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Exploring Plant-Based Solutions for Diarrheal Outbreaks in Vulnerable Populations

Kato Jumba K.

Faculty of Science and Technology Kampala International University Uganda

ABSTRACT

Diarrheal diseases remain one of the most pressing public health challenges, particularly in low- and middle-income countries, where poor sanitation, limited healthcare access, and malnutrition amplify their impact—especially among children under five. Despite global efforts to curb morbidity and mortality rates, outbreaks continue to affect millions, demanding alternative, cost-effective, and locally sustainable solutions. This study explores the role of plant-based treatments in addressing diarrheal outbreaks in vulnerable populations, with an emphasis on culturally appropriate, locally accessible remedies. Drawing from traditional knowledge, ethnobotanical research, and recent case studies, the paper identifies plant species with proven anti-diarrheal properties and assesses their efficacy, availability, and cultural acceptance. Implementation strategies focus on community engagement, biopreservation, and capacity building, with specific attention to women and youth as agents of change. Challenges such as behavioral resistance, infrastructural gaps, and knowledge dissemination are also discussed. This research underscores the critical importance of integrating plant-based interventions into public health strategies, offering a complementary approach aligned with global goals for health equity and sustainable development.

Keywords: Diarrheal diseases, plant-based medicine, vulnerable populations, traditional remedies, Asteraceae, herbal therapy, public health.

INTRODUCTION

Diarrheal disease continues to be an alarmingly critical public health challenge and is recognized as the second most common cause of infant mortality worldwide, tragically claiming the lives of at least 1.5 million innocent children each year. This shocking and heart-wrenching statistic serves to highlight the urgent and immediate need for effective, evidence-based interventions aimed at combating this largely preventable condition. Furthermore, diarrheal disease is also ranked among the five most significant infectious illnesses that severely affect not only older children but also adults, particularly in low-income countries, where access to clean water and proper sanitation facilities remains persistently limited. In many such regions, the prevalence of this disease is exacerbated by the lack of resources and infrastructure necessary to ensure basic hygiene. The most widely known plants that have been associated with the treatment and alleviation of symptoms linked to this distressing condition include Artemisia abrotanum and Echinacea angustifolia, along with several other notable species within the sprawling and diverse family Asteraceae. However, it is crucial to acknowledge that these specific plants may not be readily available in Bangladesh, creating a significant challenge for individuals seeking herbal remedies or traditional methods of treatment within this particular area. This scarcity emphasizes the

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importance of exploring local alternatives and sustainable solutions to address the pressing health needs of the population [1, 2].

Understanding Diarrheal Diseases

Diarrheal disease, more frequently referred to as diarrhea, is defined as the passage of three or more watery stools in a 24-hour period. A diarrhea-related disease refers to a disease that directly causes diarrhea. Diarrhea is a common aliment among all children globally, and it has been estimated that each child under the age of five experiences three episodes of diarrhea annually. In some developing countries, however, the rates are much higher, particularly among children under three years of age. In the past decade, an average of 20% of infants under the age of six months and over 80% of children aged six months to four years experienced three episodes of diarrhea in the past two weeks. These episodes account for many of the cases of malnutrition and have been concerted efforts using their short-term and long-term mortality and morbidity. The most severe threat that can be posed by diarrhea is dehydration due to the concomitant loss of water and electrolytes. Children's diarrhea again becomes much more dangerous, because the same degree of diarrhea as in an adult can be fatal in a child. In developing countries, diarrhea remains a major cause of both death and non-fatal disease. It is estimated that approximately 1.5 million children die from diarrhea each year, making it the second leading cause of death among children under five. Given the prevalence of diarrhea in infants and their high susceptibility, it could be expected that diarrhea in very young children would pose a particularly serious problem. In fact, approximately 20% of deaths from diarrhea occur in infants aged less than six months, and over 40% occur among children under 12 months. This is despite very low rates of hospital attendance for diarrhea prior to six months of age, with such visits typically occurring at a median age of 15 months. The incidence of non-fatal diarrhea in children under 12 months is estimated to be a little lower than in those aged between one and four years, but this is likely an underestimate due to limitations in recall periods in surveys. Risk factors for infant diarrhea, studied primarily between the ages of one month and one year, have identified recent illness, mothers' education, child position in the family, siblings, and day-care attendance as important determinants. Yet, the majority of births occur at home, without skilled assistance, and with little to no postnatal care [3, 4].

Epidemiology of Diarrheal Diseases

Diarrheal diseases continue to be an important cause of morbidity and mortality worldwide, particularly among children. Estimates indicate that 1.5 million deaths occurred due to diarrhea, accounting for 8% of the total mortality in children less than 5 years, a marginal decrease as compared to 1.63 million in 2016. Globally, the burden of diseases has decreased by 24.2% since 1990, but the morbidity associated with diarrhea remains significant, with 1.735 billion diarrheal disease episodes among children under five reported in 2010. Diarrheal disease is still among the five major killers of this vulnerable group. Nineteen percent of deaths associated with diarrhea were in children who died from other causes, including malnutrition, HIV, malaria, and pneumonia. In total, 525 million children under five years of age experience diarrheal disease each year; of these, 1.57 million die. The largest burden (>80%) of deaths is in the African and south-east Asia regions, where Rotavirus and non-Rotavirus pathogens are already established as important causes of mortality and morbidity, respectively. These pathogens are also important causes of moderate to severe gastroenteritis in Benin, a west African nation, with the burden of disease being highest in infants. The Global Enteric Multicenter Study (GEMS) is the largest and most comprehensive study of childhood diarrhea diseases. It was conducted in both urban and rural slums in Africa (7 sites) and Asia (1 site). The primary objectives of GEMS were to identify the diarrhea-causing pathogens and the burden of diarrheal illness in children <5 years of age across the 7 GEMS sites in developing countries over a 3-year period [5, 6].

Impact on Vulnerable Populations

Diarrhoea significantly impacts morbidity and mortality, especially among vulnerable groups like young children, the elderly, and immunocompromised individuals in developing countries. The incidence in children under 5 in low- and middle-income countries (LMICs) is alarmingly high. In 201, diarrhoea resulted in around 431,000 deaths and about 1.7 million child fatalities. Children aged 0–4 in the Global South experience the highest mortality due to various socioecobiological vulnerabilities and systemic inequalities in nutrition and health services. Many childhood diarrhoea deaths occur after non-clinical cases, emphasizing the need for scalable, cost-effective prevention strategies. Investments in clean water, sanitation, and hygiene have led to health improvements, yet millions in LMICs still lack basic services.

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Health interventions targeting drinking water, sanitation, and hygiene can mitigate risks, but the uptake of effective measures remains low. A deeper understanding of disease exposure patterns in LMICs is crucial for developing scalable, affordable prevention strategies. Insights from Q-learning indicate that inequalities in exposure primarily stem from unmet age-specific needs for water, sanitation, and hygiene, and public health policy can address these without significant cost increases [7, 8].

Plant-Based Solutions

Between 1900 and 2008, diarrhoeal illnesses were the fifth leading cause of mortality globally and the second major cause of death among children under five in developing countries, leading to 1.5 million deaths annually. Allopathic treatments for diarrhoea, although effective for dysentery and cholera, are often unavailable or unaffordable in rural Africa. Since 1853, indigenous medicinal remedies have been used, and this study explored their potential. Various indigenous plants used by rural individuals, traditional healers, and health practitioners were identified for home-based treatment of diarrhoea. Most remedies involved pulverizing plant parts or boiling them in water to extract medicinal properties. The study documented 200 indigenous plants and 94 plant-derived remedies in the Eastern Cape. Previously, formal documentation of these medicinal plants and their preparation for diarrhoea treatment was lacking. Key features of identification, conservation, and broader distribution of these plants were also not available. Observations showed that dried plant parts were commonly used as anti-diarrhoeal remedies, differing from other studies. Treatment outcomes were rarely assessed, leading to potential misuse of some remedies. Evidence of washing, chewing, soaking, and salivating plant parts before use was also noted. Additionally, new plant-derived remedies and traditional containers were identified [9, 10].

Case Studies

In Ujjain, India, 327 children aged 6 months to 6 years with diarrhea were surveyed using a semi-structured questionnaire administered to mothers. Simple proportion methods were used to compute variables of interest, crude odds ratios (OR) were calculated, and a forward logistic regression long model explored associations of various factors with childhood diarrheal case management. Results showed that 214 children (65.4%) were taken to some mode of healthcare provider; the majority was taken to private providers (146/327, 44.7%) and only 13 (0.04%) were taken to Anganwari workers. Report of pig farm possession in the household (adjusted OR [AOR] = 6.65, $P < 0.001$), residing location in the city (AOR = 2.73, $P = 0.017$) and health history of the child (AOR = 3.69, $P = 0.055$) were most strongly associated with children being taken to various providers. Children's healthcare should be prioritized by Anganwari workers as part of their Primary Healthcare Service provision; more avenues should be created for rural populations to access healthcare. A cross-sectional survey was conducted in churches in the Ujjain city area of India to assess whether there are gaps in current WASH practices and their perceptions from a religious point of view. The results provide insight into the awareness of church communities regarding WASH facilities and practices. Recommendations suggest a framework for implementing and enhancing current WASH practices in church communities [11, 12].

Cultural Considerations

The perception, expression, and management of health and illness vary greatly across cultures. Individual beliefs regarding the body, disease causes, symptoms, and appropriate treatments are influenced by cultural models pervasive in all societies. Cultural epidemiology examines how these beliefs circulate at the population level, intertwined with a broader worldview that includes societal knowledge, explanatory concepts, and community socialization. This knowledge shapes health behaviors and disease spread. Understanding cultural beliefs about health is essential, especially concerning new diseases. Medical anthropology acknowledges that culture includes explanatory models but transcends them. This paper suggests viewing cultural models as motivational frameworks for social engagement, highlighting the roles of social interactions and desires. It challenges anthropologists to balance explanation localization with broader cultural dynamics. Treatment believing shifts focus from mere representation to action, illustrating culture's active role in shaping health practices. This reconstruction of community beliefs should be viewed as an inquiry process, emphasizing local models as vibrant resources rather than static templates for behavior [13, 14].

Implementation Strategies

Implementing a local biopreservation solution to combat diarrheal outbreaks in vulnerable populations seeks a partnership with a prominent development organization known for its unique scale of hygiene programs and exemplary inclusive safety-net systems for base-of-pyramid families. A focused effort will

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showcase the local biopreservation technology's benefits and the socio-economic value of food safety. Communities will be engaged to understand the business model and provide feedback, with priority given to areas with multiple families. Local entrepreneurs, secondary processors, and skilled women will be identified and involved. Capacity-building sessions for best practices in fermented food processing will be organized. Over time, 40+ adolescents and women will be trained in microbiology, food safety, and fermentation processes using locally available resources. A mindset shift towards resource-efficient alternatives will also be promoted. Entrepreneurs will gain access to low-budget social media platforms, and local markets will be developed with financial inclusion support. Hygiene education will be integrated into schools, along with community outreach about the benefits of biopreservation technology. Community radio programs will broadcast relevant information. Biopreservation kits will be produced with essential ingredients and sold by women microentrepreneurs or cooperatives. Rigorous testing of inputs will be conducted through extensive sampling and lab tests. Marketing strategies will include strong follow-up planning after three years of grant support, ensuring community capability for societal monitoring and acceptance of niche strategies. Forums with stakeholders will promote mass acceptance and acceleration of technology and products developed [15, 16].

Challenges and Barriers

Real or perceived failures in interventions may hinder motivation and usage. Identifying and addressing behaviors of interest prior to implementing new tools is crucial. Participants noted challenges in using interventions for safe drinking water post-outbreak, including perceived difficulty, time requirements, lack of knowledge, and feelings of unnecessary intervention. Individual circumstances, such as prioritizing other chores and lack of expertise, represented significant barriers. Ongoing motivation and persistence were highlighted as essential, alongside skills and awareness of outcomes. Social norms, particularly at home, played a critical role in initial and sustained motivation. Continued motivation for safe drinking water was infrequent amid post-outbreak challenges. Future research should explore key social and motivational factors influencing ongoing pursuit of household water treatments. Engaging with behavioral interventions can be challenging, with unforeseen issues and barriers such as prior beliefs and environmental conditions affecting treatment adoption. Shared history related to the outbreak may have provided initial motivation to engage with interventions. Qualitative interviews can shed light on initial motivational influences and help develop strategies that enhance social and motivational feedback, potentially leading to better engagement in future similar contexts [17-20].

Future Directions

As populations of immunologically naïve children cluster in environments deficient of clean drinking water and sanitation, outbreaks of enteric viral, bacterial, and parasitic infections are expected to follow. With up to 16 million suspected cases of infectious diarrhea occurring annually, there is a need for scientific solutions to treat and/or prevent these diseases in vulnerable populations. Current treatments employ medicines such as antibiotics and antivirals, but such therapies are ill-suited for global needs. New plant-based solutions for the treatment and prevention of diarrheal outbreaks occurring in vulnerable populations are sought. Existing information housing plant-based substances with anti-diarrheal activities will be collected and will populate interactive web-application(s) to discover plants for the treatment/prevention of diarrheal disease. Computational identification will be performed to 1) rapidly discover new aptamer agents that bind and inhibit enteric pathogens, and 2) screen databases of small-molecule plant products against enteric pathogen proteins to discover new lead agents. The output of these 1, 2 will feed downstream work to test efficacy of new agents against enteric pathogens in vitro/ex vivo/in vivo, and mechanistic studies will also be pursued. Underlying science will also be pursued, such as the effects of small-molecule plant products on enteric-pathogen infection and pathogenicity, and target-identification will be done to uncover the molecular basis of action for Aptamer and Bioproducts against enteric pathogens. Deliverable from the work will serve Direct Projects in Vulnerable Populations seeking ways to enable Vulnerable Populations to consume Safe and Nutritious Fruits, Vegetables, Cereals, and Food Beans-Global Goals on Poverty Reduction and Global Funding Scenarios for the 2030s [21, 22, 23].

CONCLUSION

Diarrheal disease, while preventable and treatable, continues to claim millions of lives annually, disproportionately affecting the most vulnerable—children, the elderly, and the immunocompromised in resource-limited settings. In exploring plant-based solutions, this paper reveals the untapped potential of

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indigenous knowledge and traditional practices in managing diarrheal outbreaks effectively. Locally available medicinal plants not only offer therapeutic benefits but also align with cultural norms and economic realities, making them a pragmatic alternative or complement to allopathic treatments. Sustainable implementation requires investment in education, capacity building, and infrastructure to support the use and acceptance of these remedies. Furthermore, leveraging community health workers, particularly women and youth, can foster grassroots ownership and continuity. Future research and innovation, including computational drug discovery and community-led biopreservation initiatives, can drive scalable, context-sensitive solutions. Ultimately, integrating plant-based interventions into mainstream public health responses presents a promising path toward reducing diarrheal burden and achieving equitable health outcomes globally.

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