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The benefits of innovative diagnostic tools for neglected tropical diseases: A scoping review

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ABSTRACT

Vulnerable populations all around the world, especially those in low-resource settings, continue to suffer the consequences of neglected tropical diseases (NTDs). Methods of diagnosis that are considered traditional are frequently insufficient when it comes to the successful identification and management of NTDs related issues. This study examines how novel diagnostic technologies improve diagnosis accuracy, accessibility, and cost-effectiveness for NTD management. In carrying out this review, a scoping review was adopted using PubMed and grey literature sources. The search yielded 336 articles, of which 23 were selected through title and abstract screening. After reviewing the complete text, 9 studies met the eligibility criteria for inclusion. New diagnostic techniques like rK39 and rK28 NTDs, molecular diagnostics, and point-of-care testing showed better sensitivity, specificity, and accessibility than older methods. Studies also showed that they might be used in the field to improve disease surveillance and treatment uptake, especially for visceral leishmaniasis, schistosomiasis, and lymphatic filariasis. The use of innovative diagnostic technologies is very helpful for controlling NTDs because they make it easier to get accurate diagnoses in places where resources are limited. Subsequent study must concentrate on the expansion of these technologies, the resolution of infrastructural constraints, and the investigation of their contribution to global efforts in the eradication of NTDs.

Keywords: neglected tropical diseases, innovative diagnostic tools, molecular diagnostics, rapid diagnostic tests, digital health technologies

INTRODUCTION

Disabling neglected tropical diseases (NTDs) disproportionately affect the poor, mainly in tropical countries [1]. NTDs cause major sickness, disability, and mortality, especially in low-income and resource-constrained nations, but over time, they receive limited attention from the global health community [2]. Over one billion people worldwide suffer from viruses, bacteria, parasites, fungi, and non-infectious conditions like schistosomiasis, onchocerciasis, lymphatic filariasis (LF), leishmaniasis, and Chagas disease, which cause chronic disability, social stigma, and economic hardship, perpetuating cycles of poverty and suffering.

However, traditional diagnostic techniques like the microscopy and culture-based NTD diagnosis have some limitations in several ways. In endemic areas, these methods lack sensitivity and specificity and require specialist laboratory infrastructure and well-trained people [3, 4]. Moreover, these techniques are time and resources consuming, delaying diagnosis, causing inappropriate treatment, and increasing morbidity [5]. Misdiagnosis or undiscovered NTDs lead to inefficient treatment and prevention [6, 7]. Therefore, there is an urgent requirement for disease diagnosis methods that are faster, more accurate, and more accessible, particularly in remote or resource-limited regions.

The resolution of these issues could be achieved through the application of whole genome sequencing (WGS), molecular diagnostics, rapid diagnostic tests (RDTs), digital health technology, and AI-assisted interpretation tools. The implementation of these methods has the potential to significantly enhance the accuracy of NTD diagnosis, as well as improve surveillance and facilitate disease control and elimination in settings with limited resources [4, 8]. The World Health Organization 2030 roadmap for NTDs emphasizes the importance of advancing and implementing innovative diagnostic technologies aimed at the elimination and control of global diseases [9]. The roadmap outlines the need for diagnostic breakthroughs that are sensitive, specific, affordable, and user-friendly, particularly in resource-limited settings characterized by weak healthcare infrastructure [9].

Innovative diagnostics present significant potential. RDTs are effectively detecting malaria and dengue in low-resource environments, facilitating prompt treatment decisions [10].

Table 1. Database search strategy

Database	Compiled search term	SY	Filters applied	YFF
PubMed	(((((point-of-care testing [Title/Abstract]) OR (whole genome sequencing [Title/Abstract])) OR (rapid diagnostic tests [Title/Abstract])) OR (molecular diagnostics [Title/Abstract])) OR (artificial intelligence [Title/Abstract])) OR (innovative technologies [Title/Abstract])) AND ((((((neglected tropical diseases [Title/Abstract]) OR (NTDs [Title/Abstract])) OR (schistosomiasis [Title/Abstract])) OR (leishmaniasis [Title/Abstract])) OR (lymphatic filariasis [Title/Abstract])) OR (Onchocerciasis [Title/Abstract]))	336	Free full text, comparative study, multicenter study, observational study, randomized controlled trial, English, humans	15

Note. SY: Search yield & YFF: Yield following filters

loop-mediated isothermal amplification has the capability to identify pathogens at the molecular level without the need for sophisticated laboratory equipment, positioning it as an optimal solution for remote point-of-care (POC) testing [11]. Rapid detection and simpler transport of large diagnostic equipment and samples are vital in sociopolitically unstable places like Africa [11, 12].

Sociopolitically unstable areas pose challenges despite diagnostic advancements. Armed conflicts, governance issues, and forced displacement make it hard for countries to enhance their health systems and control NTDs [8]. Such limitations make breakthrough diagnostic procedures harder to deploy and impede global health goals, especially in shaky health infrastructure countries. Thus, satisfying NTD diagnostic needs in such countries requires technological innovation and an understanding of their geopolitical and logistical restrictions.

This scoping review examines the pros and cons of innovative NTD diagnosis methods to fill these gaps. This study examines how diagnostic advances promote disease detection, surveillance, and control in low-resource locations. This study synthesises studies to detect trends, appraise diagnostic tools, and identify knowledge gaps. The review will guide NTD research, policy, and practice in low-resource and conflict-affected areas.

METHODOLOGY

This study utilised the methodology established in Arksey and O'Malley (2005) [13] to thoroughly delineate the existing data about the advantages of new diagnostic methods for NTDs. The main source of literature was PubMed. Search terms include “innovative diagnostic tools”, “point-of-care testing”, “rapid diagnostic tests”, “molecular diagnostics”, “artificial intelligence”, “innovative technologies”, and NTDs related terms such as “neglected tropical diseases”, “NTDs”, “schistosomiasis,” “leishmaniasis,” and “lymphatic filariasis,” were used to retrieve the literature and were combined using Boolean operators. The search was limited to articles published in English between 2000 and 2025 to ensure relevance to current technological advancements. **Table 1** contains details of the search strategy.

Studies were included if they were original research articles in English language, published within 2010 to the search date (July 20, 2025) and reported on the application, evaluation, or impact of innovative diagnostic tools in the detection, monitoring, or management of NTDs in human populations. Research focusing solely on veterinary applications, basic laboratory assays without field relevance, or non-NTD conditions was excluded. Conference abstracts without full text, opinion pieces, and studies lacking sufficient methodological detail were also excluded. Titles and abstracts were screened independently by two reviewers, with discrepancies resolved through consensus. Full-text screening was conducted using the same criteria, ensuring that only studies meeting the inclusion criteria were included.

Data extraction was carried out by two independent reviewers and discrepancy was resolved through consensus. The data collected were information relating study characteristics (author(s), year of publication, study design, and country of study), NTDs targeted, innovative diagnostic tools used, and key findings on benefits and limitations.

RESULTS

Literature Selection

The literature search in PubMed yielded 336 publications which was reduced to 15 articles through application of appropriate filters. Additionally, a grey literature search was carried out in Google search engine and 10 publications were considered for screening. After screening titles and abstracts of the 25 publications, 16 were considered for full-text review. The study selection process is detailed in **Figure 1**.

Study Characteristics

The 9 studies included in this review were published between 2010 and 2025, with a strong representation of research from countries in sub-Saharan Africa, Latin America, and Asia. These studies focused on several NTDs, notably visceral leishmaniasis (VL), schistosomiasis, onchocerciasis, and LF. VL emerged as the most frequently examined NTD, with four studies focusing on its diagnosis utilizing a range of innovative tools, including rK39 and rK28 RDTs, WGS, and polymerase chain reaction methods. The majority of publications appeared in PLoS Neglected Tropical Diseases (5), with a notable prevalence of comparative studies. Research frequently focused on RDTs, molecular diagnostics, and WGS. The implementation of these techniques has the potential to enhance the accuracy, accessibility, and efficiency of NTD diagnostics in resource-limited environments, suggesting a significant movement towards innovative and contextually suitable diagnostic technologies. **Table 2** shows the study characteristics.

Narrative Synthesis

This section presents a thematic synthesis of innovative diagnostic tools for NTDs, derived from nine studies included in this scoping review. The literature highlights key themes such as enhanced diagnostic accuracy, increased accessibility, practical field application, and improved cost-effectiveness. Advanced diagnostic technologies have the potential to enhance the identification, monitoring, and management of NTDs, particularly in settings with limited resources.

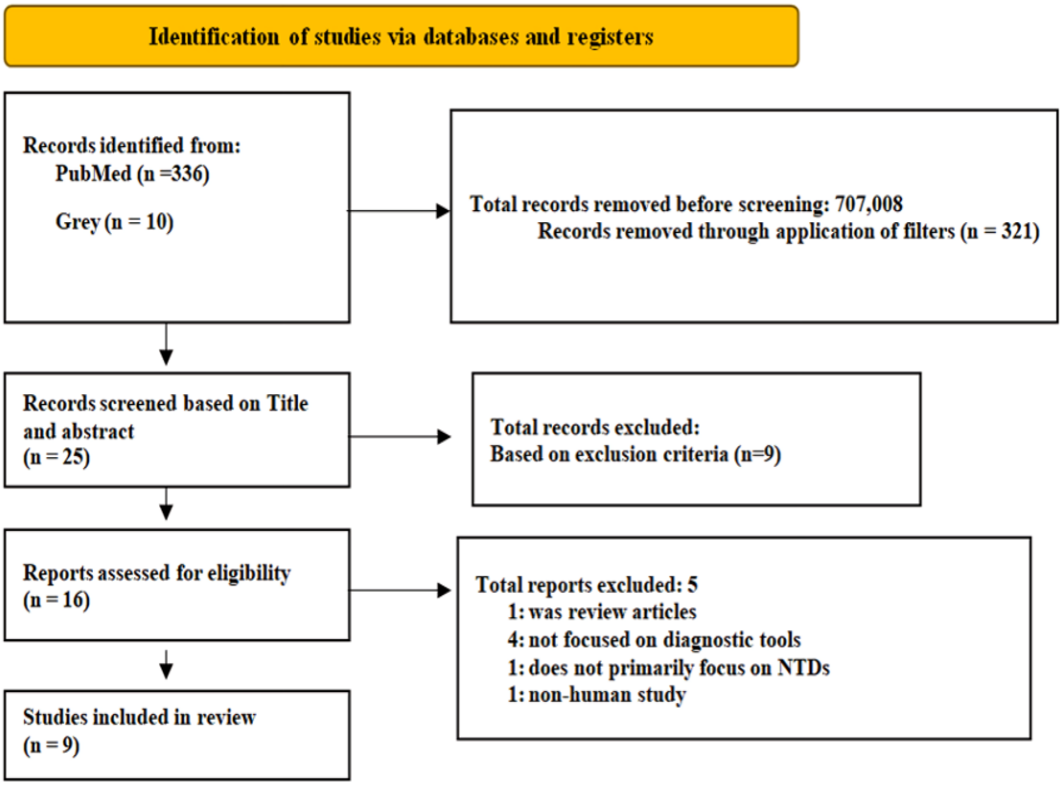

Figure 1. Preferred reporting items for systematic reviews and meta-analyses flow diagram [13]

Table 2. Study characteristics

SID	Country/region	NTD	IDT	SD	Key findings on benefits	Source journal
[14]	Sudan & Ethiopia	VL	rK39 and rK28 RDTs	Field study	rK28 RDT showed higher sensitivity and specificity than rK39, especially useful in VL endemic areas.	American Journal of Tropical Medicine and Hygiene
[15]	Côte d'Ivoire	Onchocerciasis	qPCR for onchocerciasis volvulus DNA detection	Case-control study	qPCR detected higher onchocerciasis prevalence (56.9%) than traditional methods, showing potential for elimination programs.	Acta Tropica
[16]	Latin America	Tegumentary leishmaniasis	WGS	Comparative study	WGS outperformed standard RFLP and Sanger sequencing in species identification and detecting hybrid infections.	American Journal of Tropical Medicine and Hygiene
[17]	India	VL	rK39 RDT (whole blood vs. serum)	Cross-sectional study	rK39 whole blood RDT had excellent concordance (kappa = 0.88) with serum, offering a practical alternative for field diagnosis.	PLoS Neglected Tropical Diseases
[18]	Sudan & Bangladesh	VL	rK28-based RDT	Field study	rK28 RDT showed superior sensitivity (96.8%) and specificity (96.2%) compared to rK39, highlighting its potential for field use.	PLoS Neglected Tropical Diseases
[19]	Samoa	LF	QFAT and FTS	Comparative study	QFAT demonstrated similar performance to FTS but with advantages in usability, requiring less blood and providing faster results.	PLoS Neglected Tropical Diseases
[20]	Tanzania	Schistosomiasis	POC-CCA test	Cluster RCT	POC-CCA test improved drug uptake and compliance in mass drug administration campaigns, contributing to higher treatment coverage.	BMC Public Health
[21]	Bangladesh	VL	rK39-based immunochromatographic RDTs	Comparative study	RDTs on whole blood showed similar accuracy to serum tests, offering better field applicability.	Parasites & Vectors
[22]	Kenya	Soil-transmitted helminths	AI-based deep learning for Kato-Katz thick smears	Comparative study	Expert-verified AI provided superior sensitivity for detecting light infections, improving diagnostic accuracy.	Scientific Reports

Note. SID: Study ID; IDT: Innovative diagnostic tool; & SD: Study design

Enhanced diagnostic accuracy

This review's studies indicate that innovative diagnostic technologies enhance diagnostic accuracy. In regions where the disease burden is high, microscopy and serological testing generally do not succeed in diagnosing NTDs [17, 21]. The studies indicated that RDTs, molecular diagnostics, and WGS have significantly enhanced the sensitivity and specificity of diagnostic tools for VL, schistosomiasis, and LF.

Multiple studies indicate that rK39-based RDTs for VL demonstrate high sensitivity and specificity, similar to conventional serum tests [14, 17, 21]. However, they offer advantages in terms of user-friendliness and speed, which is particularly beneficial in remote locations. In comparison to rK39, rK28-based RDTs demonstrated greater sensitivity in detecting VL, particularly among patients exhibiting low antibody levels [18]. These advancements facilitate the identification of asymptomatic or low-titer conditions that could remain undetected otherwise.

Molecular diagnostics such as PCR and WGS enhance the precision of species identification. It was shown that WGS was more effective than restriction fragment length polymorphism and Sanger sequencing in detecting mixed infections of Leishmania viannia species [16]. The advancements enhance species identification, a critical factor for precise therapy and disease management [16].

Improved accessibility and field applicability

Advanced diagnostic technologies enhance both field accessibility and applicability. In low-resource countries where NTDs are most prevalent, conventional diagnostic methods require laboratory infrastructure, specialised personnel, and extended turnaround times [20]. POC diagnostic tests, molecular assays, and RDTs effectively identify NTDs in remote regions with limited resources, thereby enhancing accessibility and informing treatment decisions.

The MDA campaigns in Tanzania incorporated the POC-CCA schistosomiasis test as outlined in [20]. The implementation of this field-based diagnostic tool by community health workers resulted in a notable increase in the uptake of praziquantel treatment among rural adults. The POC-CCA test enhanced treatment coverage, particularly in regions with insufficient healthcare infrastructure, owing to its straightforwardness and rapidity [20].

In Samoa, the QFAT and FTS LF assays demonstrated effective detection of LF antigen in whole blood [19], indicating potential for decentralised, field-based diagnosis. The design's user-friendliness and rapid outcomes facilitated quicker detection and treatment, which is crucial for reducing LF transmission [19]. The ability to conduct tests with minimal equipment and training illustrates the ways in which these diagnostic technologies enhance healthcare accessibility, particularly in underserved regions.

Lab-based WGS for Leishmania viannia species demonstrated potential for precise and rapid species identification when compared to conventional methods [16]. WGS necessitates a more sophisticated infrastructure; however, its capacity to transform diagnosis and species identification illustrates the movement towards employing molecular technologies to tackle NTD challenges.

Cost-effectiveness and potential for widespread use

The cost-effectiveness of innovative diagnostic techniques emerged as a significant aspect in the research analyzed. Conventional diagnostic methods such as microscopy and culture-based techniques necessitate advanced laboratory facilities and skilled personnel, rendering them both time-consuming and costly. Nonetheless, various studies included in this review indicate that RDTs, POC tests, and molecular diagnostics present a cost-effective and sustainable solution for the detection of large-scale NTDs.

In regions where endemic diseases prevail and diagnostic infrastructure is limited, the use of rK39 and rK28 RDTs for VL demonstrates both cost-effectiveness and efficiency [14, 21]. The appeal of these RDTs lies in their suitability for remote areas, where other diagnostic instruments may be impractical due to factors such as low cost, mobility, and ease of use [18].

A further economical diagnostic method is the POC-CCA schistosomiasis test implemented in community-based MDA programs in Tanzania [20]. This test improved treatment adherence and lowered schistosomiasis control costs by facilitating early diagnosis, thereby decreasing morbidity and the need for more costly treatments [20].

Automating slide analysis through AI-based methods, such as deep learning applied to Kato-Katz thick smears [22], has the potential to lower diagnostic costs in endemic regions. These AI solutions enhance diagnostic efficiency and accuracy, while also potentially lowering manual microscope labour costs, indicating their potential for widespread application in resource-constrained environments.

Contribution to surveillance and disease control

The effectiveness of disease monitoring and control is significantly influenced by the implementation of innovative diagnostic techniques. Early discovery of NTDs is essential for effective control and prevention of transmission. Several studies indicate that molecular diagnostics and RDTs enhance disease surveillance, particularly in situations where conventional diagnostic methods are inadequate.

It was observed that qPCR is capable of identifying onchocerciasis in areas with low prevalence, where traditional methods might overlook infections [15]. This diagnostic approach, characterised by high sensitivity, has the potential to enhance the monitoring of illness prevalence and progression [15]. WGS for Leishmania species identification has the potential to enhance molecular epidemiology through a detailed analysis of species distribution and transmission dynamics [16].

In Tanzania, the implementation of POC-CCA testing during mass schistosomiasis treatment campaigns facilitated more targeted treatments, thereby ensuring that those affected received the necessary care [20]. This approach improves treatment results and disease monitoring by enabling health professionals to observe and record cases in real time, thereby refining disease management strategies.

DISCUSSION

This scoping review assessed 9 selected studies focusing on innovative diagnostic methods for NTDs. The data suggests that emerging diagnostic methods are increasingly sensitive, accessible, and cost-effective, which plays a vital role in the

identification and management of diseases in endemic regions. The reviewed studies confirm that RDTs, POC assays, and molecular diagnostics play a significant role in the control of NTDs.

Additional studies indicate that rK39 and rK28 RDTs for VL demonstrate significant effectiveness in field environments [17, 20]. The research indicated an improvement in diagnostic accuracy. The studies under review consistently employed the rK39 test, recognized for its elevated specificity and sensitivity, to diagnose VL in settings with limited resources. The studies in [14, 18] observed that rK28 RDTs, while less prevalent, demonstrated superior performance compared to rK39 in certain instances, especially among patients exhibiting low antibody levels. This indicates that rK28-based tests may enhance diagnostic precision.

The studies in [16, 19] highlight the significance of molecular diagnostics and WGS in species identification, thereby enhancing their applicability. The limited application of these tools in the field can be attributed to their infrastructure requirements. However, they offer significant precision in analyzing transmission patterns, species diversity, and drug resistance, particularly concerning onchocerciasis and leishmaniasis [16].

This study aligns with the increasing focus on innovative diagnostics for NTDs, as observed in previous research on related topics. Recent evaluations indicate that RDTs and POC technologies significantly enhance diagnostic access in low-resource settings [3, 23]. The findings of our investigation align with those of the study in [24], indicating that POC-CCA tests for schistosomiasis present a viable strategy for decentralized disease management, thereby improving treatment coverage and monitoring capabilities.

The persistent challenges in diagnosing NTDs, particularly in resource-constrained environments and regions experiencing sociopolitical instability, underscore the significance of our study. Advanced diagnostic technologies play a crucial role in the identification and management of diseases under challenging circumstances. The integration of these technologies into health systems has the potential to enhance surveillance and disease monitoring, thereby aiding in the elimination and control of various NTDs.

This review presents findings that indicate novel diagnostic tools enhance the treatment and control of NTDs through various mechanisms. The advancements enhance diagnostics, healthcare accessibility, and the monitoring and management of diseases, thereby playing a significant role in the global health agenda aimed at eliminating NTDs.

The findings of this review highlight the need for policymakers and healthcare practitioners to prioritize the integration of innovative diagnostic tools, such as RDTs and POC tests, into national health systems to improve the diagnosis and management of NTDs. By doing so, they can enhance disease surveillance, treatment outcomes, and ultimately, contribute to the elimination of NTDs. However, additional research is necessary to enhance the accessibility, affordability, and scalability of these diagnostic tools, particularly in regions facing resource limitations and conflict.

CONCLUSION

This scoping review indicates that innovative diagnostic methods for NTDs enhance precision, availability, and economic efficiency. In settings with limited resources, the implementation of RDTs, molecular diagnostics, and POC technology has enhanced disease diagnosis and management, which is crucial for the control of NTDs.

Integrating these techniques into national health systems, particularly in endemic regions, is essential for enhancing disease surveillance and treatment outcomes. Further development of these concepts, a thorough examination of infrastructural challenges, and an analysis of their impact on disease elimination objectives should be prioritised moving forward. The enhancement of accessibility and affordability is likely to facilitate broad adoption and contribute to overall success.

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