Dengue in Pediatric Populations: Challenges and Management Strategies

Abstract

Dengue fever, caused by the dengue virus (DENV), represents a significant public health concern worldwide, particularly among pediatric populations in tropical and subtropical regions. Recent decades have witnessed a marked increase in incidence, with children being disproportionately affected due to their immature immune systems and difficulty in timely diagnosis. Pediatric dengue manifests with a broad clinical spectrum, ranging from mild febrile illness to severe complications such as dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS). These complications, including plasma leakage, hemorrhage, and multi-organ failure, are more frequent and severe in children. Risk factors like obesity, secondary dengue infections, maternal antibodies, and age contribute to disease severity. One of the key challenges in managing pediatric dengue lies in its clinical overlap with other febrile illnesses, leading to diagnostic delays, particularly in resource-constrained settings. Supportive management, including timely fluid replacement and constant monitoring, remains the mainstay of treatment, as no specific antiviral therapy is currently available. Nurses play a vital role in early identification, fluid administration, health education, and community awareness. Despite advances, dengue vaccines like Dengvaxia present limitations based on serostatus and age, calling for more inclusive pediatric vaccine development. This article presents a comprehensive review of the epidemiology, pathophysiology, risk factors, diagnostic approaches, nursing responsibilities, and prevention strategies specific to pediatric dengue. It also emphasizes the critical need for enhanced diagnostics, better vaccine development, and the integral role of nursing education in reducing the dengue burden. Through evidence-based insights, this review aims to better equip healthcare professionals to tackle the ongoing challenges of pediatric dengue, promote early intervention, and improve clinical outcomes.

Keywords: Dengue, Pediatric, Severe Dengue, Management, Nursing, Epidemiology

Introduction

Dengue is a mosquito-borne viral infection primarily transmitted by Aedes aegypti mosquitoes. According to the WHO, approximately 390 million dengue infections occur annually, with a large proportion affecting children. Pediatric cases are of particular concern due to the higher risk of severe complications such as dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS). Children often present with atypical signs and symptoms, complicating early diagnosis and management. The burden is especially high in tropical and subtropical countries, including India, where monsoon seasons foster mosquito breeding. This review examines the

complexities of dengue in children, focusing on epidemiology, clinical features, risk factors, diagnostic approaches, and management strategies, drawing from numerous peer-reviewed sources.

Review of Literature

Several studies have examined the complex interplay of clinical, immunological, and environmental factors contributing to pediatric dengue. Simmons et al. (2012) emphasized the rising incidence in younger populations and the need for age-specific care protocols. Gubler (2011) linked urbanization and climate change to increasing outbreaks in previously low-risk areas. Kliks et al. (1988) highlighted the antibody-dependent enhancement (ADE) phenomenon, where maternal antibodies in infants exacerbate disease severity. Zulkipli et al. (2018) conducted a meta-analysis showing that childhood obesity significantly raises the risk of severe dengue. Peeling et al. (2010) and Lanciotti et al. (1992) discussed diagnostic limitations in children due to fluctuating immune responses and restricted access to molecular diagnostics. Hadinegoro et al. (2015) and Sridhar et al. (2018) raised concerns regarding the safety of Dengvaxia in seronegative children, stressing the need for improved vaccines. These findings underline the necessity for multidisciplinary efforts involving clinicians, researchers, and nursing professionals to address pediatric dengue more effectively

Epidemiology of Dengue in Pediatric Populations

Dengue is endemic in more than 100 countries. Asia and Latin America report the highest pediatric burden. Children aged 1–9 years are particularly susceptible. In India, children account for 30–50% of dengue cases in endemic regions, particularly during monsoon seasons. Contributing factors include climate change, poor sanitation, urban crowding, and ineffective vector control.

Pathophysiology of Dengue in Children

Dengue fever is caused by the dengue virus (DENV), a single-stranded RNA virus belonging to the *Flaviviridae* family. There are four antigenically distinct serotypes: DENV-1, DENV-2, DENV-3, and DENV-4. Infection by any serotype confers lifelong immunity against that specific serotype but only temporary and partial immunity against the others. This sets the stage for secondary infections, which are often more severe due to a phenomenon known as antibody-dependent enhancement (ADE).

1. Viral Entry and Replication

After the bite of an infected Aedes aegypti or Aedes albopictus mosquito, the virus enters the bloodstream and infects monocytes, dendritic cells, and macrophages. The virus uses receptors like DC-SIGN to enter cells and replicate. Infected cells release viral particles and pro-inflammatory cytokines into circulation.

2. Immune Response

The innate immune system reacts with an influx of interleukins (IL-6, IL-8), TNF-α, and interferons, causing fever and constitutional symptoms. The adaptive immune response is triggered with T-cell activation and production of dengue-specific antibodies.

In primary infections, the immune response often controls the virus, and the disease remains mild. However, in secondary infections, non-neutralizing antibodies from the first infection can bind to the new serotype but fail to neutralize it. These antibody-virus complexes facilitate viral entry into immune cells via Fc receptors, enhancing viral replication — the mechanism known as antibody-dependent enhancement (ADE).

3. Plasma Leakage

The hallmark of severe dengue is increased vascular permeability, leading to plasma leakage, hemoconcentration, pleural effusion, and ascites. The exact mechanism is not fully understood but involves:

- Endothelial dysfunction due to cytokine storm,
- Complement activation,
- Release of vasoactive mediators.

This results in hypovolemia and, in severe cases, dengue shock syndrome (DSS).

4. Hemostatic Abnormalities

Dengue causes a reduction in platelet production (bone marrow suppression) and increased platelet destruction, leading to thrombocytopenia. This, along with:

- Coagulopathy,
- Liver dysfunction,
- Capillary fragility,

contributes to bleeding tendencies, especially in severe cases.

5. Organ Involvement

In severe pediatric cases, dengue may affect:

- **Liver** – elevated transaminases, hepatomegaly.
- **Central nervous system** – seizures, encephalitis (rare).
- **Kidneys** – acute kidney injury in prolonged shock.
- **Heart** – myocarditis or pericardial effusion (infrequent)

Clinical Manifestations

Pediatric dengue presents with a spectrum of symptoms, from mild fever to life-threatening DHF and DSS. Common symptoms include high fever, retro-orbital pain, headache, myalgia, arthralgia and rash, but children may also exhibit atypical signs like abdominal pain, vomiting, and lethargy, making clinical diagnosis critical. Severe dengue is characterised by plasma leakage, bleeding, and organ dysfunction, with children at higher risk due to immature vascular and immune responses. The risk of shock is notably higher in children. Obesity has been identified as a risk factor for severe dengue in children, increasing the odds of severe outcomes by 38% (Odds Ratio = 1.38; 95% CI: 1.10, 1.73).

Risk Factors

Several factors exacerbate dengue severity in children:

Several risk factors intensify dengue severity among children:
- Obesity: Obese children are more prone to inflammatory responses and vascular permeability (Zulkipli et al., 2018).
- Maternal Immunity: Infants with maternal dengue antibodies are vulnerable to ADE, leading to more severe presentations (Kliks et al., 1988).
- Secondary Infections: Prior infection with a different serotype increases the risk of DHF/DSS.
- Age: Children under five are particularly susceptible to DSS due to underdeveloped immunity.

Diagnostic Challenges

Diagnosing dengue in children is challenging due to nonspecific symptoms and limited access to advanced diagnostics in resource-poor settings. Common tests include NS1 antigen detection and IgM/IgG ELISA, but these have variable sensitivity in children . RT-PCR, while accurate, is costly and unavailable in many endemic areas. Misdiagnosis with other febrile illnesses like malaria or typhoid is common, delaying treatment. Nurses play a critical role in early recognition of warning signs, such as persistent vomiting and mucosal bleeding .

Management Strategies

Management of pediatric dengue focuses on supportive care, as no specific antiviral therapy exists. Key strategies include:

- **Fluid Management**: Judicious fluid replacement is critical to prevent plasma leakage and shock. WHO guidelines recommend crystalloids for initial resuscitation.
- **Monitoring**: Regular monitoring of hematocrit, platelet count, and vital signs is essential, particularly in severe cases.
- **Nursing Care**: Nurses are pivotal in administering fluids, monitoring for warning signs, and educating families on mosquito control.
- **Vaccination**: The Dengvaxia vaccine is approved for children aged 9–16 in endemic areas but is limited by serostatus requirements. Research into pediatric-safe vaccines is ongoing.

Challenges in Pediatric Dengue Control

- **Vaccine Limitations**: Current vaccines are not universally safe for children, especially seronegative individuals.

- **Vector Control**: Community-based mosquito control programs are inconsistently implemented.
- **Healthcare Access**: Rural areas lack trained personnel and diagnostic facilities .
- **Public Awareness**: Low awareness of dengue prevention among caregivers hinders early intervention.

Future Directions

Future efforts should focus on:

- Developing affordable, child-friendly diagnostics.
- Creating safe and effective vaccines for all pediatric age groups.
- Strengthening nursing education on dengue management to enhance early detection and care.

Conclusion

Pediatric dengue remains a global health challenge, with children facing higher risks of severe outcomes due to physiological and diagnostic complexities. Nurses, as frontline caregivers, are crucial in managing cases and educating communities. This review underscores the need for targeted research, improved diagnostics, and accessible vaccines to reduce the pediatric dengue burden.

References

1. World Health Organization. Dengue and severe dengue. Geneva: WHO; 2020.
2. Kliegman RM, St Geme JW, Blum NJ, Shah SS, Tasker RC, Wilson KM, editors. Nelson Textbook of Pediatrics. 21st ed. Philadelphia: Elsevier; 2020.
3. Simmons CP, Farrar JJ, Nguyen VV, Wills B. Dengue. N Engl J Med. 2012;366(15):1423-32.
4. Halstead SB. Dengue. Lancet. 2007;370(9599):1644-52.
5. National Vector Borne Disease Control Programme. Dengue cases in India. New Delhi: Ministry of Health, India; 2021.

6. Gubler DJ. Dengue, urbanization and globalization: the unholy trinity of the 21st century. Trop Med Int Health. 2011;16(10):1289-95.

7. Thisyakorn U, Thisyakorn C. Dengue in children. J Trop Pediatr. 2014;60(4):271-8.

8. Guzman MG, Harris E. Dengue: a continuing global threat. Nat Rev Microbiol. 2010;8(12 Suppl):S7-16.

9. Zulkipli MS, Dahlui M, Jamil N, Peramalah D, Wai HVC, Bulgiba A, et al. The association between obesity and dengue severity among pediatric patients: a systematic review and meta-analysis. PLoSNegl Trop Dis. 2018;12(2):e0006263.

10. Kliks SC, Nimmanitya S, Nisalak A, Burke DS. Evidence that maternal dengue antibodies are important in the development of dengue hemorrhagic fever in infants. Am J Trop Med Hyg. 1988;38(2):411-9.

11. Sangkawibha N, Rojanasuphot S, Ahandrik S, Viriyapongse S, Jatanasen S, Salitul V, et al. Risk factors in dengue shock syndrome: a prospective epidemiologic study in Rayong, Thailand. Am J Epidemiol. 1984;120(5):653-69.

12. Hammond SN, Balmaseda A, Perez L, Tellez Y, Saborio SI, Mercado JC, et al. Differences in dengue severity in infants, children, and adults in a 3-year hospital-based study in Nicaragua. Am J Trop Med Hyg. 2005;73(6):1063-70.

13. Peeling RW, Artsob H, Pelegrino JL, Buchy P, Cardosa MJ, Devi S, et al. Evaluation of diagnostic tests: dengue. Nat Rev Microbiol. 2010;8(12 Suppl):S30-8.

14. Lanciotti RS, Calisher CH, Gubler DJ, Chang GJ, Vorndam AV. Rapid detection and typing of dengue viruses from clinical samples by using reverse transcriptase-polymerase chain reaction. J Clin Microbiol. 1992;30(3):545-51.

15. Potts JA, Rothman AL. Clinical determinants of dengue severity in children. Clin Infect Dis. 2008;47(8):1043-9.

16. International Council of Nurses. Role of nurses in vector-borne diseases. Geneva: ICN; 2019.

17. World Health Organization. Dengue: guidelines for diagnosis, treatment, prevention and control. Geneva: WHO; 2009.

18. Ranjit S, Kissoon N. Dengue hemorrhagic fever and shock syndromes. Pediatr Crit Care Med. 2011;12(1):90-100.

19. Chaorsiya A. Personal communication on nursing roles in dengue management. 2025.

20. Hadinegoro SR, Arredondo-Garcia JL, Capeding MR, Deseda C, Chotpitayasunondh T, Dietze R, et al. Efficacy and long-term safety of a dengue vaccine in regions of endemic disease. N Engl J Med. 2015;373(13):1195-206.

21. Thomas SJ, Rothman AL. Dengue vaccine development: challenges and opportunities. J Infect Dis. 2015;212(Suppl 1):S3-10.

22. Sridhar S, Luedtke A, Langevin E, Zhu M, Bonaparte M, Machabert T, et al. Effect of dengue serostatus on dengue vaccine safety and efficacy. N Engl J Med. 2018;379(4):327-40.

23. Erlanger TE, Keiser J, Utzinger J. Effect of dengue vector control interventions on entomological parameters in developing countries: a systematic review and meta-analysis. Med Vet Entomol. 2008;22(2):87-99.

24. Bhatt S, Gething PW, Brady OJ, Messina JP, Farlow AW, Moyes CL, et al. The global distribution and burden of dengue. Nature. 2013;496(7446):504-7.

25. Wong LP, Shakir SMM, Atefi N, AbuBakar S. Factors affecting dengue prevention practices: nationwide survey of the Malaysian public. PLoSNegl Trop Dis. 2015;9(6):e0003850.

26. TDR/WHO. Diagnostics for dengue: a global research agenda. Geneva: WHO; 2018.

27. Whitehead SS, Durbin AP, Pierce KK, Elwood D, McElvany BD, Fraser EA, et al. Prospects for a dengue virus vaccine. Nat Rev Microbiol. 2017;15(4):239-49.