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Research Article

Bovine Zoonoses in Sub-Saharan Africa: A Review of Epidemiology, Impact and Control-Prevention Strategies

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Abstract | This review provides a comprehensive analysis of the epidemiology, economic impact, and control measures associated with major bovine zoonoses in sub-Saharan Africa, including brucellosis, tuberculosis, anthrax, salmonellosis, Rift Valley fever, cysticercosis, toxoplasmosis, fasciolosis and bovine trypanosomiasis. Articles were identified through searching databases such as PubMed, Web of Science, Scopus, Embase, and Google scholar using key search terms to find studies published from 2000 to 2024 (few additional articles were identified from grey literature especially WHO reports). Articles that did not focus on the study's subject matter or whose findings were not from sub-Saharan Africa were excluded. The reported prevalence of brucellosis (2.3% to 30%), tuberculosis (6.8% to 94%), anthrax (31% to 88%), salmonellosis (4.8% to 15%), Rift Valley fever (5% to 70%), cysticercosis (11% to 23%), toxoplasmosis (3.85% to 17%), fasciolosis (13% to 31.49%) and bovine trypanosomiasis (1.38% to 41.92%) has largely varied depending on several factors, including the country and study area, herd size, individual or herd-level prevalence, diagnostic tests used, and abattoirs or farms data, among others. The main risk factors associated with these diseases stem from climatic and environmental conditions, the movement and trade of animals, farming methods, closeness to wildlife, hygiene and biosecurity protocols, and restricted access to veterinary services and resources. The review highlights the economic consequences of these zoonoses, including reduced milk yield, reproductive losses, and trade restrictions, while also emphasizing their significant impact on human health through foodborne transmission and occupational exposure. Current control strategies, such as vaccination, surveillance, biosecurity measures, and antimicrobial regulations, remain insufficient due to logistical and financial constraints. To mitigate the impact of bovine zoonoses, this review recommends strengthening disease surveillance, expanding vaccination coverage, improving biosecurity practices, and promoting responsible antibiotic use as well as promoting and better implementation of the One Health approach. Addressing these challenges through coordinated public health interventions and policy reforms will be essential in safeguarding both animal and human populations in sub-Saharan Africa.

Keywords | Bovine zoonoses, Epidemiology, Impact, Public health, Control strategies, Sub-Saharan Africa

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INTRODUCTION

The livestock subsector is among the priority subsectors of the National Development Plan of most sub-Saharan African countries. The supervisory ministries in these respective countries are currently focused on certain main strategic axes of livestock development. These axes are, among others, the improvement of animal production systems, the preservation and improvement of animal health, the security of breeding, the improvement of the conditions for placing animal products on the market, support for policies of ministries (ECOWAS and NEPAD, 2017). However, the region faces persistent challenges from zoonotic diseases, which are transmitted between animals and humans. Zoonoses account for a high proportion of newly identified infectious diseases as well as many existing diseases (FAO, 2018). Bovine zoonoses, in particular, are a major concern due to their impact on both animal productivity and public health but also the close relationship between the breeder and the animals. Despite efforts by international organizations such as the World Health Organization (WHO) and the World Organisation for Animal Health (OIE), the burden of these diseases remains and seems to be exacerbated by factors such as urbanization, climate change, and inadequate healthcare infrastructure (WHO, 2022; FAO, 2019). However, although some reviews and meta-analyses focus on specific zoonoses, no study objectively summarizes the current state of knowledge on all zoonotic diseases still active in sub-Saharan Africa. In order to inform policymakers, researchers, and practitioners for a more effective integrated approach in preserving both animal and public health, it is imperative to conduct an assessment of the bovine zoonoses still prevalent in sub-Saharan Africa, as well as the control strategies employed in recent decade. This review seeks to present an overview of knowledge on bovine zoonoses still active in sub-Saharan Africa. Specifically, it aims to:

- summarize the epidemiology of major bovine zoonoses.
- assess their impact on human and animal productivity
- discuss current control measures and propose integrated strategies for disease management.

Concept and Summary of Bovine Zoonoses in Sub-Saharan Africa

Bovine zoonosis concept, In Veterinary Sciences, a bovine zoonosis is a disease naturally transmissible from cattle to humans and vice versa (WHO, 2022). These diseases are caused by a variety of pathogens, including bacteria, viruses, parasites, and prions. The primary modes of transmission include direct contact, consumption of contaminated food or water, and environmental exposure (Amona *et al.*, 2016; Ranjan and Read, 2016). In cattle breeding, the main zoonoses are, among others, bovine tuberculosis, brucellosis, anthrax, fasciolosis, trypanosomiasis (WHO, 2022; Roelandts, 2023). These zoonoses represent a major public health problem in worldwide due to our close relationship with animals in different contexts (agriculture, domestic animals and the natural environment). Overall, zoonoses can also disrupt the production and trade of animal products for food or other purposes (WHO, 2022).

Summary of Bovine Zoonoses in Sub-Saharan Africa

There are 3 categories of bovine zoonoses in sub-Saharan Africa: bacterial zoonoses, viral zoonoses and parasitic zoonoses.

Bacterial zoonoses: This section provides a descriptive summary of the knowledge on the four bovines bacterial zoonoses still encountered in sub-Saharan Africa. These are brucellosis by *Brucella abortus*, tuberculosis by *Mycobacterium bovis*, anthrax by *Bacillus anthracis* and salmonellosis by *Salmonella enterica*. The summary covers the names of the zoonoses, the etiological agents, reservoirs, modes of transmission, and clinical diagnosis of these diseases. This information is compiled in Table 1, along with references. In addition, laboratory diagnostic methods and medical treatments used for each of these diseases have been reviewed. For instance, bovine brucellosis is diagnosed by several methods: Blood culture, Serology: ELISA, Rose Bengal (Dean *et al.*, 2013; Kouamé *et al.*, 2015; Amona *et al.*, 2016; Sanogo *et al.*, 2017; Craighead *et al.*, 2018); and for its treatment antibiotics are used: - doxycycline or - trimethoprim/ sulfamethoxazole plus -gentamicin, -streptomycin, or rifampicin (Elelu *et al.*, 2016; Sanogo *et al.*, 2017). With regard to bovine tuberculosis, blood test is widely used (interferon gamma release test which detects a cell-mediated immune response during infection by M. bovis) (Roelandts, 2023). For all forms of tuberculosis, treatment is primarily based on antibiotics which must be administered over long periods of time (several months) and by combining several molecules. It should be noted that the bacteria responsible for tuberculosis can develop resistance to certain antibiotics; which complicates treatments (Acha and Szyfres, 2003; Roelandts, 2023). Anthrax or antrax is detected in samples of blood, spleen or milk for strain isolation, Gram staining and culture, direct immunofluorescence test (DFA) and Polymerase Chain Reaction (PCR) (Roelandts, 2023) and antibiotics (penicillin, fluoroquinolones) used in the early stage of the disease are effective (Roelandts, 2023). Bovine salmonellosis is detected after isolation and identification of salmonella. Given the multi-resistance of salmonella, an antibiogram is necessary (FAO, 2018; Klous *et al.*, 2016). Oral administration of Colistin is recommended in calves (fight against the multiplication of salmonella in the digestive tract).

Table 1: Summary of bovine bacterial zoonoses in sub-Saharan Africa.

Bovine Brucellosis	Bovine Tuberculosis	Anthrax	Bovine Salmonellosis
Causal Agent			
Brucella abortus (a Gram-negative bacterium)	*Mycobacterium bovis* (Gram-positive)	*Bacillus anthracis* (Gram-positive)	Salmonella enterica
Reservoirs			
Sheep, goats, cows, camels, bison, elk	Cattle, goats, pigs, deer, wild boars, badgers	No animal reservoirs. Spores remain in soil for decades.	Gastrointestinal tract of mammals and birds. Survives long-term in the environment without multiplying.
Transmission			
Spread of *Brucella* during calving, abortions (secretions), and in dairy products (appendix)	Respiratory route, sometimes digestive route (appendix)	Ingestion of *Bacillus anthracis* spores while grazing on contaminated fields (appendix)	Transmission through water and food contaminated by feces of infected animals (appendix)
Clinical Diagnosis			
Flu-like symptoms: fever, fatigue, malaise, or weight loss, abortion	Weakness, anorexia, emaciation, fluctuating fever, intermittent dry cough, diarrhea, significant lymphadenopathy	Severe colic, hemorrhagic diarrhea, muscle tremors, edema (throat, neck, jaw, abdomen), mucosal congestion, high fever, dyspnea, black tarry blood discharge post-mortem	Diarrhea (sometimes hemorrhagic) with fever in adults or calves. Can be sporadic or epidemic.
Laboratory Diagnosis			
Blood culture; Serology: ELISA, Rose Bengal test	Blood test: Interferon-gamma release assay (detects cell-mediated immune response to *M. bovis*)	Blood, spleen, or milk samples for strain isolation; Gram staining, culture, direct immunofluorescence (DFA), PCR	Isolation and identification of *Salmonella*. Antibiotic susceptibility testing due to multi-drug resistance.
Treatment			
Two antibiotics: doxycycline or trimethoprim/sulfamethoxazole plus gentamicin, streptomycin, or rifampicin	No specific treatment. Long-term antibiotic therapy (several months) with multiple drugs. Note: Antibiotic resistance complicates treatment	Early-stage antibiotics (penicillins, fluoroquinolones) are effective.	Oral colistin for calves. Symptomatic treatment: antipyretics, analgesics, coagulants, digestive protectants, oral/parenteral rehydration, fluid therapy.
Geographical distribution			
Benin- Burkina Faso, Ivory Coast, Gambia, Ghana, Guinea, Mali, Niger, Nigeria, Mauritania, Senegal, Togo, Cameroon, Central African Republic, Chad, Republic of the Congo, Democratic Republic of the Congo, Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Rwanda, Somalia, Tanzania, Uganda, Zambia, Zimbabwe, South Africa, Botswana, Eswatini, Lesotho, Namibia	Benin- Burkina Faso, Ivory Coast, Gambia, Ghana, Guinea, Mali, Niger, Nigeria, Mauritania, Senegal, Togo, Angola, Cameroon, Central African Republic, Chad, Republic of the Congo, Democratic Republic of the Congo, Burundi, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Rwanda, Somalia, Tanzania, South Sudan, Uganda, Zambia, Zimbabwe, South Africa, Botswana, Eswatini, Lesotho, Namibia	Burkina Faso, Ivory Coast, Mali, Nigeria, Mauritania, Senegal, Cameroon, Chad, Democratic Republic of the Congo, Ethiopia, Kenya, Madagascar, South Sudan, Tanzania, Uganda, Zambia, Zimbabwe, South Africa	Burkina Faso, Ivory Coast, Nigeria, Senegal, Cameroon, Democratic Republic of the Congo, Ethiopia, Kenya, South Sudan, Tanzania, Uganda, Zimbabwe, South Africa
Sources			
Dean *et al*. (2013); Boukary *et al*. (2014); Sanogo *et al*. (2015); Craighead *et al*. (2018)	Acha and Szyfres (2005); Roelandts (2023)	Measure (2019); Roelandts (2023)	Klous *et al*. (2016); FAO (2018)

Viral zoonosis: In terms of bovine viral zoonosis, only the Rift Valley Fever (RVF) remains indexed in the literature. The Table 2 provides a brief summary of causal agent, tanks, transmission and clinical diagnosis of the RVF. Furthermore, cattle Rift Valley Fever is diagnosed by blood tests (during the illness) or other post-mortem tissue sample

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Table 2: Summary of bovine viral zoonosis: Rift valley fever.

Rift Valley Fever
Causal Agent
Phlebovirus sp. (family Bunyaviridae)
Reservoirs
Mosquitoes of genera: *Aedes*, *Anopheles*, *Culex*, *Eretmapodites*, *Mansonia*
Transmission
Bite of infected mosquitoes (appendix)
Clinical Diagnosis
Nasal discharge, hypersalivation, anorexia, fatigue, diarrhea
Laboratory Diagnosis
Blood analysis (during illness) or post-mortem tissue sampling: virus isolation via cell culture, RT-PCR, ELISA
Treatment
No FDA-approved treatment. Most cases are mild and self-limiting; no specific treatment established.
Geographical distribution
Burkina Faso, Côte d'Ivoire (Ivory Coast), Mali, Nigeria, Mauritania, Senegal, Cameroon, Chad, Democratic Republic of the Congo, Ethiopia, Kenya, Madagascar, Somalia, South Sudan, Tanzania, Uganda, Zambia, Zimbabwe, South Africa
Sources
Geering *et al.* (2003); Bezeid (2011)

taken in laboratories: isolation of the virus by cell culture from post-mortem tissues sample taken in laboratories: isolation of the virus by cell culture from post-mortem tissues and by molecular techniques (Reverse Transcription Polymerase Chain Reaction or RT-PCR) or ELISA text: the antibody test using the enzyme-linked immunosorbent assay immunoassay (Geering *et al.*, 2003; Bezeid *et al.*, 2011). For the treatment, there is no FDA-approved treatment for Rift valley Fever for most cases of RVF are mild and self-limiting so specific treatment has not been established (Bezeid *et al.*, 2011).

Parasitic zoonoses: In total, 04 mains parasitic zoonoses of cattle continue to persist in Sub-Saharan Africa. This includes bovines fasciolosis, bovine trypanosomiasis, bovine toxoplasmosis and bovine cysticercosis or bovine ladreria.

Table 3 provides a brief summary of causal agent, tanks, transmission and clinical diagnosis of bovine parasitic zoonoses. In addition to the summary presented in the table, the laboratory diagnostic tests and medical treatments for these diseases are outlined as follows.

- For the bovine fasciolosis, the diagnosis is serology and coprology (Assogba *et al.*, 2001; Siama and Nloga, 2018). Its treatment is Rumeil at a chose of 10 mg/kg (Chauvin *et al.*, 2007; Siama and Nloga, 2018).
- For the bovine trypanosomiasis, the diagnosis is nematologiy (Boka *et al.*, 2019). Its medical treatment is done with veridium, Trypamidium, samorin (Boka *et al.*, 2019).
- For the bovine toxoplasmosis, the diagnosis is PCR on aborted brains and serological diagnosis: carried out on 5 females who has recently aborted, by taking 2 series of blood spaced 15 days apart to see possible seroconversion (Davoust *et al.*, 2015; Maman, 2022). Its treatment is based on anti-folinic: pyrimethamine (Maman, 2022).
- For the bovine cysticercosis or bovine ladreria, the diagnosis is coproscopy and search after slaughter, for larval cysts, in classic locations (Takayanagui and Odashima, 2006). There is no appropriate treatment of this disease in cattle. However, some antiparasitic can be used: Niclosamide, albendazole, mebendazole, praziquantel can be used (Zoli *et al.*, 2003; Takayanagui and Odashima, 2006).

Epidemiology of Bovine Zoonoses in Sub-Saharan Africa

Epidemiology of bovine bacterial zoonoses in sub-Saharan Africa: Epidemiology of bovine brucellosis: Several epidemiological studies indicate varying prevalence rates of bovine brucellosis across different countries in sub-Saharan Africa. In East Africa, seroprevalence rates in dairy cattle range from 5% up to 22% depending the agroecological zone, herd size and pastoral (breeding) system (Kiiza *et al.*, 2021). Studies estimate a prevalence of 7.6%–20.2% in various cattle populations in west Africa (Ogugua *et al.*, 2018; Alhaji *et al.*, 2016) while Matope *et al.* (2011) reported prevalence rates ranging between 2.3% and 12.6%, particularly in communal and smallholder dairy farms in southern Africa (Zimbabwe). In South Sudan, prevalence is estimated at 21.3 %, with higher rates in pastoral herds compared to intensively managed dairy farms

Table 3: Summary of bovine parasitic zoonoses in sub-Saharan Africa.

Bovine Fasciolosis	**Bovine Trypanosomiasis**	**Bovine Toxoplasmosis**	**Bovine Cysticercosis**
Causal Agent			
Fasciola gigantica, *Fasciola hepatica*	*Trypanosoma vivax*, *T. congolense*, *T. brucei*, *T. rhodesiense*, *T. gambiense*	Toxoplasma gondii	*Taenia saginata*, *Taenia solium*
Reservoirs			
Water sources for cattle grazing, snails, cattle	Tsetse flies (*Glossina palpalis*), cattle	Felidae family (cats)	Humans
Transmission			
Consumption of forage or vegetation containing metacercariae (appendix)	Bite of tsetse flies in humid areas (appendix)	Transmission via cat saliva (scratches, bites) (appendix)	Grazing areas contaminated by human and pig feces (appendix)
Clinical Diagnosis			
Abdominal pain, hepatomegaly, fever, vomiting, diarrhea, urticaria, eosinophilia	Fever, anemia, weight loss, abortion, potentially fatal	Fever, paralysis, inflammation of palatine tonsils, respiratory distress, diarrhea, unilateral blindness	Convulsions, epileptic seizures, edema, visible and palpable subcutaneous nodules
Laboratory Diagnosis			
Serology, coprology	Hematology	PCR on aborted brain tissue; serological diagnosis: blood samples from 5 recently aborted females, 15 days apart to detect seroconversion	Coproscopy; post-slaughter detection of larval cysts in typical locations
Treatment			
Rumenil® at 10 mg/kg	*Veridium*, *Trypamidium Samorin*	Anti-folate treatment: pyrimethamine	No specific treatment for cattle. Dewormers: niclosamide, albendazole, mebendazole, praziquantel
Geographical distribution			
Benin, Burkina Faso, Ghana, Guinea, Mali, Niger, Nigeria, Mauritania, Senegal, Togo, Angola, Cameroon, Central African Republic, Chad, Republic of the Congo, Democratic Republic of the Congo, Burundi, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Rwanda, Somalia, South Sudan, Tanzania, Uganda, Zambia, Zimbabwe, South Africa, Botswana, Eswatini, Lesotho, Namibia	Benin, Burkina Faso, Cape Verde, Ivory Coast, Gambia, Ghana, Guinea, Mali, Niger, Nigeria, Mauritania, Senegal, Togo, Angola, Cameroon, Central African Republic, Chad, Republic of the Congo, Democratic Republic of the Congo, Kenya, Madagascar, Mozambique, Somalia, South Sudan, Tanzania, Uganda, Zambia, Zimbabwe, South Africa	Burkina Faso, Ivory Coast, Ghana, Mali, Nigeria, Mauritania, Senegal, Togo, Cameroon, Chad, Democratic Republic of the Congo, Ethiopia, Kenya, Madagascar, South Sudan, Tanzania, Uganda, Zambia, Zimbabwe, South Africa	Benin, Burkina Faso, Ivory Coast, Ghana, Mali, Niger, Nigeria, Mauritania, Senegal, Togo, Cameroon, Chad, Democratic Republic of Congo, Ethiopia, Kenya, Madagascar, South Sudan, Tanzania, Uganda, Zambia, Zimbabwe, South Africa
Sources			
Assogba and Youssao (2001); Siama and Nloga (2018)	Boka *et al.* (2019)	Davoust *et al.* (2015); Maman *et al.* (2022)	Zoli *et al.* (2003); Takayanagui *et al.* (2006)

(Lita *et al.*, 2024). The variation in prevalence is influenced by factors such as the presence of climatic factors, livestock management practices, and the level of veterinary intervention. Brucella species survive in cool, moist environments, favoring transmission in regions with high humidity. Studies show increased transmission in areas with seasonal rainfall patterns that facilitate Brucella persistence in soil and water sources (Mangen *et al.*, 2002). Additionally, the disease is prevalent in dry savannah and pastoralist zones where cattle graze over extensive areas, increasing exposure risks. The movement of livestock across national borders, as seen in the Sahel and East Africa, facilitates brucellosis transmission and could explain high prevalence rates (for example 30% in Niger) reported in these areas (Adamou, 2008; Kouamé *et al.*, 2015). Transhumant cattle mix with local herds, allowing the disease to spread. Also, Wildlife such as African buffalo (*Syncerus caffer*) species (antelopes and warthogs) plays a crucial role in maintaining Brucella transmission cycles, particularly in ecosystems where livestock and wild animals interact (mixed grazing areas) (Mengele *et al*., 2023; Ntivuguruzwa *et al*., 2020). High herd density (7.6% for small herds versus 23.8% for medium and large herds) and poor hygiene practices (consumption of unpasteurized milk and raw animal products) contribute to the spread of this disease (Kiambi *et al*., 2020; Amona *et al*., 2016; Bayang and Ndukum, 2014). Moreover, many countries in Sub-Saharan Africa lack the necessary diagnostic tools and trained personnel to detect and control brucellosis effectively (Ducrotoy *et al*., 2017).

Epidemiology of bovine tuberculosis: Bovine tuberculosis is endemic in livestock in sub-Saharan Africa. Literature data show that the disease is widely distributed in animal populations in sub-Saharan Africa, but with a highly variable prevalence rate (De Garine Wichatitsky *et al*., 2013). This pathology is dominant in East Africa, more precisely in Ethiopia (48%), in Uganda (74%) and in West Africa, particularly in Ghana (39%) and Mali (94%) (Sidibé *et al*., 2003; Addo *et al*., 2007; Regassa *et al*., 2010). Agbalaya *et al*. (2020) reported prevalence range between 7.0% and 25.7%, with abattoir-based studies in Nigeria versus 3.6% in Niger (Boukary *et al*., 2011). Zambia shows significant prevalence variations, with rates from 7.4% (in 2012) to 39.7% (in 2023), highlighting the ongoing challenges in managing this disease particularly in communal grazing systems (Monde *et al*., 2023; Munyeme *et al*., 2012). In central Africa, Kouengoua *et al*. (2024) reported a 6.8% prevalence in Cameroon with evidence of transmission at the wildlife-livestock-human interface. Higher prevalence is often linked to extensive farming practices, poor biosecurity, and the presence of wildlife reservoirs. For instance, a 2014 study by Awah-Ndukum *et al*. in the highlands of Cameroon highlighted that husbandry practices and environmental factors significantly influence bTB prevalence. The research suggested that certain farming practices and ecological conditions could facilitate the survival and transmission of Mycobacterium bovis. So, extensive systems facilitate wider spread via grazing and wildlife interactions while intensive dairy farms have higher prevalence rates due to close animal contact (Akinseye *et al*., 2018). Nomadic herding increases the risk of bTB spread across national borders (Kelly *et al*., 2022). Slaughtering infected animals without proper inspection facilitates human exposure, especially in informal meat markets (Boukary *et al*., 2011). This factor is complicated by the lack of advanced diagnostic tools especially in rural areas that delays detection and intervention (Agbalaya *et al*., 2020). It's important to underline that wildlife plays a crucial role in BTB transmission, acting as a persistent reservoir. De Garine-Wichatitsky *et al*. (2013) reported African Buffalo as one of the primary reservoirs, but also warthogs, Antelopes, etc.; their interactions with livestock in protected areas increase transmission risks. Hunting and consumption of infected wildlife pose therefore additional zoonotic risks.

The presence of numerous risk factors for disease transmission and the absence of adequate control measures strongly contribute to the dissemination of *M. bovis tuberculosis.* sub-Saharan Africa. The prevalence of Bovine Tuberculosis varies significantly from one geographical area to another (depending on the country and region) and within the same geographical area (depending on the breeding systems practiced) (Vordermeier *et al*., 2012). Extensive livestock farming is very exposed to tuberculosis. These generally concern farms in permanent contact with an uncontrolled environment. In general, extensive breeding practices not only predominate but also hygiene rules are neglected within cattle herds (Faye *et al*., 2022).

Epidemiology of anthrax: Anthrax, also called anthrax, is enzootic in Senegal and Niger, mainly affecting cattle. In Senegal, it affects the southern half of the country where it poses a real public health problem, causing numerous cases of animal mortality, especially ruminants, as well as human mortality (FAO, 2018). The prevalence reaches 31% in Niger, which is undermined by cursed fields (Roelandts, 2023). Uganda recorded multiple outbreaks between 2017 and 2018 affecting mostly cattle (86%) with confirmed incidence rate of 79.2% and fatality of 66.4% (Omodo *et al*., 2023) while Nigeria has experienced anthrax outbreaks in livestock recently with sudden death of eight (8) animals (NCDC, 2023). The persistence of anthrax is largely attributed to environmental contamination by long-lived spores, combined with high-risk livestock management practices. High temperatures favor bacterial sporulation, increasing the risk of outbreaks during dry seasons (Aminu *et al*., 2022). These spores persist in alkaline and calcium-rich soils, creating natural reservoirs (Pittiglio *et al*., 2022). Heavy rains followed by droughts enhance spore exposure by concentrating spores in water sources and vegetation (Carlson *et al*., 2019). In addition, livestock management practices as free-range grazing expose cattle to spores, particularly in known anthrax-endemic zones (Mogaji *et al*., 2024). Improper disposal of infected carcasses contributes to environmental contamination and subsequent outbreaks (Aladejana *et al*., 2023). While vaccines exist, coverage remains low due to logistical challenges and vaccine hesitancy among farmers (Adesola *et al*., 2024). Moreover, scavengers and wild herbivores contribute to the environmental spread of spores by feeding on infected carcasses. Human exposure occurs then through handling and consumption of infected wildlife. Culturally, some traditional practices, such as consuming meat from sick or dead animals, elevate zoonotic risks (Ateudjieu *et al*., 2023).

Epidemiology of bovine salmonellosis: Epidemiologically, a cow having had an abortion linked to salmonellosis is a silent and dangerous factor in the spread of salmonella. This female may excrete salmonella in her uterine secretions for a month after the abortion. On rare occasions, milk may be contaminated (Klous *et al*., 2016). Bovine salmonellosis is very little documented in sub-Saharan Africa. The majority of work relates to poultry (FAO, 2018). However, some studies report prevalence rates between 7.07% and 9.3% in east Africa with significant antimicrobial resistance observed in isolates from cattle (Tadesse *et al*., 2024; García-Díez *et al*., 2024; Asefa *et al*., 2023). In Nigeria (west Africa), seroprevalence surveys estimate 4.8% of cattle harbor Salmonella spp., particularly in urban abattoirs (15.5%) (Aworh *et al*., 2024). High animal densities increase direct and indirect transmission risks. Heavy rainfall increases the risk of Salmonella spread through runoff and contaminated drinking water. Lack of proper waste disposal and inadequate hygiene in farms and slaughterhouses contribute to bacterial transmission. Rodents and wild birds as well as wild herbivores act as carriers, contaminating feed and water sources (García-Díez *et al*., 2024; Tadesse *et al*., 2024; Aworh *et al*., 2024; Asefa *et al*., 2023). Another risk factor is antimicrobial resistance. Overuse and misuse of antibiotics in livestock contribute to the emergence of multidrug-resistant Salmonella strains. Studies in SSA indicate that over 55% of Salmonella isolates show resistance to at least three antibiotic classes (Tadesse *et al*., 2024).

Epidemiology of a bovine viral zoonosis in sub-Saharan Africa: case of rift valley fever: The risk factors for this fever are often linked to torrential rains, floods, hydraulic developments (Dams, etc.). This explains its presence, its predominance (70%) and its spread around the Rift Valley in Kenya, its main focus. This pathology also extends to Botswana, Angola, Democratic Republic of Congo, Congo, Gabon, Cameroon, Nigeria, Central African Republic, Chad, Niger, Burkina Faso, Mali, Guinea, in Tanzania, Malawi, Uganda, Ethiopia and Somalia. In these countries, prevalence rates are variable, low and well below that of the original household (Diallo *et al*., 2000; Swanepoel and Coetzer, 2004). The prevalence of RVF in cattle varies across regions due to environmental and ecological differences. Studies have reported seroprevalence rates ranging from 5% to over 60%, depending on the location and outbreak history. For example, a comprehensive seroepidemiological survey conducted in Uganda found an overall Rift Valley fever virus (RVFV) seroprevalence of 6.9% among livestock with higher seroprevalence rate (10.7%) in Cattle (Nyakarahuka *et al*., 2023). In Tanzania, a cross-sectional study reported a seroprevalence of 5.5% to 22.7%, with variations linked to proximity to wetlands and livestock density (Sumaye *et al*., 2013). These prevalence estimates indicate that RVF is an ongoing concern for livestock health, with endemic regions experiencing sporadic re-emergence due to favorable climatic conditions and vector population dynamics. Heavy rains and subsequent flooding create ideal breeding conditions for mosquitoes (the primary vectors of RVFV) that maintain the virus in transovarial transmission cycles (Pascoe *et al*., 2022). Increased mosquito populations lead to heightened transmission risks. Warmer temperatures accelerate viral replication in mosquitoes, while high humidity enhances vector survival, facilitating transmission and outbreaks. For example, Kenya, Tanzania, and Uganda report frequent outbreaks, especially in regions with extensive livestock farming and seasonal flooding (Nyakarahuka *et al*., 2023; Pyere *et al*., 2015; Sumaye *et al*., 2013). In rural and resource-limited settings, inadequate surveillance and vaccination coverage contribute to the persistence of RVFV. Furthermore, unregulated trade routes and the movement of infected cattle across borders often facilitate RVFV spread and cross-border transmission events. Nomadic pastoralists who move livestock in search of pasture and water sources may inadvertently introduce RVFV into previously unaffected areas. RVFV has been detected in Nigeria, Senegal, and Mauritania, often associated with transhumance and trade routes. Additionally, the World Organisation for Animal Health (WOAH) has noted that bans on livestock exports to Gulf States have led to a resurgence of illegal trade in the Horn of Africa region, further exacerbating the risk of RVFV spread (Mosomtai *et al*., 2023; Mhamadi *et al*., 2023; Bouslikhane, 2015). In terms of susceptibility, exotic breeds of livestock are much more susceptible to the disease than indigenous breeds (Geering *et al*., 2003; Leumbe *et al*., 2015).

Epidemiology of bovine parasitic zoonoses in sub-Saharan Africa: Epidemiology of bovine fasciolosis: The existence of wetlands, or the presence of calcareous soil, are factors favorable to the development of limnaea. As an illustration, in the tropics, especially in central Africa, an overall prevalence of fasciolosis of 28.87% is reported with higher rates in the rainy season (24% to 31.49%) than in the dry season (13 % to 23.81%). Females are more infested than males with respective rates of 29.56% and 24.18% on average. Parasitemia rates increase with the age of cattle, so calves are less parasitized than young people and adults. Butcheries in floodplains have a higher infestation rate than butcheries in other arid, sub-Saharan zones (Jaja *et al*., 2017; Siama and Nloga, 2018). Such prevalence trends are also reported in southern Africa by Jaja *et al*. (2017). Overall, central Africa (Cameroon, Central African Republic, etc.) and southern Africa (Zambia, South Africa, etc.) are zones by definition of rain and humidity (Siama and Nloga, 2018). Literature suggests that bovine fasciolosis is an endemic problem in many sub-Saharan African countries, particularly in regions with suitable environmental conditions for intermediate host snails.

High rainfall and warm temperatures favor the survival and reproduction of intermediate host snails, particularly Lymnaea spp., which are essential for the fluke's life cycle (Singleton *et al*., 2024). Marshy areas and irrigated farmlands create ideal habitats for snail vectors, increasing infection risks for grazing cattle. These snails thrive in slow-moving or stagnant water bodies. Snail populations peak during wet seasons, leading to increased transmission rates. In many rural areas, lack of access to anthelmintic treatments contributes to high infection rates. Many cattle owners do not recognize fasciolosis as a major threat, leading to inadequate control measures (Feucherolles *et al*., 2021).

Epidemiology of bovine trypanosomiasis: Transhumance is a major epidemiological factor in bovine trypanosomiasis, especially in countries with a strong pastoral vocation such as Niger, Mali and Burkina Faso. The prevalence of trypanosomiasis reaches 40% for these transhumant herds. During transhumance, cattle suffer lesional trauma caused by thorny plants and once in contact with tsetse fly environments, they are infested. The prevalence rate of older cattle is around 41.92%. As a general rule, cattle taken for transhumance are the oldest. Health controls and monitoring are poorly managed in these Sudano-Sahelian countries (Dabis, 2010; Koné *et al*., 2012; Harouna *et al*., 2017). Bovine trypanosomiasis remains a significant challenge in many African countries, with prevalence rates varying widely depending on geographical location, vector density, and control measures: 1.38% to 17.15 % in Ethiopia, more than 14% in the Democratic Republic of the Congo; 23.00% in Cameroon with a variation from 10.0% to 37.70% in some endemic zones; 6% in Côte d'Ivoire with variation from 2.99% to 25.28%; 7.54% in Burkina-Faso; 10.8% in Togo (Mekuria *et al*., 2024; Lokinda *et al*., 2024; Ekra *et al*., 2023; Boka *et al*., 2019; Tchamdja *et al*., 2017; Leta *et al*., 2016; Dayo *et al*., 2010). The presence of Glossina spp determines the geographic spread of trypanosomiasis. Areas with high tsetse fly densities correspond to elevated bovine infection rates Tsetse flies prefer dense vegetation, such as savannahs and riverine forests. Deforestation and land conversion for agriculture can reduce vector density, but also create fragmented habitats that support pockets of infection. (Leta *et al*., 2016; Mekuria *et al*., 2024). In West Africa, T. vivax can be transmitted by biting flies such as Stomoxys spp., allowing the disease to persist in areas beyond the tsetse belt (Odeniran *et al*., 2020). The proximity of cattle to wildlife-inhabited areas increases the risk of cross-species transmission because various wild ungulates, such as African buffalo and antelopes, act as reservoirs for Trypanosoma spp (Mamoudou *et al*., 2009). Furthermore, many smallholder farmers lack knowledge about the disease, leading to delayed diagnosis and treatment. Poor veterinary screening in cattle markets increases disease transmission through movement of infected animals in unregulated livestock markets. In addition, increasing resistance to trypanocidal drugs such as isometamidium and diminazene, complicating control efforts, has been documented (Degneh *et al*., 2019).

Epidemiology of Bovine Toxoplasmosis: Bovine toxoplasmosis is a neglected zoonosis and is the subject of very little research. Its prevalence in livestock globally varies from 7.5 to 59.7%. The scraps of information available specifically on this disease in sub-Saharan Africa have been reported by Adewi *et al*. (2010) and Maman *et al*. (2022), in Togo. Seroprevalence is higher in females than in males (6.17% *vs* 4.05%). The IgG rate is higher (16.46%) in the Maritime region than in the other regions (3.85% to 12.94%). Concerning contamination risk factors, data indicate that 95.65% of herds in the maritime region are in permanent contact with cats excreting oocysts. This poses a public health problem for these population. According to Tonouhewa *et al*. (2017), the prevalence of *Toxoplasma gondii* infection in cattle ranged from 8% to 17%, with an overall estimated prevalence of 12%. Many regions in sub-Saharan Africa rely on surface water sources, which can be contaminated by oocysts shed by infected felines as these *T. gondii* oocysts can survive in soil and water. Domestic as well as wild felids are the definitive hosts of T. gondii, shedding millions of oocysts in their feces, which contaminate pastures, water, and feed. In areas where cattle graze near game reserves, interactions with wildlife species, such as rodents and primates, may contribute to disease persistence. Moreover, many cattle producers are unaware of the risks associated with toxoplasmosis, leading to inadequate preventive measures. So free-range cattle are at higher risk of T. gondii exposure due to increased contact with contaminated environments. In many African countries, routine screening for toxoplasmosis in livestock is not commonly practiced, limiting control efforts (Masombuka *et al*., 2024; Mangena *et al*., 2023; Tonouhewa *et al*., 2017).

Epidemiology of Bovine Cysticercosis: The lack of reliable epidemiological data, the high cost of diagnostic means and the lack of knowledge of the disease by the populations concerned mean that the global prevalence of the teniosis /cysticercosis complex is poorly known. Latin America, Africa and Asia are endemic regions because all elements favor the cycle of *Taenia cycle solium* and *T. saginata* are united there: significant fecal danger, free-range breeding of pigs, extensive cattle breeding system, access of pigs to human faeces, great human-pig-cattle promiscuity, lack of food and general hygiene, sometimes slaughter domestic or clandestine pigs, cattle and insufficient veterinary control of meat (Mafojane *et al*., 2003; Yanagida *et al*., 2010; Bouteille, 2014). However, according to the available data, cysticercosis has been described much more in pigs in West and Central Africa (Ivory Coast, Togo, Mali, Benin, Nigeria, Cameroon, Central African Republic, etc.). Its prevalence varies from 11% to 21% (Roth and Menor, 2003; Yanagida *et al*., 2010). Furthermore, many rural communities lack proper sanitation facilities, leading to widespread environmental contamination with *T. saginata* eggs. Many abattoirs in sub-Saharan Africa lack proper meat inspection protocols, allowing infected carcasses to enter the food chain. Infected cattle serve as reservoirs, and human infection occurs when people consume raw or undercooked beef containing Cysticercosis.

Impact of Zoonoses on Animal and Human Productivity

Economic impact of zoonotic diseases in livestock production: Zoonoses cause significant losses in animal production. Zoonotic diseases in sub-Saharan Africa threaten food security by affecting animal health, reducing livestock productivity, and limiting access to safe and nutritious food. Economic losses caused by diseases such as brucellosis, bovine tuberculosis, and Rift Valley fever undermine the livelihoods of livestock farmers and exacerbate food insecurity. Furthermore, the contamination of animal products (milk, meat) with zoonotic pathogens exposes consumers to health risks, limiting their access to essential protein sources. (Grace D *et al*., 2012; WHO/FAO/OIE, 2006; Havelaar *et al*., 2015).

A cross-sector analysis is given by Roth *et al*. (2003), Zoonoses mainly affect herd fertility and reduce milk production. Zoonotic diseases significantly impact livestock production, leading to substantial economic losses. Chronic infections such as bovine tuberculosis (bTB) and brucellosis reduce growth rates, feed efficiency, and overall productivity. Research indicates that bTB alone can cause a 10 to 25% of their productivity including 10–18% decline in milk yield per infected cow (Muhammed *et al*., 2017). Additionally, reproductive failures, particularly due to Brucella abortus results in abortion rates of 13.8% in affected herds, inflicting severe financial losses on farmers (Megersa *et al*., 2011).

Beyond productivity losses, zoonotic diseases also affect meat quality and supply. Conditions like bovine cysticercosis (*Taenia saginata*) and tuberculosis lead to the condemnation of infected carcasses in slaughterhouses, significantly reducing available meat. In Nigeria, for instance, up to 76% of certain muscles of slaughtered bovine were condemned due to bovine cysticercosis (Rabi'u and Jegede, 2010). To combat these issues, farmers face increased veterinary costs, investing heavily in diagnostics, treatments, and vaccination programs.

On a broader economic scale, these diseases impose trade restrictions that further impact livestock markets. Animals from regions with high zoonotic disease prevalence are often devalued due to perceived health risks, leading to reduced market prices. Moreover, international trade barriers limit meat and dairy exports from sub-Saharan Africa, where the disease burden remains high, stifling economic growth in the livestock sector. Despite the lack of economic data, it is clear that countries pay a heavy price for these zoonoses. In a review by Peyre *et al*. (2015) for example, between 2006 and 2007, RVF alone caused a loss ranging $6.7 million and $421 million to Tanzania and Somalia respectively while the annual losses per household due to bovine trypanosomosis were estimated to $176.4 (Tora and Dana, 2024).

Impact of bovine zoonoses on public health: Bovine zoonotic diseases pose a significant threat to human health, particularly in rural communities of sub-Saharan Africa, where close human-livestock interactions facilitate disease transmission. These infections contribute to foodborne illnesses, occupational hazards, and rising healthcare costs, exacerbating public health challenges in resource-limited settings.

Several bovine zoonoses directly infect humans, often through consumption of contaminated animal products or direct contact with infected livestock. Brucellosis is primarily transmitted through unpasteurized dairy products or handling of infected animals. It affects more than 500,000 people annually worldwide, with sub-Saharan Africa contributing a significant portion of cases (Frean *et al*., 2018). Similarly, bovine tuberculosis (bTB) can be transmitted via inhalation or consumption of raw dairy products. In Tanzania, up to 16% of human TB cases are linked to bTB (Kazwala *et al*., 2001). Anthrax is another serious concern which spreads through livestock outbreaks and primarily affects pastoralist communities. For instance, in Kenya, anthrax is the highest-ranked priority zoonotic disease, with an average of 10 outbreaks occurring annually at the human–animal interface Muturi *et al*. (2018) reported *Bacillus anthracis* seropositivity of 11.3% among humans, with some regions reporting up to 28% seropositivity while inhalation anthrax can be fatal in up to 85% of cases without treatment (CDC, 2024).

Taeniasis, caused by *Taenia saginata*, results from consuming undercooked beef infected with bovine cysticercosis and affects million of people. In some countries, cattle seroprevalence rates exceed 10% and correlate with high human infection rates. For instance, a review highlighted prevalence rates ranging from 2.2% to 26.25% in cattle across different areas of the country (Kumar and Tadesse, 2011). Another major concern is Rift Valley Fever (RVF), a viral disease that can cause fever, hemorrhagic complications, and neurological disorders in humans. RVF outbreaks in Kenya and Sudan have resulted in thousands of human cases, alongside significant livestock mortality (Peyre *et al*., 2015; Hassan *et al*., 2011).

Beyond direct health consequences, bovine zoonoses impose substantial socioeconomic burdens. The treatment of these infections generates significant healthcare costs, particularly in low-income communities with limited access to medical resources. Additionally, chronic zoonotic diseases contribute to lost workdays and reduced productivity in agricultural and livestock sectors, further straining economic stability.

People Exposed to Risks of Contagion

Zoonotic pathogens can spread to humans through any point of contact with domestic or wild cattle. Markets where beef or buffalo meat is sold have a particularly high risk due to the high number of new or unrecorded pathogens known to exist in wildlife populations (Amona *et al*., 2016; Klous *et al*., 2016). Agricultural workers in areas with high antibiotic administration to cattle may be at increased risk of pathogens resistant to current antimicrobial drugs. People living near wild areas or in semi-urban areas with higher numbers of wild animals are at risk of contracting buffalo-borne diseases. Urbanization and the destruction of natural habitats increase the risk of zoonoses by increasing contact between humans and wild animals (Boukary *et al*., 2014; WHO, 2022).

Control and Prevention Strategies for Bovine Zoonoses

Effective surveillance and monitoring are crucial for controlling zoonotic diseases. Tools like the WHO and FAO Zoonoses Prioritization Tool help African countries identify the most critical zoonoses for targeted interventions (WHO, 2022). Globally, the Global Early Warning System (GLEWS), a collaboration between WHO, FAO, and OIE, tracks emerging zoonotic diseases, including those affecting sub-Saharan Africa (FAO, 2021). In countries like Nigeria and Ethiopia, meat inspection programs have been implemented to detect bovine tuberculosis and cysticercosis in slaughtered animals (Meseko *et al*., 2021). Regular screening programs for Mycobacterium bovis (bovine tuberculosis) and Brucella abortus (brucellosis) help identify and cull infected animals, reducing disease spread (Mather *et al*., 2016). Additionally, post-mortem meat inspections at slaughterhouses play a key role in preventing contaminated meat from entering the food chain and posing risks to public health.

Vaccination remains one of the most effective strategies for controlling bovine zoonoses, with WHO, FAO, and OIE supporting various campaigns. Mass vaccination against brucellosis using Brucella abortus S19 and RB51 vaccines has helped control infections in endemic regions (Lubroth *et al*., 2007; Barrett *et al*., 2022). For Rift Valley Fever (RVF), emergency vaccination campaigns, such as the 2018 outbreak response in Kenya, have been coordinated to prevent widespread transmission (Mwacalimba *et al*., 2025). Similarly, periodic livestock vaccinations in Uganda and Zambia have significantly reduced anthrax outbreaks (Mudenda *et al*., 2023). Despite their effectiveness, vaccination programs face several challenges, including inadequate cold chain infrastructure in remote areas, low farmer participation due to financial constraints and lack of awareness, and political instability that disrupts vaccination efforts.

The misuse of antibiotics in livestock farming has contributed to the rise of antimicrobial resistance (AMR), making zoonotic disease treatment increasingly difficult. Unregulated antimicrobial use for disease prevention and growth promotion has accelerated resistance, prompting organizations like the FAO to implement an Action Plan on AMR, promoting responsible antibiotic use in livestock (FAO, 2016). The WHO's Global Action Plan on AMR has also helped establish surveillance programs in African countries like Tanzania and South Africa (Elton *et al*., 2020). Some nations are exploring alternative strategies, such as probiotics and herbal remedies, to reduce antibiotic dependence in livestock (Arsene *et al*., 2021). However, many farmers continue to self-administer antibiotics without proper veterinary oversight, further exacerbating AMR and complicating zoonotic disease control (Mather *et al*., 2016).

The One Health approach integrates human, animal, and environmental health to effectively combat zoonotic diseases. Strengthening collaboration between veterinary and human health sectors is a key focus of the FAO-OIE-WHO Tripartite partnership. Public education and awareness campaigns have played an essential role in disease prevention, such as those in Nigeria, where initiatives promoting milk pasteurization have helped reduce human brucellosis cases (Meseko *et al*., 2021). Improving sanitation and waste management is also important; WHO-supported clean water projects in pastoral communities have helped reduce the spread of *Taenia saginata* (Anyango *et al*., 2023). Enforcing food safety regulations, including milk pasteurization and thorough meat inspections, enhances consumer protection against zoonotic infections. Additionally, controlled animal movement through quarantine measures helps prevent the cross-border spread of diseases, safeguarding both livestock and human populations.

Recommendations for Strengthening Zoonotic Disease Control

To enhance the control and prevention of bovine zoonoses in sub-Saharan Africa, a combination of policy interventions and practical solutions is essential. Expanding vaccination coverage is a critical step, requiring increased investment in thermostable vaccines that can be easily distributed to remote areas. Strengthening antimicrobial resistance (AMR) policies is also necessary by enforcing strict regulations on antibiotic use in livestock and promoting alternative disease control strategies such as improved biosecurity. Additionally, improving disease surveillance through the use of digital reporting systems can enable real-time tracking of zoonotic outbreaks, facilitating faster responses and containment measures.

Strengthening veterinary services and disease surveillance is fundamental to effective zoonotic disease control. Expanding disease reporting systems and enhancing laboratory diagnostic capacities will improve early detection and response. Coordination between veterinary and public health authorities should be reinforced to ensure a unified approach to disease prevention. Vaccination programs also require significant improvement, with greater investment in vaccine research and local production. The development of thermostable vaccines that do not require refrigeration would further increase accessibility and effectiveness, especially in rural areas where cold chain infrastructure is limited.

Promoting responsible antibiotic use is another crucial measure in mitigating zoonotic risks. Regulations on antimicrobial use in livestock must be strictly enforced to curb the rise of antimicrobial resistance. Alternative disease control strategies, such as improved farm biosecurity, should be encouraged to reduce reliance on antibiotics. Additionally, improving public health measures can significantly reduce zoonotic transmission. Expanding educational campaigns on food safety and hygiene will increase awareness among farmers and consumers. Strengthening meat inspection protocols and enforcing food safety laws will further ensure that contaminated animal products do not enter the human food chain.

Enhancing public-private partnerships is vital in securing the necessary funding and resources for zoonotic disease control programs. Collaboration with non-governmental organizations (NGOs) and private sector stakeholders can support large-scale vaccination campaigns, disease monitoring initiatives, and educational outreach efforts. By integrating these strategies, sub-Saharan African countries can strengthen their defenses against bovine zoonoses and protect both animal and human health.

CONCLUSIONS AND RECOMMENDATIONS

Bovine zoonoses remain a significant public health and economic concern in sub-Saharan Africa, affecting both livestock productivity and human well-being. The major bovine zoonoses that persist in the region are brucellosis, tuberculosis, anthrax and salmonellosis (bacterial zoonoses) as well as the Rift Valley Fever (Viral zoonosis) and parasitic zoonoses such as bovine fasciolosis, bovine toxoplasmosis, bovine cysticercosis and bovine trypanosomiasis. The prevalence of these diseases varies from one area to another depending on various factors. The primary risk factors for these diseases are related to climatic and environmental conditions, animal movement and trade, farming practices, proximity to wildlife, hygiene and biosecurity measures, as well as limited access to veterinary services and inputs. The findings highlight the economic burden associated with reduced livestock productivity, trade restrictions, and increased healthcare costs. Some diagnostic and treatment methods exist but challenges such as inadequate healthcare infrastructure, antimicrobial resistance, human-livestock interactions and limited vaccination coverage hinder effective disease management. The persistence of these zoonoses highlights the need for strengthened surveillance, improved biosecurity, and coordinated control strategies. This includes implementing a One Health approach that integrates human, animal, and environmental health to mitigating the impact of zoonotic diseases on public health and livestock productivity. Additionally, expanding vaccination programs, enforcing food safety regulations and promoting a comprehensive strategy that includes policy interventions, public awareness campaigns, and international collaboration will help improve animal health, safeguard public health, and enhance agricultural productivity, ultimately contributing to regional food security and economic stability. Given the growing concerns of antimicrobial resistance and climate change, future research should focus on innovative control strategies, including the development of thermostable vaccines and alternative disease mitigation approaches.

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NOVELTY STATEMENTS

The novelty of this paper lies in its comprehensive analysis of bacterial, viral, and parasitic zoonoses in cattle. It examines the economic and public health impacts of these diseases on humans and proposes preventive control measures for such zoonotic pathogens.

AUTHOR'S CONTRIBUTIONS

Djibril D, Bothon D and Adjibode G: Definition of the Title, plan, redaction of introduction, conclusions, recommendations and active participation to writing all aspects of the article, plus references and annex.

Djegui F, Allanonto V and Akpata Desire A: Writing of Concept and Bovine Zoonoses in sub-Saharan Africa.

Aholou R and Boko K: Writing of: Summary and epidemiology of bovine Zoonoses in Sub-Saharan Africa.

Farougou S and Koutinhouin GB: Wrote the impact of Zoonoses on Animal And human productivity.

Conflict of Interest

The authors have declared that no competing interest exists.

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