REVIEW ARTICLE

Implementation Strategy for Dengue Vaccine Rollout in Bangladesh: Challenges and Opportunities

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ABSTRACT

One of the recent evidence-based interventions for dengue prevention is the tetravalent dengue vaccine TAK-003, which can play a vital role in reducing both the incidence and severity of dengue infections in endemic regions like Bangladesh. This vaccine can serve as a complex, multilevel intervention targeting primary prevention by immunizing individuals against all four dengue virus serotypes. By reducing the incidence of dengue infections, TAK-003 provides a preventive strategy that complements traditional vector control efforts. This paper aims to discuss implementation strategy for dengue vaccine rollout in Bangladesh. Implementing a school-based dengue vaccination program in Bangladesh involves tackling challenges like vaccine hesitancy, misinformation, and broader health behaviour determinants. Ensuring acceptance of the dengue vaccine, such as TAK-003, is crucial, as concerns about safety and misinformation can influence public perception. We also have proposed a multi-level, evidence-based intervention for dengue prevention among school-going children (aged 5–16 years) in Bangladesh, which has been structured around the Behaviour Change Wheel (BCW). It has included key components such as vaccination, vector control, school-based awareness campaigns, early diagnosis, and digital health interventions. These components aim to address factors influencing Capability, Opportunity, and Motivation. Implementing such a complex intervention in a low-resource setting like Bangladesh necessitates a critical feasibility assessment. The BCW's APEASE framework (Affordability, Practicability, Effectiveness, Acceptability, Side Effects, and Equity) could be used for this evaluation. This approach ensures that the intervention is not only theoretically sound but also adaptable to the Bangladeshi context, making it affordable, practical, and effective while addressing potential ethical concerns, including equity and community acceptability.

Keywords: Bangladesh, dengue prevention, dengue vaccine, implementation strategy, public health

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INTRODUCTION

Bangladesh, with an estimated population of 174 million, is one of the most densely populated countries globally. The country faces significant health challenges, including a high burden of communicable and non-communicable diseases, inadequate healthcare infrastructure, and limited access to quality medical services.[1] Among these challenges, dengue fever has emerged as a critical concern, with increasing outbreaks in recent years. Dengue, a mosquito-borne arboviral disease

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that has evolved from an intermittent public health concern into a persistent and widespread endemic threat in Bangladesh – with seasonal outbreaks, particularly during the monsoon season when mosquito populations increase. Sporadic dengue cases were reported between 1964 and 1999, but the first major outbreak in 2000 led to 5,551 hospitalizations and 93 deaths.[2] The World Health Organization (WHO) played a key role in developing the National Strategic Plan (NSP) for Surveillance, Prevention, and Control of Dengue, highlighting the importance of multisectoral collaboration in Bangladesh. At the primary level, vector control measures such as fogging, larvicide application, sanitation improvements, and public awareness campaigns are emphasized. Secondary-level efforts focus on early detection, strengthening surveillance, and establishing dedicated hospital wards. Tertiary interventions include critical care for severe dengue cases, ensuring essential medical supplies, and government policies promoting sustainable dengue management.[3] The National Seven-Year Dengue Control Plan (2024-2030) aims to limit the incidence of dengue to no more than 1 case per 1,000 individuals and to reduce the mortality rate to 0.1% by 2030.[4] In 2019, Directorate General of Health Services recorded 101,354 cases and 164 deaths.[5] According to the WHO Southeast Asia Region Health Bulletin in 2023, cases skyrocketed to 308,126, with 1,598 deaths and as of week 47 in 2024, 86,791 cases and 441 deaths were reported,[6] though lower numbers were influenced by interrupted reporting due to political unrest. Alarming trend of dengue transmission have been observed in the last five years.[7]

Dengue transmission in Bangladesh is influenced by various factors aligned with the Rainbow Model of health determinants.[8] At the individual level, Bangladesh is endemic for all four dengue serotypes, with DENV-2 and DENV-3 being more prevalent and responsible for large outbreaks, increasing the risk of severe secondary infections.[9] Social determinants such as limited awareness of dengue prevention, ineffective vector control programs, and insufficient community engagement create barriers to effective prevention and treatment.[10] Organizational factors, including inadequate healthcare systems, delayed diagnoses, and lack of resources in lower-income areas, reduce the capacity to manage outbreaks, while efforts in vector control and healthcare delivery remain.[11,12] Community-level factors like unplanned urban expansion, inadequate drainage, and stagnant water from heavy monsoon rainfall create ideal breeding grounds for Aedes mosquitoes, facilitating dengue transmission.[12] Policy-level barriers include the lack of a dengue vaccination program, reflecting government decisions regarding public health infrastructure, vector control, and healthcare access, which shape the national response to the disease.[13] High-risk groups include school-aged children, particularly those living in urban slums, due to greater exposure to mosquito breeding sites and inadequate protection against bites.[14] Lower-risk groups include children from higher-income families with access to protective measures such as insect repellents and screened living spaces.[15] These disparities highlight the need for targeted dengue prevention measures among vulnerable school-aged populations.

Dengue Vaccine

One of the most promising evidence-based interventions for dengue prevention is the tetravalent dengue vaccine TAK-003, which serves as a complex, multilevel intervention targeting primary prevention by immunizing individuals against all four dengue virus serotypes. By reducing the incidence of dengue infections, TAK-003 provides a preventive strategy that complements traditional vector control efforts.[16] The effectiveness of TAK-003 has been demonstrated through several trials conducted in dengue-endemic countries, e.g., Thailand, Brazil, and the Philippines. The study found that TAK-003 provided 61.2% protection against virologically confirmed dengue cases and 84.1% efficacy in preventing hospitalization due to severe dengue. These findings indicate that vaccination could play a vital role in reducing both the incidence and severity of dengue infections in endemic regions.[17-19] The effectiveness of TAK-003 can be attributed to several factors. First, its broad serotype coverage allows protection against multiple strains of dengue, reducing the risk of severe outcomes. Second, its long-term protection ensures immunity for up to 4.5 years, minimizing the annual disease burden in affected communities. Third, its favourable safety profile means that it can be safely administered across diverse populations, making it a viable public health intervention for dengue-endemic countries.[16-20]

Therefore, integrating TAK-003 into Bangladesh's existing dengue control program can significantly enhance current prevention efforts. This intervention can target school-aged children and adolescents, a primary demographic evaluated in the clinical trials, ensuring early immunization and long-term protection for future generations. Additionally, the vaccine can reduce the strain on healthcare systems by lowering hospitalization rates and the financial burden on families affected by severe dengue cases.

Implementing Dengue Vaccination in Bangladesh

Implementing a school-based dengue vaccination (e.g., TAK-003) programme in Bangladesh involves tackling challenges like vaccine hesitancy, misinformation, and broader health behaviour determinants.[21-23] Implementing and achieving success in the programme are based on addressing the capability, opportunity, and motivation of individuals, communities, and policymakers, as outlined in the Behaviour Change Wheel (BCW).[24]

At the individual level, the program provides primary prevention by immunizing children against dengue before peak transmission seasons.[25] Educational sessions and community engagement will empower children and parents with knowledge about the vaccine's safety and efficacy, building confidence and awareness campaigns and discussions about the benefits of vaccination will motivate parents to participate.[20,26] Engaging activities like quizzes, storytelling, and poster competitions will further motivate them to adopt preventive behaviours.[27] Organizationally, school-based vector control measures will reduce mosquito transmission risk by creating a mosquito-free environment through infrastructure improvements, such as mosquito-proof windows and eliminating breeding sites.[20,28] Regular training and inspections will ensure students and staff can identify and eliminate potential breeding grounds. At the community level, mHealth platforms will provide real-time alerts about dengue outbreaks, enhancing opportunity by keeping the community informed and enabling preventive actions[29] – that platform may enable the programme disseminate accurate, evidence-based information about dengue and vaccination, countering all misinformation. Besides, regular reminders and updates via mobile platforms will motivate individuals to engage in preventive behaviours and vaccination efforts.

At the policy level, integrating dengue prevention into the national school health policy will ensure program sustainability. Policies should focus on creating opportunities for effective vector control and mandatory vaccination in high-risk areas, while enhancing capability through training for teachers, school administrators, and health workers. Incentives for schools that successfully implement these measures and prioritizing vaccination and vector control at the national level will increase motivation.[30] By combining these strategies with the BCW's emphasis on enhancing capability, opportunity, and motivation, the dengue vaccination program can be successfully implemented, significantly reducing the disease burden in Bangladesh. A logic model for implementation is shown in Table 1.

Table 1: Logic model for behaviour change based on the Behaviour Change Wheel (BCW)[24]

BCW Level	Intervention Inputs	Outputs	Short-term Outcomes	Medium-term Outcomes	Long-term Outcomes
Individual	School vaccination programs (addressing vaccine hesitancy through educational sessions and communication strategies)	Increased vaccination coverage and reduced vaccine hesitancy	Fewer new dengue cases among students due to higher vaccine uptake	Reduced hospitalizations and severe dengue cases because of increased vaccine acceptance	Herd immunity and reduced dengue transmission, with lower levels of misinformation about the vaccine
Interpersonal	Health education for students & parents (focusing on debunking misinformation and improving vaccine confidence)	Increased awareness and understanding, countering misinformation	Improved mosquito control behaviours at home and increased willingness to vaccinate	Long-term behaviour changes in dengue prevention, including consistent vaccination uptake	Lifelong adoption of disease prevention behaviours with reduced impact of misinformation on decision-making

BCW Level	Intervention Inputs	Outputs	Short-term Outcomes	Medium-term Outcomes	Long-term Outcomes
Organizational	School-based vector control measures (linked with vaccine education to address both prevention strategies)	Fewer mosquito breeding sites and improved support for vaccination programs	Reduced mosquito density around schools and less misinformation regarding vaccine safety	Decreased dengue cases among students, enhanced by a combination of vector control and vaccination	Sustainable dengue-free school environments with higher vaccine participation due to better education and fewer misconceptions
Community	mHealth alerts & real-time disease surveillance (with built-in information about vaccine availability and safety)	Early disease detection and response, complemented by accurate vaccine information	Improved timeliness of outbreak responses and increased vaccine uptake due to real-time information	Enhanced disease surveillance and monitoring, with reduced vaccine misinformation	Fewer large-scale dengue outbreaks and better public trust in vaccines
Policy	Integration into national school health policy (with a focus on accurate vaccine information in policy communications)	Institutionalization of dengue prevention, including mandatory vaccination and public education on vaccine safety	Increased government funding for dengue control, including vaccine awareness programs	National reduction in dengue prevalence, partly due to addressing misinformation and promoting vaccination	Sustainable public health impact across Bangladesh, with consistent support for the vaccine program and reduced hesitancy

DISCUSSION

The proposed multi-level, evidence-based intervention for dengue prevention among school-going children (ages 5-16) in Bangladesh is structured around the Behaviour Change Wheel (BCW). It includes key components such as vaccination, vector control, school-based awareness programs, early diagnosis, and digital health interventions. These components aim to address factors influencing Capability, Opportunity, and Motivation.

Implementing such a complex intervention in a low-resource setting like Bangladesh necessitates a critical feasibility assessment. The BCW's APEASE framework (Affordability, Practicability, Effectiveness, Acceptability, Side Effects, and Equity) will be used for this evaluation.[31] This approach ensures that the intervention is not only theoretically sound but also adaptable to the Bangladeshi context, making it affordable, practical, and effective while addressing potential ethical concerns, including equity and community acceptability.

Complexity of the multilevel intervention: The proposed intervention is highly complex as it addresses multiple determinants of dengue transmission and incorporates strategies at different levels of influence (individual, interpersonal, organizational, community, and policy levels). Complexity arises due to the integration of diverse approaches, such as vaccination, vector control, behaviour change education, and digital health interventions. One of the strengths of this multi-pronged approach is that it does not rely solely on one method, such as vector control, which has proven ineffective due to insecticide resistance and urbanization challenges.[32] A key challenge is ensuring policy alignment and sustained funding, as multi-level interventions often require long-term financial and political commitment.[33]

Impact of changing modifiable determinants on outcomes the intervention: Specifically targets modifiable determinants such as initial hesitancy to a new vaccine, lack of dengue awareness, poor mosquito control practices in schools and households, inadequate early diagnosis, and weak public health surveillance. By addressing these determinants, the intervention is expected to result in positive health outcomes for school-aged children, including reduced dengue incidence due to vaccination, lower mosquito breeding in schools and homes through improved vector control, increased health-seeking behaviour due to mHealth alerts and school-based awareness programme and improved outbreak response

through real-time disease surveillance in schools.[20,29,34] However, some determinants are difficult to modify, such as climate change, rapid urbanization, and population density, which continuously increase dengue transmission risk.[34]

Strengths of the intervention: One of the biggest strengths of this intervention is its evidence-based approach. The TAK-003 dengue vaccine has been proven to be effective in reducing severe dengue and hospitalizations,[21] while school-based vector control and health education interventions have been shown to reduce mosquito density and disease burden in similar settings.[35] Additionally, the intervention is cost-effective in the long run. The use of existing school infrastructure for vaccine delivery and awareness campaigns further enhances affordability and feasibility.[20] Furthermore, mHealth interventions provide a scalable and low-cost method for real-time disease tracking and public engagement.[29]

Limitations and potential barriers to implementation: Despite its strengths, financial barrier may hinder the successful implementation of the programme. The cost of implementing TAK-003 vaccination at scale is a major concern. While Gavi and WHO support can subsidize vaccine costs, Bangladesh's low health budget may limit long-term sustainability.[36] Moreover, vector control measures and digital health platforms require ongoing investment in infrastructure and workforce training.[36] Delivering vaccines to school-aged children in urban and rural areas requires robust supply chains and trained healthcare workers. Ensuring cold-chain storage for vaccines in remote areas could be challenging. Additionally, coordinating multiple interventions across different levels (schools, health agencies, municipalities) increases the complexity of program management.[37] Apart from that, despite the proven efficacy of TAK-003, vaccine hesitancy remains a challenge in Bangladesh due to fear of side effects, misinformation, and lack of awareness.[21-23,36,37]

Public heath ethics consideration: The intervention must balance public health benefits with ethical concerns. One potential ethical issue is equity in vaccine access. Since dengue disproportionately affects low-income urban populations, ensuring equal access to vaccination, vector control, and digital health interventions is critical. Targeting schools high-risk areas first can help address this inequality. Another ethical challenge is informed consent for vaccination. Parents must have clear, evidence-based information on TAK-003's safety and efficacy to make informed decisions for their children. Privacy concerns also arise with digital health interventions. The collection of dengue surveillance data from schools and mobile-based reporting systems must ensure data security and confidentiality.[38,39]

Balancing feasibility, impact, and challenges: Using the BCW APEASE criteria,[31] the intervention is affordable (with external funding), practical (leveraging schools as a delivery platform), effective (based on proven strategies), acceptable (with strong community engagement), and equitable (targeting high-risk populations first). However, logistical, financial, and policy barriers remain significant challenges, requiring multi-sectoral coordination and long-term investment. Pilot implementation in select high-risk districts is recommended before national scale-up.[36] Effective behaviour change communication (BCC) model helps in designing interventions by using behavioural and social determinants of vaccination to increase vaccine uptake.[26,40,41] Besides, rigorous impact evaluation and stakeholder feedback mechanisms will ensure adaptation and sustainability.[36] While no single intervention can fully eliminate dengue, this multi-level approach addresses key determinants of transmission and provides a feasible, ethical, and evidence-based strategy to protect school-going children from dengue in Bangladesh.

CONCLUSION

The proposed multi-level intervention for dengue prevention among school-going children (ages 5-16) in Bangladesh integrates vaccination, school-based awareness, vector control, digital health strategies, and policy advocacy to create a comprehensive and sustainable strategy for dengue prevention. The inclusion of TAK-003 vaccination as a primary prevention measure offers a long-term solution to reducing severe dengue cases and hospitalizations. Complementing this, school-based vector control measures will help reduce mosquito breeding sites. Additionally, digital health interventions such as mHealth alerts and disease surveillance systems will ensure early outbreak detection and improved response strategies. Despite its strengths, implementation challenges must be acknowledged. Financial constraints, logistical barriers in vaccine distribution, vaccine hesitancy, and the need for

strong policy commitment remain significant obstacles. Furthermore, structural determinants such as rapid urbanization, inadequate waste management, and climate change continue to contribute to dengue transmission, requiring multi-sectoral collaboration beyond the health sector. However, these challenges can be mitigated through strong governmental leadership, public-private partnerships, and sustained international support. To ensure successful implementation, it is essential to pilot this intervention in high-burden districts such as only in Dhaka City Corporation (DCC), the capital city of Bangladesh, allowing for impact evaluation, stakeholder engagement, and policy refinement before national scale-up. By ensuring long-term commitment from the government, adequate funding, and continuous monitoring, this intervention has the potential to significantly reduce the dengue burden in Bangladesh and improve overall public health outcomes.

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