). To truly make a change, the involvement of the government, NGOs, educators, and public health officials is necessary to immediately integrate safe water infrastructure, sanitation, and school nutrition programs, ensuring that everyone is supported by the needed policies and framework to obtain the needed resources (Kumar et al., 2021).

Despite growing awareness, significant gaps remain. Most studies focus on children under five, leaving ages 6–12 underrepresented. Few longitudinal studies track how early exposure to malnutrition and unsafe water affects cognitive and economic outcomes in adulthood (Prado et al., 2014). Moreover, research often isolates nutrition and water quality, limiting understanding of their combined effects (Georgieff et al., 2018). Methodological inconsistencies and challenges in isolating variables further complicate findings (Walker et al., 2011).

Reliable data collection in underserved regions is hindered by poor infrastructure, limited funding, and political instability (Victora et al., 2008; Black et al., 2013). Cultural and linguistic barriers complicate standardized cognitive assessments, while inadequate monitoring systems obscure the true scale of exposure to pathogens and nutrient deficiencies (Prüss-Ustün et al., 2014).

Works Cited

- Abdullah Shinwari, Alain Véron, Abdianwall, M. H., Jouve, E., & Laporte, R. (2022). Tap Water Consumption Is Associated with Schoolchildren's Cognitive Deficits in Afghanistan. *International Journal of Environmental Research and Public Health*, 19(14), 8252–8252. <https://doi.org/10.3390/ijerph19148252>
- Baeribameng Yiran, G. A., Atubiga, J. A., Kusimi, J. M., Kwang, C., & Owusu, A. B. (2022). Adaptation to perennial flooding and food insecurity in the Sudan savannah agroecological zone of Ghana. *Environmental Research*, 214, 114037. <https://doi.org/10.1016/j.envres.2022.114037>
- Benton, D. (2008). Micronutrient status, cognition and behavioral problems in childhood. *European Journal of Nutrition*, 47(S3), 38–50. <https://doi.org/10.1007/s00394-008-3004-9>
- Chala Daba, Berhanu, L., Belay Desye, Gete Berihun, & Abebe Kassa Geto. (2025). Bacteriological quality of drinking water and its associated factors in Ethiopia: A systematic review and meta-analysis. *PLOS ONE*, 20(1), e0310731. <https://doi.org/10.1371/journal.pone.0310731>
- Chard, A. N., Trinies, V., Edmonds, C. J., Sogore, A., & Freeman, M. C. (2019). The impact of water consumption on hydration and cognition among schoolchildren: Methods and results from a crossover trial in rural Mali. *PLOS ONE*, 14(1), e0210568. <https://doi.org/10.1371/journal.pone.0210568>
- Choudhary, N., Schuster, R. C., Brewis, A., & Wutich, A. (2021). Household Water Insecurity Affects Child Nutrition Through Alternative Pathways to WASH: Evidence From India. *Food and Nutrition Bulletin*, 42(2), 170–187. <https://doi.org/10.1177/0379572121998122>

- Clasen, T. F., Alexander, K. T., Sinclair, D., Boisson, S., Peletz, R., Chang, H. H., Majorin, F., & Cairncross, S. (2015). Interventions to improve water quality for preventing diarrhoea. *Cochrane Database of Systematic Reviews*.
<https://doi.org/10.1002/14651858.cd004794.pub3>
- Diaz, T., Strong, K. L., Cao, B., Guthold, R., Moran, A. C., Moller, A.-B., Requejo, J., Sadana, R., Thiagarajan, J. A., Adebayo, E., Akwara, E., Amouzou, A., Aponte Varon, J. J., Azzopardi, P. S., Boschi-Pinto, C., Carvajal, L., Chandra-Mouli, V., Crofts, S., Dastgiri, S., & Dery, J. S. (2021). A call for standardised age-disaggregated health data. *The Lancet Healthy Longevity*, 2(7), e436–e443. [https://doi.org/10.1016/s2666-7568\(21\)00115-x](https://doi.org/10.1016/s2666-7568(21)00115-x)
- Drozdowska, A., Falkenstein, M., Jendrusch, G., Platen, P., Luecke, T., Kersting, M., & Jansen, K. (2020). Water Consumption during a School Day and Children's Short-Term Cognitive Performance: The CogniDROP Randomized Intervention Trial. *Nutrients*, 12(5), 1297.
<https://doi.org/10.3390/nu12051297>
- Georgieff, M. K., Ramel, S. E., & Cusick, S. E. (2018). Nutritional Influences on Brain Development. *Acta Paediatrica (Oslo, Norway : 1992)*, 107(8), 1310–1321.
<https://doi.org/10.1111/apa.14287>
- Grantham-McGregor, S., Cheung, Y. B., Cueto, S., Glewwe, P., Richter, L., & Strupp, B. (2007). Developmental potential in the first 5 years for children in developing countries. *The Lancet*, 369(9555), 60–70. [https://doi.org/10.1016/s0140-6736\(07\)60032-4](https://doi.org/10.1016/s0140-6736(07)60032-4)
- Humphrey, J. H. (2009). Child undernutrition, tropical enteropathy, toilets, and handwashing. *The Lancet*, 374(9694), 1032–1035. [https://doi.org/10.1016/s0140-6736\(09\)60950-8](https://doi.org/10.1016/s0140-6736(09)60950-8)

Institute of Medicine (US) Food Forum. (2010). *Nutrition Concerns for Aging Populations*.

National Library of Medicine; National Academies Press (US).

<https://www.ncbi.nlm.nih.gov/books/NBK51837/>

Kafatos, A., Manios, Y., & Moschandreas, J. (2005). Health and nutrition education in primary schools of Crete: follow-up changes in body mass index and overweight status. *European Journal of Clinical Nutrition*, 59(9), 1090–1092. <https://doi.org/10.1038/sj.ejcn.1602216>

Kalid, M., Osman, F., Sulaiman, M., Dykes, F., & Erlandsson, K. (2019). Infant and young child nutritional status and their caregivers' feeding knowledge and hygiene practices in internally displaced person camps, Somalia. *BMC Nutrition*, 5(1).

<https://doi.org/10.1186/s40795-019-0325-4>

Kenney, E. L., Long, M. W., Craddock, A. L., & Gortmaker, S. L. (2015). Prevalence of Inadequate Hydration Among US Children and Disparities by Gender and Race/Ethnicity: National Health and Nutrition Examination Survey, 2009–2012. *American Journal of Public Health*, 105(8), e113–e118. <https://doi.org/10.2105/ajph.2015.302572>

Khan, I., & Leventhal, B. L. (2023). *Developmental Delay*. PubMed; StatPearls Publishing.

<https://www.ncbi.nlm.nih.gov/books/NBK562231/>

Laron, Z. (2001). Insulin-like growth factor 1 (IGF-1): a growth hormone. *Molecular Pathology*, 54(5), 311–316. <https://doi.org/10.1136/mp.54.5.311>

Lauer, J. M., Duggan, C. P., Ausman, L. M., Griffiths, J. K., Webb, P., Bashaasha, B., Agaba, E., Turyashemererwa, F. M., & Ghosh, S. (2018). Unsafe Drinking Water Is Associated with Environmental Enteric Dysfunction and Poor Growth Outcomes in Young Children in Rural Southwestern Uganda. *The American Journal of Tropical Medicine and Hygiene*, 99(6), 1606–1612. <https://doi.org/10.4269/ajtmh.18-0143>

- Lee, H., Lee, M. W., Warren, J. R., & Ferrie, J. (2022). Childhood lead exposure is associated with lower cognitive functioning at older ages. *Science Advances*, 8(45).
<https://doi.org/10.1126/sciadv.abn5164>
- Liu, J., Raine, A., Venables, P. H., Dalais, C., & Mednick, S. A. (2003). Malnutrition at Age 3 Years and Lower Cognitive Ability at Age 11 Years. *Archives of Pediatrics & Adolescent Medicine*, 157(6), 593. <https://doi.org/10.1001/archpedi.157.6.593>
- Maria Elena Capra, Stanyevic, B., Giudice, A., Monopoli, D., Nicola Mattia Decarolis, Esposito, S., & Giacomo Biasucci. (2024). Nutrition for Children and Adolescents Who Practice Sport: A Narrative Review. *Nutrients*, 16(16), 2803–2803.
<https://doi.org/10.3390/nu16162803>
- Mayo Clinic. (2022, September 30). *Nutrition for kids: Guidelines for a healthy diet*. Mayo Clinic.
<https://www.mayoclinic.org/healthy-lifestyle/childrens-health/in-depth/nutrition-for-kids/art-20049335>
- Morales, F., Montserrat-de, S., Leon, M. J., & Rivero-Pino, F. (2023). Effects of Malnutrition on the Immune System and Infection and the Role of Nutritional Strategies Regarding Improvements in Children’s Health Status: A Literature Review. *Nutrients*, 16(1), 1–1.
<https://doi.org/10.3390/nu16010001>
- Patlán-Hernández, A. R., Stobaugh, H. C., Cumming, O., Angioletti, A., Pantchova, D., Lapègue, J., Stern, S., & N’Diaye, D. S. (2021). Water, sanitation and hygiene interventions and the prevention and treatment of childhood acute malnutrition: A systematic review. *Maternal & Child Nutrition*, 18(1). <https://doi.org/10.1111/mcn.13257>
- Piper, J. D., Chandna, J., Allen, E., Linkman, K., Cumming, O., Prendergast, A. J., & Gladstone, M. J. (2017). Water, sanitation and hygiene (WASH) interventions: effects on child

development in low- and middle-income countries. *Cochrane Database of Systematic Reviews*, 3. <https://doi.org/10.1002/14651858.cd012613>

Prasetyo, Y. B., Permatasari, P., & Susanti, H. D. (2023). The effect of mothers' nutritional education and knowledge on children's nutritional status: a systematic review.

International Journal of Child Care and Education Policy, 17(1).

<https://doi.org/10.1186/s40723-023-00114-7>

Prüss-Ustün, A., Bartram, J., Clasen, T., Colford, J. M., Cumming, O., Curtis, V., Bonjour, S., Dangour, A. D., De France, J., Fewtrell, L., Freeman, M. C., Gordon, B., Hunter, P. R., Johnston, R. B., Mathers, C., Mäusezahl, D., Medlicott, K., Neira, M., Stocks, M., & Wolf, J. (2014). Burden of disease from inadequate water, sanitation and hygiene in low- and middle-income settings: a retrospective analysis of data from 145 countries. *Tropical Medicine & International Health*, 19(8), 894–905. <https://doi.org/10.1111/tmi.12329>

R, F., G, R., D, G., M, P., R, F., Cm, C., & J, S. (2012, December 1). *Effects of Drinking Supplementary Water at School on Cognitive Performance in Children*. Appetite.

<https://pubmed.ncbi.nlm.nih.gov/22841529/>

Reif, S., Elbaum-Shiff, Y., Koroukhov, N., Shilo, I., Musseri, M., & Golan-Gerstl, R. (2020). Cow and Human Milk-Derived Exosomes Ameliorate Colitis in DSS Murine Model. *Nutrients*, 12(9), 2589. <https://doi.org/10.3390/nu12092589>

Silbergeld, E. K. (2016). Drinking Water and the Developing Brain. *Cerebrum: The Dana Forum on Brain Science*, 2016, cer-09-16. <https://pmc.ncbi.nlm.nih.gov/articles/PMC5198753/>

Soliman, A., De Sanctis, V., Alaaraj, N., Ahmed, S., Alyafei, F., Hamed, N., & Soliman, N.

(2021). Early and Long-term Consequences of Nutritional Stunting: From Childhood to



Adulthood. *Acta Bio Medica : Atenei Parmensis*, 92(1).

<https://doi.org/10.23750/abm.v92i1.11346>

UN Water. (2021). *Summary Progress Update 2021: SDG 6 -Water and Sanitation for All*.

https://www.unwater.org/sites/default/files/app/uploads/2021/12/SDG-6-Summary-Progress-Update-2021_Version-July-2021a.pdf

Walker, S. P., Wachs, T. D., Grantham-McGregor, S., Black, M. M., Nelson, C. A., Huffman, S. L., Baker-Henningham, H., Chang, S. M., Hamadani, J. D., Lozoff, B., Gardner, J. M. M., Powell, C. A., Rahman, A., & Richter, L. (2011). Inequality in early childhood: risk and protective factors for early child development. *The Lancet*, 378(9799), 1325–1338.

[https://doi.org/10.1016/s0140-6736\(11\)60555-2](https://doi.org/10.1016/s0140-6736(11)60555-2)

World Health Organization. (2023, September 13). *Drinking-water*. World Health Organization.

<https://www.who.int/news-room/fact-sheets/detail/drinking-water>

Yin, H., Ankers, M., Bell, A., Parry, Y., & Willis, E. (2025). Investigating Developmental Status of Children Aged 0–5 Years and Its Association With Child Gender, Family Background and Geographic Locations in Australian Community-Based Early Learning Centres. *Child Care Health and Development*, 51(4). <https://doi.org/10.1111/cch.70097>

Yüksel, S., & Akil, M. (2024). Mild Dehydration Triggered by Exercise Reduces Cognitive Performance in Children, But Does Not Affect Their Motor Skills. *Journal of the American Nutrition Association*, 43(7), 627–635. <https://doi.org/10.1080/27697061.2024.2362709>

Zavala, E., King, S. E., Sawadogo-Lewis, T., & Roberton, T. (2021). Leveraging water, sanitation and hygiene for nutrition in low- and middle-income countries: A conceptual framework. *Maternal & Child Nutrition*, 17(3). <https://doi.org/10.1111/mcn.13202>

Zerga, A. A., Tadesse, S. E., Ayele, F. Y., & Ayele, S. Z. (2022). Impact of malnutrition on the academic performance of school children in Ethiopia: A systematic review and meta-analysis. *SAGE Open Medicine*, *10*(1), 205031212211223. <https://doi.org/10.1177/20503121221122398>