

A systematic review of the prevalence and diagnostic methods of African trypanosomiasis in Nigeria: Implications for public health and agriculture

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ABSTRACT

African trypanosomiasis (AT) has continued to be a major public health and veterinary concern in Nigeria due to its effects on both human and animal populations. As a result, this study aimed to systematically review and determine the prevalence of AT in Nigeria, analyse the diagnostic techniques used, and investigate the relationship between the human and animal forms of the disease. The goal of the study is to present a thorough analysis of the current situation of AT in Nigeria, exposing the consequences for both agricultural productivity and public health. To do this, the study followed the PRISMA guidelines to carry out a thorough search of MEDLINE, CINAHL, and EMBASE databases. The review included studies published in English that reported prevalence data on AT in Nigeria. A total of 18,091 samples from 16 studies with sample sizes ranging from 19 to 7,143 were included. The Joanna Briggs Institute's critical appraisal checklist for cross-sectional studies was used to evaluate each study's methodological quality. The findings revealed a prevalence of 27.3% for African animal trypanosomiasis and 3.6% for human African trypanosomiasis in Nigeria. Based on the diagnostic techniques employed, the review found significant differences in prevalence rates, with polymerase chain reaction showing higher sensitivity than microscopy. *Trypanosoma vivax*, *T. congolense*, *T. brucei*, *T. simiae*, *T. evansi*, *T. theileri*, and *T. brucei gambiense* were found to be the most frequent species, and the study concluded that in order to address the problems caused by AT in Nigeria, there is an urgent need for better diagnostic procedures and all-encompassing disease management plans.

Keywords: African trypanosomiasis, prevalence, diagnostic methods, polymerase chain reaction, public health, veterinary medicine, Nigeria, trypanosoma species

INTRODUCTION

Over a billion people worldwide are impacted by neglected tropical diseases (NTDs). Just like malaria, which receives significant attention compared to other NTDs, numerous pathogens, including bacteria, viruses, protozoa, and parasitic worms (helminths), are responsible for this illness [1-3]. According to [4], NTDs mostly affect people in low-income countries that don't have good access to healthcare, water, and hygiene. As a result, chronic diseases put a lot of stress on developing countries and are very bad for quality of life, global public health efforts, and economic growth [4].

African trypanosomiasis (AT) is a tropical disease that can afflict both humans and animals. It is most found in sub-Saharan Africa, and it is not given enough attention. The disease is a vector-borne disease that is spread by tsetse flies [5, 6]. However, Nigeria is one of 36 sub-Saharan African nations where human African trypanosomiasis (HAT) is endemic. According to [7], approximately 60 million people are susceptible to HAT. Nonetheless, fewer than 1,000 cases of HAT were reported between 2019 and 2020. This decline resulted from the deliberate inclusion of HAT in the NTD roadmap. The objectives in this roadmap included eliminating HAT as a public health concern by 2020 and halting the spread of *Trypanosoma brucei gambiense* (Tbg) to humans by 2030 [8].

Benin, Côte d'Ivoire, Equatorial Guinea, Togo, and Uganda are the five other endemic West African nations where the goal to eradicate *gambiense* HAT (gHAT) has been confirmed. However, latent infections in humans, possible animal reservoirs, and inaccurate diagnosis are expected to pose obstacles to the goal of total elimination throughout sub-Saharan Africa, including Nigeria [9, 10]. There have been reports of primates and domestic animals such as dogs, sheep, and pigs being potential reservoir hosts for the human-infective parasite Tbg in sub-Saharan African countries [11]. One of the most important requirements for the eradication of a disease is the absence of animal reservoirs [12]. It is unknown, nevertheless, how these non-human hosts contribute to the disease's ongoing spread from one person to another. However, the fact that the human infectious parasite is present in animals shows that the transmission cycle is altered and raises the prospect of human-animal cross-infection. Therefore, if the knowledge gaps regarding the reservoir of Tbg are not addressed, the goal of eradicating gHAT cannot be fully accomplished. This is necessary to develop effective interventions for the management and eventual eradication of the disease [9, 13].

Therefore, in order to address the relationships between disease transmission patterns, parasite variety, diagnostic methods, and the potential for human-animal cross-infection, this study looked at the prevalence of AT in Nigeria in both people and animals. Exploring the complex dynamics of this disease, which has a substantial impact on livestock output, agricultural sustainability, and human health, and is made possible by Nigeria's unique terrain, ecosystem, and animal population.

African Trypanosomiasis

Both humans and animals can contract AT. It is spread by the bite of a *Glossina* tsetse fly with an infection that spreads quickly [14]. The disease is caused by trypanosomes, which are protozoan parasites belonging to the family Trypanosomatidae and the genus *Trypanosoma* (T.) [15]. HAT is also known as sleeping sickness and is caused by *Trypanosoma brucei*, or *T. brucei*. The two subspecies that cause infection are Tbg and *Trypanosoma brucei rhodesiense* [16]. During a HAT infection, trypanosomes infiltrate the central nervous system and lymphatic system to attack their hosts. Fatigue, fever, headaches, and, if left untreated, death may result from this, and people with HAT may show signs like anemia and hemodilution, which can sometimes cause the disease to be mistakenly thought to be malaria [17, 18].

However, *Trypanosoma congolense*, *Trypanosoma vivax*, and *Trypanosoma brucei* are the main species behind African animal trypanosomiasis (AAT), also known as Nagana. According to [19], these three species are the cause of moderate and fatal diseases in wild and domestic animals, respectively. However, *T. equiperdum*, *T. evansi*, *T. simiae*, *T. suis*, and *T. theileri* are among the other species that infect animals [20]. Cattle, horses, camels, dogs, goats, sheep, pigs, and wild animals have all been found to be infected by these. Due to its high mortality rates, anemia, weight loss, and decreased milk production, this disease has a major impact on the health of livestock and agricultural productivity [19, 21].

The occurrence of HAT is restricted to the distribution of its vector, the tsetse fly, which is exclusively found in sub-Saharan Africa between 14 °N and 20 °S [22]. Changes in the climate and land use patterns have led to a rise in tsetse fly populations and

the subsequent spread of the disease [23]. HAT and AAT pose a threat to public health due to the coexistence of reservoir hosts, the disease vector, and protozoan parasites [24]. They have a significant negative impact on the economy and health, raising poverty and lowering agricultural productivity [25]. Nigeria is home to millions of people who contribute to and have human-animal interactions that add to the complexity of the dynamics of trypanosomiasis transmission. Farmers and livestock farmers make up the majority of the population in many regions of the nation. Therefore, contact with infected tsetse poses a risk to both humans and animals. Disease prevalence and transmission patterns are influenced to varying degrees by differences in climate, vegetation, and cultural practices, as well as by the coexistence of humans and animals [26].

Pharmacological toxicity, the development of resistant parasites, and a lack of available medications have all had a negative impact on the treatment of AT. Three medications that have been used for more than 50 years to treat Nagana are diminazene aceturate, homidium bromide, and the related medication isometamidium chloride (berenil) [27]. The widespread and uncontrolled use of these medications for both therapeutic and preventative purposes has inevitably led to drug resistance [28].

Pentamidine, suramin, eflornithine, melarsoprol, and nifurtimox are the five medications used to treat HAT, according to [5]. The best medication depends on the specific stage of the disease and the organism causing it [29]. Finding cases using precise diagnostic methods and starting treatment as soon as possible are essential for the effective management of HAT [30]. Nonetheless, a major obstacle is the lack of vaccination against the human pathogenic subtype of HAT [31]. Yet, the drugs used to treat the condition can be somewhat harmful, pointing out the important role of a thorough diagnosis prior to starting treatment. These initiatives are limited in economically developing nations like Nigeria by a lack of access to suitable laboratory facilities, tools, and qualified staff [32].

In addition to the lack of access to adequate laboratory facilities, equipment, and trained personnel, little is known about its prevalence, distribution, and the factors influencing its transmission within Nigeria. AT management and prevention require knowledge of this information. Several researchers have independently assessed the prevalence of HAT and AAT in various Nigerian states [26, 33, 34]. However, neither the overall prevalence of both AAT and HAT nor the relationship between the disease's human and animal indications has been studied at the national level. To develop effective management plans and treatments, a comprehensive and up-to-date assessment of trypanosomiasis incidence in both human and animal populations is required. Therefore, in order to review previous research and give a thorough overview of the AT situation in humans and animals in Nigeria, this study uses a methodical process that closely resembles the PRISMA framework. The aims are to research the prevalence of *Trypanosoma* species affecting humans and animals in Nigeria, identify the different diagnostic procedures that are being used to detect these species, and evaluate the interaction between human and animal trypanosomiasis on the national level. In light of these goals, the study will investigate whether trypanosomiasis can spread from person to animal in Nigeria. What is the prevalence and proportion of AT in Nigerian humans and animals? The study is important because it could

help guide public health initiatives and policies that try to reduce the disease's effects on both human and animal populations.

METHODS

This systematic review was conducted according to PRISMA guidelines in order to ascertain the prevalence of AT in Nigeria in both humans and animals [35]. Based on the goals of the study, predetermined eligibility criteria were created to guarantee thorough and open reporting. These criteria were organized according to the PICO framework, which stands for *population* (humans and animals affected by AT), *interest* (infection with AT), and *context* (Nigeria, including both rural and urban areas).

The study concentrated on primary research using cohort, cross-sectional, and prevalence designs. According to the inclusion criteria, studies had to be in Nigeria, be written in English, and provide information on the prevalence of AT, including specifics like sample size, *Trypanosoma* species, diagnostic techniques, and the prevalence of the disease overall in the study population. Studies carried out outside of Nigeria, non-English publications, secondary research, and sources devoid of comprehensive sample data or diagnostic techniques were among the exclusion criteria. The three main databases used for data collection were MEDLINE, CINAHL, and EMBASE. Boolean operators and keywords were used in a thorough search strategy that included both general and specific terms associated with AT, including "sleeping sickness," "nagana," "Trypanosoma," and "trypanosomiasis." This approach was modified for every database, using particular filters to guarantee study type and geographic relevance.

After the search, duplicates were eliminated, and all citations were imported into EndNote version 20 (Clarivate Analytics, PA, USA). After identifying pertinent studies through a review of titles and abstracts, a full-text evaluation was carried out according to inclusion and exclusion criteria. The study selection procedure was presented using a PRISMA flow diagram, and the reasons for rejecting full-text articles were recorded [35]. A manual search was also carried out to find any studies that were overlooked during database screening in order to maximize comprehensiveness.

Based on methodological quality indicators like sample selection, measurement validity, statistical methods, and outcome reporting, each included study was critically evaluated using the Joanna Briggs Institute checklist for cross-sectional studies [36]. Based on scores given to answers for each checklist criterion, studies were grouped into three categories: low, moderate, and high risk of bias. Studies with scores of 6 to 8 that met the majority of the criteria were categorized as low risk, while those with scores of less than 4 were categorized as high risk.

Key information, such as author, year of publication, study type, sample characteristics, *Trypanosoma* species identified, diagnostic techniques, prevalence rates, and number of cases, was gathered using a structured data extraction form. To guarantee consistency, this data was methodically entered into an Excel spreadsheet.

A statistical meta-analysis was not possible because of the heterogeneity among the studies. Rather, it was used as a

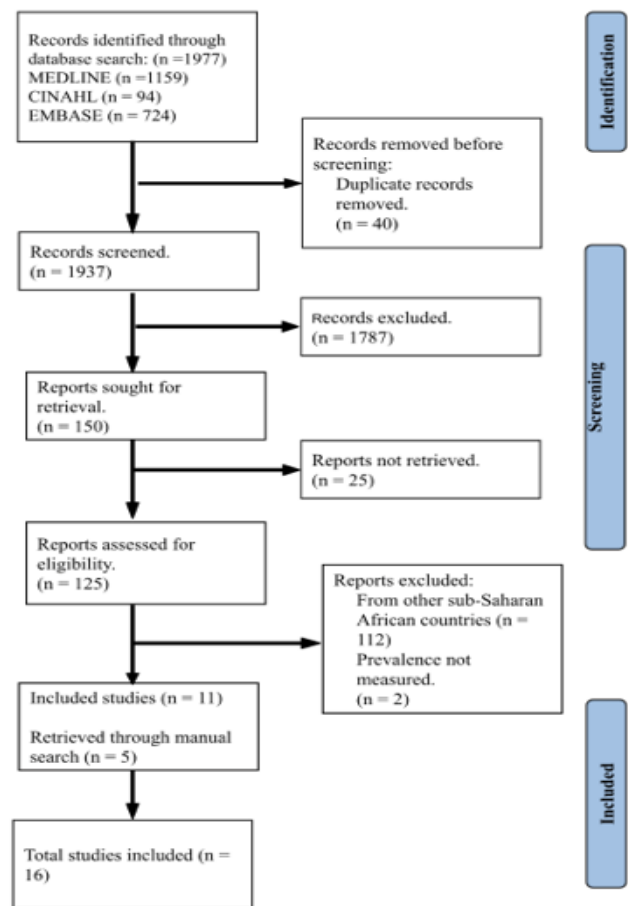


Figure 1. Flow chart of the study selection process (Source: Authors' own elaboration)

narrative synthesis approach [37]. This method allowed for a detailed examination of the data, synthesizing findings through descriptive analysis and providing insights into the prevalence trends across studies without numerical pooling.

RESULTS

1,977 articles were found after a thorough search of three databases; the majority came from MEDLINE (59%, $n = 1,159$), EMBASE (36%, $n = 724$), and CINAHL (5%, $n = 94$). There were 1,937 articles left for title and abstract screening after 40 duplicate records were found and eliminated. 1,787 articles were rejected based on pre-established eligibility criteria, mostly because they were not relevant to AT in sub-Saharan Africa, were published in non-English, or were not published in scholarly journals.

Using the inclusion and exclusion criteria, the full texts of the remaining 150 articles were evaluated. After a thorough evaluation of the remaining articles, 11 studies satisfied the inclusion requirements, while 25 articles were eliminated because their full texts were not available. 16 studies were found to be eligible for the systematic review after an extra 5 articles were found by manually going through the reference lists of the studies included. **Figure 1** shows a flowchart that illustrates this study selection procedure.

Characteristics of Included Studies

The 16 included studies examined the prevalence of AT in human and animal populations in various parts of Nigeria, including northern, eastern, and southern region. All of the

Table 1. Summary of included studies

R	Location	Study population	SS	Prevalence rate	Species identified	Diagnostic method	Outcome
[38]	Kwara	Cattle	398	0.8% (microscopy), 3.0% (PCR)	<i>T. theileri</i> , <i>T. evansi</i> , <i>T. simiae</i> , <i>T. congolense</i>	Microscopy, PCR	Bovine trypanosomiasis
[39]	Niger	Multiple species	460	2.17%	<i>T. brucei</i> , <i>T. congolense</i> , <i>T. vivax</i>	Microscopy	AT
[40]	Nsukka	Dogs	19	10.5% (Tbg)	<i>T. b. gambiense</i>	PCR	Canine African trypanosomiasis
[41]	Kaduna	Sheep	110	40.9%	<i>T. brucei</i> , <i>T. vivax</i> , <i>T. congolense</i>	Microscopy	AAT
[42]	Gboko	Humans	1,200	1.8% (CATT), 0.6% (PCR)	<i>T. b. gambiense</i>	CATT, PCR	Human trypanosomiasis
[43]	Gboko	Cattles & pigs	1,200 (600 cattle, 600 pigs)	8.9% (CATT), 0.9% (PCR)	<i>T. brucei</i> (Tbg), <i>T. congolense</i> forest, <i>T. congolense</i> savannah, <i>T. vivax</i>	CATT, PCR	AAT
[44]	Kaduna	Humans	300	0.0%	Tbg	CATT	HAT
[45]	Jos	Cattle	7143	46.8%	<i>T. congolense</i> , <i>T. vivax</i> , <i>T. b. brucei</i>	PCR	Bovine trypanosomiasis
[46]	Ogun, Kaduna	Cattle	411	15.1% (microscopy), 63.7% (PCR)	<i>T. brucei</i> , <i>T. vivax</i> , <i>T. congolense</i>	Microscopy, PCR	Bovine trypanosomiasis
[47]	Delta	Humans	474	9.3%	Tbg	Microscopy, CATT	Human trypanosomiasis
[48]	Kaduna	Cattle	1,293	8.4%	<i>T. vivax</i> , <i>T. congolense</i> , <i>T. brucei</i>	Microscopy	Bovine trypanosomiasis
[49]	Enugu	Pigs	85	22.4%	<i>T. brucei</i> gambiense, <i>T. congolense</i>	Microscopy	Porcine trypanosomiasis
[50]	Kano	Ruminants	1,424	5.3% (cattle), 0.9% (small ruminants)	<i>T. vivax</i> , <i>T. congolense</i> , <i>T. brucei</i>	Microscopy	AT
[51]	Bauchi	Sheep, goat	615	6.0%	<i>T. vivax</i> , <i>T. congolense</i> , <i>T. brucei</i>	Microscopy	AT
[52]	Anambra and Benue states	Pigs	1,954	26.8%	<i>T. congolense</i> , <i>T. brucei</i>	Microscopy	Porcine trypanosomiasis
[53]	Adamawa (Gongola)	Cattle	1,065	3.9%	<i>T. vivax</i> , <i>T. congolense</i> , <i>T. brucei</i>	Microscopy	Bovine trypanosomiasis

Note. R: Reference & SS: Sample size

studies used cross-sectional designs, and there were 18,091 samples overall, with sample sizes ranging from 19 to 7,143 subjects. A summary of the included studies is given in **Table 1**.

Human African Trypanosomiasis Prevalence

A total of 1,974 people were included in the three studies that looked into HAT. Tbg was found to be the causative organism in two of these studies, which reported a total of 72 cases, resulting in an overall HAT prevalence of 3.6% (72/1,974). The card agglutination test for trypanosomiasis (CATT) was the main diagnostic technique, though polymerase chain reaction (PCR) and microscopy were also used.

African Animal Trypanosomiasis Prevalence

With a total sample size of 16,117 animals, 13 studies documented AAT in a variety of animal hosts, including cattle, pigs, sheep, goats, dogs, and monkeys. The prevalence of AAT was 27.3% (4,404/16,117), and the trypanosome species that were found included *T. vivax*, *T. congolense*, *T. brucei*, *T. simiae*, *T. evansi*, and *T. theileri*. Tbg, which is harmful to humans, was also found in animals in two investigations. The most common diagnostic method was microscopy (10 studies), which was followed by CATT (1 study) and PCR (2 studies), with two studies combining the two methods.

Methodological Quality Assessment

The Joanna Briggs Institute's critical appraisal checklist for cross-sectional studies was used to independently assess each study's methodological quality. Six studies received medium

Table 2. Methodological quality assessment summary of included studies

Bias rating	Number of studies	Interpretation
Low risk (6-7)	10	Strong methodological rigor
Medium risk (4-5)	6	Moderate reliability

risk of bias ratings (scores of 4-5), while ten studies received low risk of bias ratings (scores of 6-7), indicating a general methodological rigor but also pointing out areas that require careful interpretation (**Table 2**).

Excluded Studies

At the full-text screening stage, 114 studies were eliminated, mostly because the full texts were not available, there were no measured prevalence data, or the study locations were outside of Nigeria.

DISCUSSION

This study investigated the prevalence and diagnostic procedures of AT in Nigeria. Significant trends in the frequency, species distribution, and diagnostic variations of AT in humans and animals were found. According to the results, the frequency of HAT was 3.6% (72 out of 1,974) in Nigeria, while the prevalence of AAT was 27.3% (4,404 out of 16,117). This high incidence, the variety of *Trypanosoma* species, and diagnostic methods expose problems with disease control and public health protection. The most common diagnostic methods in

Nigeria for identifying these trypanosomes are microscopic examination, CATT, and PCR. The majority of the pathogens responsible for trypanosomiasis infections in humans and animals have been identified as *T. vivax*, *T. congolense*, *T. brucei*, *T. simiae*, *T. evansi*, *T. theileri*, and Tbg.

Human African Trypanosomiasis

The goal of the NTDs road map is to eradicate HAT as a public health issue by 2020 and stop Tbg from spreading to people by 2030 [54]. Nigeria continues to report cases at levels above the World Health Organization threshold for elimination, despite the World Health Organization's efforts and those of groups like the Pan African tsetse and trypanosomiasis eradication campaign. The prevalence of HAT in Nigeria (3.6%) is still significantly higher than in neighboring nations that have eradicated the disease, like Uganda (0.88%) and Côte d'Ivoire (0.06%) [55, 56]. Only eight new HAT cases were reported in Nigeria by the World Health Organization between 2010 and 2016. However, over the same time period, three of the studies that are part of this analysis found 72 confirmed cases of HAT out of 1,974 people who were evaluated. Although this discrepancy is extremely concerning, it also raises the possibility that the true prevalence of HAT in Nigeria may be underreported. Under-reporting, a lack of an integrated HAT surveillance and control system in the country's healthcare system, a lack of qualified medical personnel, misdiagnosis, and inadequate funding and coordination for elimination efforts are some more factors that may have contributed to the disparity [8]. To determine the actual prevalence of HAT and create successful intervention plans, these gaps must be filled.

African Animal Trypanosomiasis

According to the study, the highest prevalence of AAT is found in ruminants, primarily cattle, which is probably related to how common these animals are in Nigeria's agricultural area. This study's 27.3% AAT frequency is greater than the earlier report of 16.1% [57]. There is a chance of zoonotic transmission to humans due to the persistence of *Trypanosoma* species in animals. The study found that several *Trypanosoma* species, including *T. vivax*, *T. congolense*, *T. brucei*, *T. simiae*, *T. evansi*, and *T. theileri*, infect animals in Nigeria. According to [40, 42, 43], the human-infecting Tbg was also discovered in animals like pigs, dogs, and cattle. The goal of eradicating HAT transmission to humans by 2030 may be jeopardized by the existence of these animal hosts, even though their exact function in animal-human transmission is not entirely clear [58].

Diagnostic Methods and Prevalence Discrepancies

The diagnostic techniques used have a significant impact on AT prevalence estimates, and each approach has varying levels of sensitivity and specificity. The most popular technique for determining whether an animal or human has trypanosomiasis is microscopic examination. This is due to the fact that it is inexpensive. However, its low sensitivity can lead to an underestimation of prevalence rates, particularly in cases with low parasitemia. However, because of its high sensitivity and ability to process multiple samples, PCR has been recognized as the best diagnostic method for epidemiological studies involving *Trypanosoma* sp. [59]. According to [46], PCR had higher prevalence rates in cattle than microscopy testing (63.7% vs. 15.1%), suggesting that PCR has a higher sensitivity for identifying *Trypanosoma* spp. in low-parasitemia conditions. The ability of diagnostic techniques to detect

trypanosomes at the subspecies level has also been linked to variations in prevalence rates. The microscopy approach has drawn criticism for its incapacity to differentiate between different species and subspecies, in contrast to the PCR method, which can directly classify trypanosomes according to their species classification [58]. According to this review, the PCR method was effective in identifying the human-infectious parasite *T. b. gambiense* in animals [40, 42]. These differences show that in order to obtain reliable prevalence estimates, appropriate diagnostic techniques must be used. However, the cost and expertise needed for better diagnostic methods continue to be prohibitive for Nigeria, which lacks sufficient resources for disease control.

Implications and Recommendations

The agricultural economy, public health, and food security are all significantly impacted by the prevalence of AT. The productivity losses of infected livestock affect the supply of meat and milk, which are essential for nutritional health and dietary diversity. To lessen the effect of AT on food systems, a multidisciplinary approach combining the veterinary, public health, and agricultural sectors is required. Additionally, Tbg's presence in animal reservoirs raises the possibility of zoonotic hazards that could worsen HAT's spread. Therefore, it is important to improve disease surveillance and diagnostics, paying special attention to zoonotic transmission pathways.

CONCLUSION

A delicate relationship between diagnostic techniques, prevalence rates, and the consequences for public health and agricultural productivity is revealed by the investigation of AT in Nigeria. The prevalence of trypanosomiasis in humans and animals has been thoroughly evaluated in this systematic review, with significant findings that underline the pressing need for improved diagnostic tools and all-encompassing disease control measures. According to the review, the prevalence of HAT is 3.6%, while that of AAT is a concerning 27.3%. These figures not only demonstrate how common the illness is, but they also point to an urgent public health issue that requires quick attention. A detailed analysis of the diagnostic techniques used to identify *Trypanosoma* species reveals significant variations in prevalence estimates, which are mostly caused by the methods' sensitivity and specificity. Despite being economical, microscopic analysis has been demonstrated to greatly underestimate prevalence rates, particularly in situations with low parasitemia. PCR, on the other hand, has emerged as a superior diagnostic technique that can identify higher prevalence rates and differentiate between species at the subspecies level. This finding emphasizes the importance of using cutting-edge diagnostic techniques to guarantee precise prevalence estimates, which are now necessary for efficient disease management and control. These findings have far-reaching implications that go beyond simple statistics; they have a profound impact on the agricultural economy, public health, and food security. The productivity losses in infected animals not only jeopardize farm livelihoods but also jeopardize the nutritional health of individuals and communities that depend on meat and milk supplies. As this study highlights the importance of developing better diagnostic techniques and comprehensive disease treatment strategies, it also calls for additional research to investigate the dynamics of human-animal cross-infection.

Developing targeted treatments that effectively lower trypanosomiasis transmission requires an understanding of these interactions. Future research should also concentrate on how socioeconomic factors affect the prevalence of illness and how easily accessible better diagnostic methods are in environments with limited resources. Solving the issues faced by AT requires a joint effort by researchers, policymakers, and healthcare practitioners. We may clear the way for more efficient control measures that protect public health and increase agricultural productivity in Nigeria and elsewhere by focusing on improving diagnostic capabilities and encouraging interdisciplinary collaboration.

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Ethical statement: The authors stated that this is a systematic literature review and did not involve human or animal subjects. Therefore, ethics committee approval was not applicable and was waived. However, the study followed strict data protection practices, including adherence to PRISMA guidelines for transparent reporting and ensuring that all data sources were publicly available and cited appropriately to maintain confidentiality and integrity.

AI statement: The authors stated that generative AI tools were used solely for language correction and proofreading. All content was generated by the authors and reviewed for accuracy. No AI tools were used for generating ideas, data analysis, or writing original content.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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