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Strengthening Uganda's Health System through Typhoid Vaccination: A Cost-Effectiveness Review with Rural and Urban Perspectives

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ABSTRACT

Typhoid fever remains a significant public health burden in Uganda, particularly in rural and urban areas where poor sanitation, limited access to safe water, and overstretched healthcare systems facilitate persistent transmission. Despite recurrent outbreaks and high morbidity, the country has yet to fully integrate typhoid vaccination into its national immunization strategy. This review examines the cost-effectiveness and health system implications of introducing typhoid conjugate vaccines (TCVs) in Uganda, with attention to rural–urban disparities. Evidence indicates that vaccination not only reduces disease incidence and treatment costs but also mitigates antimicrobial resistance and alleviates pressure on health facilities. In urban settings, vaccination helps control outbreaks fueled by overcrowding and poor sanitation, while in rural areas, it addresses gaps created by weak infrastructure and delayed access to healthcare. Policy integration of TCVs within the Expanded Programme on Immunization, combined with water, sanitation, and hygiene (WASH) improvements, offers a cost-effective and sustainable solution. The findings underscore vaccination as a transformative strategy to strengthen Uganda's health system, enhance equity, and secure long-term public health resilience.

Keywords: Typhoid fever, Uganda, typhoid conjugate vaccine (TCV), cost-effectiveness, rural health.

INTRODUCTION

Typhoid fever is one of the most persistent public health challenges in low- and middle-income countries, with sub-Saharan Africa recording some of the highest prevalence rates globally. In Uganda, typhoid fever continues to cause widespread morbidity and mortality, particularly in areas where sanitation infrastructure is weak, access to safe water is inadequate, and health services remain overstretched [1]. The disease is caused by *Salmonella enterica* serovar Typhi, a bacterium that spreads primarily through contaminated water and food. Its symptoms, which include prolonged fever, abdominal pain, malaise, and gastrointestinal disturbances, often overlap with those of other febrile illnesses such as malaria, leading to frequent misdiagnosis and delayed treatment.

Over the past decades, Uganda has experienced recurrent typhoid outbreaks, especially in densely populated urban areas like Kampala and peri-urban settlements, where rapid population growth has outpaced the expansion of clean water and sanitation systems. Similarly, rural areas remain equally vulnerable, with many households depending on unprotected water sources such as streams, ponds, and shallow wells. Limited awareness of safe hygiene practices further compounds the problem [2]. In both rural and urban contexts, the prevalence of typhoid undermines productivity, affects school attendance, and drains household resources due to direct medical costs and indirect costs related to lost income.

Globally, vaccination has emerged as a powerful public health intervention against typhoid. The World Health Organization (WHO) recommends the integration of typhoid conjugate vaccines (TCVs) into national immunization schedules, particularly in countries with a high disease burden and weak sanitation infrastructure. Unlike older typhoid vaccines, TCVs provide longer-lasting protection, are safe for children under two years, and can be easily

co-administered with other routine childhood vaccines [3]. Evidence from countries like India, Pakistan, and Malawi demonstrates that widespread vaccination significantly reduces the incidence of typhoid, lowers antibiotic use, and mitigates the threat of antimicrobial resistance.

Uganda, therefore, stands at a critical juncture where introducing and scaling up typhoid vaccination could serve as a transformative health system strategy. By reducing disease incidence and treatment costs, vaccination programs not only save lives but also strengthen resilience within the healthcare system. This is particularly vital in a country where healthcare facilities often struggle with limited human resources, stockouts of essential medicines, and overstretched laboratory services [4]. A comprehensive cost-effectiveness review focusing on both rural and urban perspectives is thus warranted to guide policy decisions, allocate resources efficiently, and protect vulnerable populations.

Despite progress in Uganda's health sector, typhoid fever remains a persistent burden with widespread socio-economic consequences. The disease continues to flourish due to poor sanitation infrastructure, unsafe water supplies, and limited access to timely treatment in both rural and urban settings. Urban centers face the additional challenge of overcrowding, informal settlements, and high population mobility, which facilitate rapid disease transmission [5]. Conversely, rural communities remain constrained by weak healthcare infrastructure, long travel distances to health facilities, and limited diagnostic capacity, leading to underreporting and poor disease management.

The economic burden of typhoid is equally concerning. Treatment is costly, often requiring prolonged antibiotic therapy and hospitalization in severe cases. These expenses strain households already facing financial constraints and contribute to catastrophic health expenditures. Moreover, the overuse and misuse of antibiotics in treating suspected typhoid cases exacerbate the growing problem of antimicrobial resistance, which poses a long-term threat to public health security [6].

While vaccination has been proven to be cost-effective in other high-burden countries, Uganda has yet to fully embrace typhoid vaccination as a national strategy. Policymakers face limited evidence on how vaccination programs would perform across different settings within the country. Without localized cost-effectiveness analyses that consider rural–urban disparities, there is a risk of inadequate resource allocation and inequitable healthcare interventions [7]. Therefore, a critical knowledge gap exists regarding the potential of typhoid vaccination to alleviate disease burden, reduce healthcare costs, and enhance overall health system resilience in Uganda. This review seeks to comprehensively examine the burden, cost-effectiveness, and potential health system impacts of introducing typhoid vaccination in Uganda, with particular attention to differences between rural and urban populations. By assessing the current epidemiological landscape, the study aims to identify populations most at risk and highlight disparities in disease burden, healthcare access, and infrastructure that influence typhoid incidence. Evaluating the cost-effectiveness of vaccination will provide essential evidence for policymakers balancing constrained health budgets, emphasizing potential reductions in hospital admissions, antibiotic use, and household treatment expenses. Furthermore, the review explores how vaccination can alleviate pressures on Uganda's healthcare system, including mitigating antimicrobial resistance and optimizing resource allocation. Comparative analyses of rural versus urban benefits will inform context-sensitive strategies that promote equity and strengthen health outcomes across diverse communities. By integrating empirical data, economic evaluations, and policy considerations, the study offers actionable recommendations for the sustainable implementation of typhoid vaccination programs. Ultimately, this review contributes not only to national health planning but also provides insights for regional public health strategies in sub-Saharan Africa, fostering broader lessons for disease prevention, health system resilience, and equitable access to care.

The Burden of Typhoid in Uganda

Uganda continues to experience a significant public health burden from typhoid fever, a disease that remains highly prevalent across both urban and rural regions. Recurrent outbreaks are frequently reported in densely populated urban centers such as Kampala, Gulu, and Mbale, where rapid urbanization has led to overcrowding, inadequate sanitation infrastructure, and widespread contamination of water supplies [8]. These conditions create an environment highly conducive to the transmission of *Salmonella Typhi*, the bacteria responsible for typhoid fever. In rural areas, the challenges are somewhat different but equally severe, with communities often relying on untreated or poorly managed water sources, limited access to healthcare facilities, and insufficient diagnostic capacity. These factors contribute to delayed detection and treatment of typhoid cases, exacerbating morbidity and mortality. The disease also has broader socioeconomic implications, including school absenteeism, reduced workforce productivity, and increased healthcare costs for affected families. Collectively, these factors highlight the urgent need for comprehensive and sustainable preventive strategies, including improvements in water, sanitation, and hygiene (WASH) infrastructure, community health education, vaccination campaigns, and strengthened healthcare systems capable of early diagnosis and effective management of typhoid fever. Addressing these challenges is critical to reducing the persistent burden of this preventable disease in Uganda [9].

Vaccination as a Cost-Effective Intervention

Vaccination is widely recognized as one of the most cost-effective public health interventions, particularly in preventing infectious diseases such as typhoid fever. The World Health Organization (WHO) strongly recommends the use of typhoid conjugate vaccines (TCVs) in countries with a high burden of the disease, emphasizing their potential to significantly reduce morbidity and mortality [10]. Multiple cost-effectiveness analyses have shown that large-scale vaccination campaigns are considerably less expensive than the repeated medical treatment of typhoid outbreaks. The costs of managing typhoid extend beyond the immediate purchase of antibiotics and routine medical care; they include laboratory diagnostics, prolonged hospital stays, and complex management of severe complications such as intestinal perforation or septicemia, which are more prevalent in delayed or advanced cases often seen in rural areas. Beyond the direct medical costs, typhoid fever imposes substantial indirect economic burdens on affected communities. Illness-related absenteeism from school and work reduces productivity and disrupts household income, while caregivers often face lost wages and additional expenses. By preventing infection, vaccination not only decreases these immediate and long-term healthcare expenditures but also strengthens community resilience, preserves educational continuity, and sustains household economic stability, making it a highly cost-effective public health strategy [11].

Rural vs. Urban Perspectives

Vaccination plays a crucial role in both urban and rural settings, though the challenges and benefits differ according to local contexts. In urban areas, high population density, frequent migration, and centralized water and sanitation systems increase the risk of infectious disease outbreaks, particularly those linked to water contamination and person-to-person transmission. Vaccination programs in cities provide a critical line of defense by reducing the incidence of preventable diseases, thereby lowering the number of cases requiring hospitalization [12]. This, in turn, alleviates pressure on urban healthcare facilities, which often operate at or above capacity due to the combined burden of chronic illnesses and infectious diseases. By maintaining lower disease prevalence, vaccination also contributes to healthier, more productive populations and reduces the risk of large-scale epidemics. In contrast, rural areas face distinct challenges, including limited healthcare infrastructure, scarce diagnostic services, and longer distances to medical facilities. In such settings, vaccination is essential for preventing severe disease progression that might otherwise go untreated due to delayed access to care. By mitigating illness early, vaccination reduces long-term treatment costs, prevents catastrophic health expenditures for households, and lessens the economic and social burden of travel for medical services, thereby promoting overall community resilience and health security [13].

System Resilience and Long-Term Benefits

Typhoid vaccination plays a pivotal role in enhancing the resilience of Uganda's health system by addressing multiple interconnected health challenges. By significantly reducing the incidence of typhoid fever, vaccination alleviates the overall disease burden, thereby freeing healthcare workers and medical facilities to allocate resources and attention to other critical health priorities, such as maternal and child health, malaria, and emerging infectious diseases. Moreover, widespread use of typhoid conjugate vaccines (TCVs) directly contributes to the prevention of antimicrobial resistance (AMR), a growing global health threat [14]. Routine treatment of typhoid with antibiotics, in the absence of vaccination, often promotes the development of resistant strains, compromising the effectiveness of essential drugs. By preventing infections, vaccination reduces unnecessary antibiotic use and preserves the efficacy of these medications for future generations. Additionally, integrating TCVs into Uganda's routine immunization schedule strengthens outbreak preparedness. Combined with existing water, sanitation, and hygiene interventions, vaccination fosters a comprehensive system-level response capable of rapidly detecting, controlling, and preventing typhoid outbreaks. Crucially, vaccination protects vulnerable populations, particularly school-aged children, who experience the highest disease burden. By safeguarding their health, vaccination supports uninterrupted education, enhances cognitive development, and contributes to long-term productivity, ultimately promoting broader societal and economic benefits [15].

Cost-Effectiveness Evidence

Global modeling studies consistently indicate that typhoid conjugate vaccines (TCVs) are highly cost-effective, particularly in countries where typhoid fever is endemic. These studies estimate the cost per disability-adjusted life year (DALY) averted to be substantially lower than the thresholds set relative to national income, highlighting the economic efficiency of vaccination programs compared with the long-term costs associated with treatment and disease management [16]. In the context of Uganda, where healthcare resources are limited and the burden of infectious diseases remains high, introducing TCVs offers a strategic opportunity to reduce both direct and indirect healthcare costs. Vaccination can prevent costly hospitalizations, reduce the need for prolonged treatment, and mitigate productivity losses due to illness, thereby generating substantial economic and social benefits. Beyond financial savings, TCV implementation enhances population-level immunity, helping to curb disease transmission, protect vulnerable groups, and decrease the likelihood of antibiotic resistance arising from repeated treatment of

typhoid cases. Integrating TCVs into national immunization schedules therefore represents not only a public health intervention but also a cost-saving investment that strengthens the resilience of the healthcare system, ultimately contributing to sustainable disease control and improved health outcomes for communities across Uganda [17].

Challenges and Policy Implications

The implementation of typhoid vaccination programs in low- and middle-income countries faces several interrelated challenges that have significant policy implications. One major barrier is vaccine financing, as many governments struggle with limited health budgets and competing public health priorities, making it difficult to allocate sufficient resources for typhoid control [18]. Cold-chain logistics also present obstacles, particularly in remote and rural districts where infrastructure is inadequate, electricity supply is unreliable, and transportation networks are weak. These challenges can hinder the delivery and storage of vaccines, thereby threatening consistent coverage. Sustaining high vaccination coverage requires not only reliable financing and logistics but also community engagement, public awareness, and health workforce training. From a policy perspective, integrating typhoid vaccination into existing immunization initiatives, such as the Expanded Programme on Immunization (EPI), offers a cost-effective approach by leveraging established systems and infrastructure. Additionally, strategic partnerships with donors and international health organizations can provide financial and technical support to strengthen national immunization programs. Importantly, vaccination should not be viewed in isolation but aligned with broader water, sanitation, and hygiene (WASH) interventions, as this integrated approach addresses the root causes of typhoid transmission and enhances overall health system resilience, ensuring long-term impact and sustainability [19].

CONCLUSION

This review demonstrates that typhoid vaccination represents a highly cost-effective and transformative strategy for strengthening Uganda's health system across both rural and urban contexts. The persistent burden of typhoid fever, fueled by inadequate sanitation, limited access to safe water, and overstretched healthcare facilities, underscores the urgent need for sustainable preventive interventions. Evidence from other high-burden countries highlights that typhoid conjugate vaccines (TCVs) substantially reduce disease incidence, treatment costs, and antibiotic misuse, while also mitigating the threat of antimicrobial resistance. For Uganda, integrating TCVs into the Expanded Programme on Immunization offers a pragmatic pathway to achieve widespread protection, particularly for vulnerable groups such as children and low-income households. However, effective implementation requires overcoming financing gaps, addressing cold-chain challenges, and ensuring community awareness. Aligning vaccination with broader water, sanitation, and hygiene (WASH) initiatives will amplify health outcomes and foster long-term resilience. Ultimately, adopting typhoid vaccination as a national strategy promises not only to save lives but also to enhance equity, reduce economic burdens, and strengthen Uganda's overall public health system.

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