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Towards a Parasite-Free India: Bridging Gaps and Building Resilience in Public Health

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A B S T R A C T

Parasitic infections continue to pose a serious public health challenge in India. While commendable progress has been made in tackling malaria, lymphatic filariasis, and visceral leishmaniasis, gaps in sanitation, healthcare access, and public awareness still allow these diseases to persist. Advances in diagnostics, treatment, and health systems have set the stage for eradication, but real progress will require a more integrated and proactive approach. Implementing the One Health framework, leveraging digital tools, and engaging communities at every level are critical for success. Addressing social factors that drive vulnerability, strengthening disease surveillance, and fostering cross-sector collaboration will be essential. India's goal of eliminating malaria and filariasis by 2030 is achievable if we build on existing knowledge and safeguard the progress we have made. A parasite-free India is within reach through sustained investment, smart policies, and strong public participation.

Introduction

The Complex Epidemiological Landscape

Deep disparities shape India's fight against parasitic diseases. While an estimated 95% of the population lives in malaria-endemic regions, nearly 80% of the disease burden is concentrated in just 20% of the population.[1] This reveals a critical truth; the challenge is not evenly spread but entrenched in specific areas, primarily tribal, hilly, and other hard-to-reach regions, where healthcare infrastructure remains fragile. The World Health Organization (WHO)'s latest report, citing 263 million global malaria cases in 2023, offers a wake-up call.[2] Yet, India has made remarkable progress, reporting an 85.1% decline in malaria cases and an 83.3% reduction in malaria-related deaths between 2015 and 2022.[3] These figures underscore the power of national programs when implemented consistently and at full scale.

The burden of lymphatic filariasis (LF) in India is huge. The country accounts for about 62% of the global

population at risk, roughly 404.3 million people. This debilitating disease, caused by parasitic nematodes such as *Wuchereria bancrofti*, is a leading cause of long-term disability. India alone reports over 619,000 cases of lymphoedema and 150,708 cases of hydrocele. In response, the nation has set an ambitious target; to eliminate LF as a public health problem by 2027, three years ahead of the global goal.[4] However, this goal faces significant hurdles, including low Mass Drug Administration (MDA) coverage and treatment gaps among mobile, urban, and other high-risk populations.[5] This highlights a disconnect between national policy and ground realities, suggesting that the current MDA model lacks the flexibility needed to serve India's diverse and highly mobile population.

In contrast, India's Kala-azar (visceral leishmaniasis) elimination program stands out as a success story. Reported cases have dropped significantly from 77,102 in 1992 to just 599 in 2023, with incidence now below the elimination threshold of one case per 10,000 people at the subdistrict level.[6] Still, the threat of resurgence persists. Cases of post–kala-azar dermal leishmaniasis (PKDL) and Leishmania-HIV coinfections can act as reservoirs for the parasite, demanding constant vigilance to prevent future outbreaks.[7, 8] This progress demonstrates that with unwavering political commitment and well-targeted strategies, even the most persistent parasitic diseases can be brought under control.

The Socio-economic and Human Development Toll

The true cost of parasitic diseases in India goes far beyond numbers; it represents a serious threat to the nation's socio-economic progress and human development. These illnesses, often classified as Neglected Tropical Diseases (NTDs), disproportionately affect the poor and most marginalized communities, populations that already lack access to clean water, sanitation, and quality healthcare.[9] This creates a vicious cycle; poverty increases vulnerability to infection, and the debilitating effects of these diseases make it harder to overcome poverty.[10]

The financial impact is immense; One analysis estimates that malaria alone imposes an economic burden of approximately US$1.94 billion in India.[11] About 75% of this burden comes from forgone income, while only 24% is attributed to direct treatment costs. This imbalance shows how these diseases affect productivity and family well-being. When primary earners in low-income households fall ill, they cannot work, cutting household income and, at a national level, dragging down productivity and economic growth.[12] Combating parasitic diseases is not just a health issue; it is a critical driver of economic development.

The economic toll also extends to agriculture and aquaculture. Gastrointestinal parasitic infections are widespread in livestock across India's northeastern states, causing major financial losses for farmers.[13] Similarly, India's aquaculture sector faces an estimated economic burden of about US$2.48 billion from parasitic and other diseases, representing nearly 15% of annual production value.[14] The emergence of zoonotic diseases, where parasites once confined to animals, such as *Sarcocystis nesbitti*, now infect humans, poses a growing public health threat.[10] This interconnectedness between human, animal, and environmental health calls for a paradigm shift toward a One Health approach. A truly comprehensive strategy cannot operate in isolation; it must integrate veterinary, agricultural, and human health sectors to tackle the intricate nature of parasite threats and provide a more resilient system that protects public health and economic sustainability.

A Retrospective Analysis of India's Public Health Interventions against parasitic diseases

India's public health journey has been a roller coaster, marked by remarkable victories and painful setbacks.

Malaria: The first major national effort, the National Malaria Control Programme (NMCP), launched in 1953, was scaled up to the National Malaria Eradication Programme (NMEP) in 1958 with an aggressive focus on widespread DDT spraying. The initial results were nothing short of extraordinary; by 1961, malaria cases had fallen to fewer than 50,000, and reported deaths had dropped to zero.[15] However, this success was short-lived as significant complacency led to a sharp decline in research and surveillance efforts. Combined with operational failures, such as irregular DDT supplies, poorly trained staff, and the complete exclusion of urban areas from the initial plan, these gaps lead to a massive resurgence. By 1976, malaria cases had soared to a staggering 6.47 million, marking a dramatic reversal of earlier achievements.[15] The resurgence was also fueled by growing resistance of the mosquito vector, *Anopheles culicifacies*, to DDT and other insecticides.[16] The hard lessons from the NMEP's failure prompted a strategic

reevaluation. In 1982, India introduced a National Antimalarial Drug policy to strengthen case management. New vector control measures were also deployed, including insecticide-treated nets (ITNs) and biological interventions such as the use of larvivorous fish.[17] Today, the National Vector Borne Disease Control Programme (NVBDCP) functions as an umbrella initiative, reflecting a shift toward a more holistic and integrated approach to combating multiple vector-borne diseases under the broader National Health Mission (NHM).[18,19] This transition from vertical, disease-specific campaigns to a more horizontal framework underscores a deeper understanding of the complexities of public health in a vast and diverse country like India.

For malaria, targeted interventions have proven highly effective. One powerful example is the Durgama Anchalare Malaria Nirakaran (DAMaN) project in Odisha, a state historically burdened by malaria. [20] Launched in 2017, the project introduced 'malaria camps' that delivered mass screening, treatment, education, and intensified vector control in hard-to-reach, high-burden villages.[21] These interventions, together with other state programs, led to a remarkable 95% reduction in malaria cases in Odisha between 2016 and 2022.[22] The success of the DAMaN project illustrates that a comprehensive, integrated approach combining 'hard' interventions such as medical camps with 'soft' strategies like community education can be both effective and financially viable.

Dracunculiasis: The Guinea Worm Eradication Programme (GWEP) stands out as a powerful example of a community-centric approach. India was officially certified Guinea Worm-free in 2000, a milestone achieved not through a single "magic bullet", but through a multi-pronged strategy that targeted the entire disease lifecycle. Key interventions included providing safe drinking water via boreholes, closing unsafe step wells, and applying larvicides such as Temephos.[23] Most importantly, GWEP's success was driven by intensive health education and a pioneering model of community participation, where local volunteers were empowered to become the primary agents for this change.[24] This demonstrates that effective public health initiatives need to be deeply rooted in the communities they aim to serve.[25]

Leishmaniasis: The Kala-azar Elimination Programme (KAEP) offers a recent example of success, driven by strong political commitment, strategic partnerships, and medical innovation. A key turning point was the adoption of a single-dose treatment using liposomal amphotericin B, which ensured treatment completion and simplified the process. KAEP further strengthened its impact by decentralizing care to lower-level health care facilities, implementing a real-time data management system, and providing financial incentives to health care workers for case detection and follow-up.[6] The combination of these factors, a simplified and effective medical intervention, sustained political will, and a strong operational framework, was the driving force behind its remarkable success.

Lessons from these programs highlight that the most reliable path to achieving and sustaining elimination lies in a blend of medical innovation, political commitment, and community-based strategies.

Gaps and Challenges on the Path to Elimination

The Evolving Threat of Resistance

The fight against malaria remains a constant race against a moving target due to the ever-changing nature of pathogens and vectors. Drug resistance, particularly in malaria, has historically undermined control efforts. The resurgence of malaria in the 1970s was largely driven by the growing resistance of *Plasmodium falciparum* to chloroquine, first reported in 1973.[17] Today, India relies on more effective artemisinin-based combination therapies (ACTs). However, reports of artemisinin resistance emerging in Southeast Asia pose a serious concern, threatening to overcome a key pillar of India's current malaria treatment strategy.[11]

A similar issue comes from widespread insecticide resistance. The primary malaria vector in rural India, *Anopheles culicifacies*, has developed resistance to DDT and malathion in several districts across Madhya Pradesh, Andhra Pradesh, Odisha, Jharkhand, and West Bengal.[26] This resistance undermines the effectiveness of core vector control strategies, such as Indoor Residual Spraying (IRS) and Long-Lasting Insecticidal Nets (LLINs).[27]

One critical gap is the absence of a comprehensive, nationwide analysis of drug resistance data across all institutions.[17] Without centralized data, proactive monitoring and timely responses to emerging resistant

strains remain a significant challenge. The history of the NMEP demonstrates that prolonged reliance on a single insecticide is unsustainable and inevitably triggered a biological backlash. This underscores the urgent need for a dynamic, diversified approach to vector control.

Systemic and Operational Gaps

Biological threats aren't the only obstacles. Deep, systemic defects in the foundation of public health continue to hinder progress. Despite decades of control efforts, health systems in many endemic regions remain under-resourced, with limited vector surveillance and severe staff shortages.[28] The historical decision to convert the Malaria Institute of India into a Generic communicable diseases institute, effectively de-emphasizing specialized malaria research, was a strategic misstep that underscores the need for continuous, dedicated research.[15] While programs like the NVBDCP provide a national framework, their effectiveness is often constrained by implementation and monitoring challenges at the state and district levels.[19]

Beyond these structural issues, population dynamics add another layer of complexity. The highly mobile nature of India's population, particularly labor migration, poses a significant barrier to achieving and sustaining program coverage. This challenge is especially evident in the lymphatic filariasis elimination program, where mobile populations often act as "never-treated" reservoirs, making it nearly impossible to interrupt disease transmission.[4]

Climate change compounds these challenges. Rising temperatures and humidity, particularly in coastal regions, create ideal conditions for mosquito breeding and disease transmission, threatening to reverse the hard earned gains in disease control.[20]

These factors underscore the urgent need for a flexible, adaptive public health strategy, one that can respond to dynamic population movements and shifting environmental conditions.

Failure in increasing Public Awareness

One often-overlooked challenge is the lack of public awareness. There is a profound disconnect between the actual epidemiological burden of certain diseases and the attention they receive. Analyses of social media and news coverage reveal that diseases like dengue dominate online discourse, while others with comparable or even higher burdens, such as lymphatic filariasis and, particularly, Kala-azar, remain almost invisible. This "information desert" surrounding neglected diseases erodes public urgency and, in turn, weakens their prioritization in health policy and resource allocation.[28]

The paradox is striking: even successful programs, such as the Kala-azar elimination initiative, fail to effectively communicate their achievements or the ongoing need for vigilance. This reflects a broader issue: current public health communication strategies have not fully adapted to the digital age. The solution is not simply broadcasting more information but adopting a strategic, platform-specific approach.

For example, leveraging health vloggers on YouTube to deliver self-care tutorials for lymphoedema or creating awareness clips for Kala-azar in regional languages could help bridge this critical gap.[28] Such approaches harness the power of digital communication not only to inform the public but also to foster a sense of community around disease management and prevention ultimately strengthening the broader public health ecosystem.

Building Resilience: A Forward-Looking Strategy

Strategic Recommendations for an Integrated Approach

The path to a parasite-free India demands a fundamental shift—from a reactive, disease-specific approach to a proactive, integrated public health strategy.

Recommendation 1: A Unified Research-to-Implementation Framework

A persistent challenge in India's public health landscape is the disconnect between research and on-the-ground program implementation, which often causes frustrating delays in translating scientific findings into actionable policy.[29] To address this, a "virtual amalgamation" of research bodies can be considered. This integration would foster demand-driven research, ensure timely translation of evidence into policy, and enable more efficient resource allocation. In this model, researchers would transition from being passive advisors to active partners in policy formulation and implementation, creating a more cohesive and accountable system.[30]

Recommendation 2: A Data-Driven, Technological Overhaul

The future of parasite control lies in harnessing technology. This includes expanding the use of Geographical Information System (GIS) mapping to gain a granular understanding of high-risk areas and guide targeted interventions.[19] Equally crucial is the adoption of advanced diagnostic tools. Innovations such as AI-powered imaging, molecular and biosensor-based testing, and non-invasive biomarker assays offer the potential for more accurate and timely case detection, particularly for asymptomatic cases. These technologies must be integrated with digital patient management systems to streamline workflows, enhance data accuracy, and minimize manual errors.[31] Together, these measures can transform surveillance and case management from reactive to predictive, enabling faster, smarter responses to emerging threats.

Recommendation 3: Community-Centric and Behavioural Interventions

The success stories of the Global Guinea Worm Eradication Program (GWEP) and India's DAMaN project underscore the non-negotiable role of community empowerment and behavioural change in achieving and sustaining disease elimination.[22] A resilient public health system must be built from the ground up by decentralizing care and empowering community health workers, such as Accredited Social Health Activists (ASHAs).[32] ASHAs should be equipped with Rapid Diagnostic Kits (RDKs) and authorized to provide timely treatment, strengthening the first line of defense in remote areas.[19] Additionally, innovative Behaviour Change Communication (BCC) campaigns that incorporate local cultural elements such as folk troupes and mobile vans with loudspeakers are essential to bridge awareness gaps and ensure community compliance with control measures.[32] These culturally tailored strategies foster trust, improve participation, and make interventions more sustainable.

Recommendation 4: Fostering Strategic Partnerships and International Collaboration

The success of the Kala-azar elimination program, driven in part by a strong network of partners and donors, underscores the critical role of collaboration.[6] Public-private partnerships (PPPs) can be leveraged to secure funding, share expertise, and accelerate the development and distribution of affordable, high-quality medicines and diagnostics.[29] India should also actively pursue international collaboration, sharing lessons from its successful programs while learning from global best practices such as Argentina's environmental engineering methods for forest malaria and Sri Lanka's robust surveillance systems.[33] These partnerships can strengthen technical capacity, foster innovation, and ensure that India remains aligned with global strategies for vector-borne disease control.

Recommendation 5: One Health Integration

Combating zoonotic parasitic diseases requires a collaborative One Health approach that integrates human, animal, and environmental health systems. This holistic strategy acknowledges the interconnectedness of these domains and promotes coordinated efforts to prevent and control disease outbreaks. To strengthen this approach, establishing One Health Coordination Units within state health departments can play a pivotal role. These units would enable real-time data sharing across sectors, fostering timely and informed responses to emerging threats. India's National One Health Programme exemplifies this model, mandating coordination at multiple administrative levels: national, state, district, block, and village. This is operationalized through multisectoral committees and coordination networks, as outlined by the National Centre for Disease Control (NCDC) and the Office of the Principal Scientific Adviser to the Government of India.[34,35] Furthermore, it is essential to mandate surveillance of zoonotic parasites in both livestock and wildlife. This effort should be carried out in collaboration with the Ministries of Animal Husbandry and Environment, aiming to enhance early detection and rapid response to potential outbreaks. Such integrated surveillance is a cornerstone of effective One Health implementation and a critical step toward safeguarding public health.[34]

Recommendation 6: Integrate Parasitic Disease Control into Urban Planning and Smart Cities

To strengthen urban health systems, it is essential to incorporate vector surveillance, sanitation, and waste management as core indicators within Smart City Health Indices. These components are vital for monitoring and controlling parasitic diseases in densely populated areas. India's National Strategic Plan for Malaria Elimination

underscores the importance of integrating real-time surveillance and vector control measures within urban environments, aligning with global best practices.[34,36] Urban Local Bodies (ULBs) must also take an active role in parasite control by embedding relevant measures into their health action plans. Special attention should be given to informal settlements, which are often underserved yet highly vulnerable to vector-borne diseases. This approach is consistent with international calls for a stronger urban malaria focus and supports equitable health outcomes across all urban populations.[36]

Recommendation 7: Expand Universal Health Coverage for Parasitic Infections

To ensure equitable access to parasitic disease management, essential diagnostics such as PCR, rapid diagnostic tests (RDTs), and stool microscopy should be included under the Ayushman Bharat Health & Wellness Centres (AB-HWCs). These centres already provide free essential drugs and diagnostic services as part of their integrated primary healthcare packages, which cover a wide range of communicable diseases.[37] [38] Additionally, antiparasitic medications should be made available free of cost or at subsidized rates through both public and empanelled private healthcare facilities under the Pradhan Mantri Jan Arogya Yojana (PM-JAY). This flagship health insurance scheme offers coverage that includes diagnostics and drug therapies, making it a vital platform for expanding access to parasite control interventions.[38]

Recommendation 8: Strengthen Surveillance through Mandatory Reporting and Private Sector Integration

To improve national surveillance and response to parasitic diseases, it is crucial to enforce mandatory reporting of parasitic infections by private hospitals and laboratories. This can be achieved by integrating these facilities into the Integrated Disease Surveillance Programme (IDSP), which already mandates weekly laboratory-based reporting across public health systems. In addition, private healthcare providers should be trained on national treatment protocols to ensure consistency in care delivery. Strengthening IDSP laboratories and promoting intersectoral coordination will enhance public-private outreach and improve the overall effectiveness of disease monitoring and control efforts.[34,39]

Recommendation 9: Invest in Local Research and Innovation

To accelerate research and innovation in parasitic disease control, block grants should be allocated to ICMR institutes, public health schools, and medical colleges for operational research. The Indian Council of Medical Research (ICMR) already supports both intramural and extramural biomedical and public health projects, providing a strong foundation for evidence-based interventions.[40] Additionally, startup hubs developing point-of-care diagnostics, digital surveillance tools, and community engagement platforms should be supported under ICMR's operational research mandate. These innovations are critical for addressing parasitology and emerging health threats, and institutions like the National Institute of Cholera and Enteric Diseases (NICED) play a key role in fostering such advancements.[41]

Recommendation 10: Strengthen Community-Based Monitoring

To strengthen parasite control at the community level, flexible funding should be allocated to Panchayati Raj Institutions (PRIs) for local initiatives such as sanitation drives and school-based deworming programs. These community-led efforts are essential for addressing parasitic infections in rural and semi-urban areas, where environmental and behavioral factors often contribute to disease transmission. Community health workers, including Accredited Social Health Activists (ASHAs) and Anganwadi Workers (AWWs), should be actively engaged in ongoing education campaigns focused on hygiene, safe water practices, and treatment adherence. Their role is especially critical during National Deworming Days, where they administer albendazole and educate families on sanitation and hygiene. These efforts are supported by training materials and guidelines provided by the Ministry of Health and Family Welfare (MOHFW).[37]

Recommendation 11: Embed Climate Surveillance in Early Warning Systems

To strengthen climate-resilient health systems, parasitic disease forecasting should be integrated into early warning systems managed by the National Disaster Management Authority (NDMA) and the India Meteorological Department (IMD). The existing IMD–

NDMA multi-hazard early warning system already monitors weather and hydrometeorological hazards that influence vector ecology and disease transmission dynamics.[42] Developing district-level climate vulnerability maps for diseases such as malaria, leishmaniasis, and filariasis is a critical next step. These maps should be based on environmental and climatic data, aligning with India's growing emphasis on climate-informed, impact-based forecasting. Such tools can guide targeted interventions and resource allocation in high-risk areas.[43]

Recommendation 12: Expand Deworming and Screening Programs

To broaden the reach of parasitic disease prevention, National Deworming Day (NDD) should be extended to include out-of-school children, adolescents, and high-risk adult populations. Since its launch in 2015, NDD has targeted both enrolled and non-enrolled children aged 1–19, with mop-up rounds to ensure broad coverage. Expanding its scope would help address gaps in deworming among vulnerable groups often missed by school-based programs.[37, 44]

In addition, routine antenatal screening for parasitic infections such as toxoplasmosis, giardiasis, and cryptosporidiosis should be introduced in endemic regions. A prospective study in India reported a 10.3% seropositivity rate for gestational toxoplasmosis using serology and PCR, highlighting the need for early screening and timely treatment with spiramycin to prevent adverse pregnancy outcomes.[45]

In conclusion, India stands at a critical crossroads in the fight against parasitic diseases. History shows that achieving a parasite-free status is not a one-time milestone but a continuous process requiring a resilient, adaptive, and integrated public health system.

The blueprint for a sustainable future must build on past successes, sustained political will, innovative diagnostics, and community-centric approaches while addressing systemic challenges such as drug and insecticide resistance, information gaps, and operational weaknesses.

By embracing a One Health philosophy, fostering a unified research-to-policy ecosystem, and leveraging technology and strategic partnerships, India can not only meet its ambitious elimination targets but also create a public health infrastructure capable of withstanding future threats.

The ultimate goal is more than a parasite-free India; it is a healthier, more productive, and more equitable nation for all.

Author Contributions

Swathi Gurajala: Investigation, formal analysis, writing—original draft. Sai Saranya Gurajala: Validation, methodology, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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