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Review Article

Enhancing Veterinary Services for Smallholder Farmers in Zimbabwe: A Comprehensive Literature Review

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In Zimbabwe, the smallholder farming sector holds over 90% of the country's livestock, playing a vital role in the rural economy. However, low productivity and livestock offtake persist due to various challenges, primarily stemming from animal diseases. This literature review examines the provision of veterinary services in the smallholder sector, focusing on the Zimbabwean context. Through a desktop review of published literature, the study investigates the evolution of veterinary services for smallholder farmers, the key actors involved, and their interactions. It also explores the challenges faced by farmers in accessing veterinary services and identifies the gaps in and scope of service provision with a view to identifying ways of improving service delivery. The study showed that the arrangements for the provision of veterinary services to smallholder farmers in Zimbabwe were inadequate. The findings highlight the critical need for an integrated approach to service delivery, involving state veterinary services, the private sector, and community-based animal health workers. The paper concludes by offering recommendations on the specific roles of each service provider within an integrated system to enhance service provision in the smallholder sector. This research contributes to the understanding of effective veterinary services and their role in supporting agricultural growth in Zimbabwe.

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Introduction

Smallholder farmers in Zimbabwe, defined as those who manage areas varying from less than one hectare to 10 hectares, mostly subsistence-focused and relying primarily on family labour, constitute a vital segment of the agricultural sector. Their livestock holdings not only serve as a source of income but also contribute significantly to food security and rural livelihoods^{[1][2]}. However, the provision of veterinary services to support the health and productivity of these livestock has been a persistent challenge in Zimbabwe, leading to significant economic losses and threatening the sustainability of smallholder farming systems.

The problem of inadequate veterinary services in the smallholder sector is well-documented in the literature^[3] (Kusina et al., 2018). The inadequacy of current veterinary services in Zimbabwe has resulted in numerous livestock deaths and economic losses experienced by smallholder farmers^[4]. This situation is further exacerbated by the lack of a viable and sustainable animal disease control service tailored to the specific needs and circumstances of smallholder farming communities.

In Zimbabwe, the Department of Veterinary Services (DVS) plays a central role in delivering veterinary care. However, the current system falls short in terms of availability, accessibility, and cost-effectiveness, particularly for smallholder farmers who are often located in remote rural areas^[3]. A study by Ilukor^[5] emphasizes the need for a conducive arrangement that promotes collaboration between veterinarians and para-veterinarians to ensure that there is timely and efficient reporting, treatment, and control of animal diseases.

The lack of legal recognition and a clearly defined role for non-veterinarians within the veterinary system poses additional challenges. Without a proper legislative framework, the relationships between para-professionals/paravets, private veterinary services, and public sector veterinary services remain ambiguous, hindering effective coordination and service delivery. For the purposes of this study, paravets shall be used to denote all non-veterinarians conducting animal health work. The study by Leonard^[6] points out that this lack of clarity often results in paravets' work being regarded as threatening the livelihoods of veterinarians and the integrity of the veterinary profession, rather than as potential allies in addressing the veterinary needs of smallholder farmers.

In light of the aforementioned challenges, this article presents a comprehensive literature review aimed at enhancing veterinary services for smallholder farmers in Zimbabwe. By synthesizing existing research, identifying gaps, and proposing strategies for improvement, we aim to contribute to the ongoing discussions and efforts to establish a more effective and inclusive veterinary services delivery system. Through an examination of the literature, we explore potential mechanisms for improving availability, accessibility, and cost-effectiveness while fostering collaboration and improving community participation.

By conducting this comprehensive review, we seek to provide valuable insights that can inform policy development, provide guidance to future research, and ultimately contribute to the sustainability and resilience of smallholder farming systems in Zimbabwe.

Methods and Materials

A systematic review of peer-reviewed literature on livestock production systems and veterinary service provision to smallholder farmers was conducted. The aim of the study was to find journals and articles to map the existing knowledge on veterinary service provision to smallholder farmers and identify the gaps and scope of service provision now and in the future with reference to the Zimbabwean situation. Searches were conducted on ResearchGate, Academia, and Google Scholar using the keywords `veterinaryservices+provision+smallholder farmers+Zimbabwe`. The papers and articles were screened on the basis of title and abstract. Citation searching involved browsing reference lists and following them up on Google Scholar. A

total of 60 articles were reviewed, and 45 were selected as relevant. The saturation point was reached when there was consistency in the findings.

Findings

Smallholder Livestock Sector in Zimbabwe

The livestock sector plays a significant role in promoting wealth creation and poverty alleviation in rural communities of Zimbabwe^[7]. Livestock serves as a crucial component of sustainable food systems, providing a source of animal protein and other essential nutrients^[1]. In many rural areas, the rearing of livestock, including cattle, sheep, goats, pigs, and chickens, contributes substantially to family food supplies through the provision of meat, milk, and eggs, which are essential for community health and the proper development of children^[8]. Additionally, livestock provides draught power and manure, supporting the production of staple foods^[2]. They also act as a form of wealth storage and insurance against emergencies, such as crop failure due to drought, while generating cash income to meet family financial needs^[9]. Animal sales serve as monetary reserves for families and facilitate access to goods and social services, while livestock ownership is often associated with affluence, social status, prestige, and security.

Moreover, livestock plays a vital role in cultural practices and ceremonies within Zimbabwean communities. Livestock, with their diverse species, are integral to festivals and broader socio-cultural rituals, serving to strengthen relationships and settle disputes. Livestock are slaughtered as part of celebrations, such as weddings, funerals, and religious festivals^[10]. The strong cultural attachments to livestock often make farmers reluctant to sell their stock, even in the face of impending droughts^[2].

The second Crop and Livestock Assessment report of the 2020-21 season indicates that the smallholder sector in Zimbabwe holds a substantial share of the national livestock herd. It is estimated that the smallholder sector accounts for 90% of the nearly 5.5 million national cattle herd, 98% of the 4 million goat flock, 90% of the 0.7 million sheep flock, and 80% of the 0.3 million pig herd^[11]. Enhancing livestock production and productivity in the smallholder sector becomes essential for improving the overall contribution of the livestock and agriculture sector to the national gross domestic product (GDP) and the livelihoods of rural communities^[12].

However, diseases pose a significant constraint to livestock production in Zimbabwe's smallholder sector, threatening food security, economic development, and human well-being. The most common diseases reported are the tick-borne diseases: heartwater, babesiosis, anaplasmosis, and theileriosis, with heartwater being the single most prevalent tick-borne disease, rated as the most predominant tick-borne disease^[13]. Other diseases of significant importance include blackleg, Lumpy skin disease, internal parasites, mastitis, Newcastle Disease, Fowl pox, and internal and external parasites. Other cases reported included pulpy kidney, rabies, and abscesses. The country has experienced multiple outbreaks of animal diseases, which have had detrimental impacts on rural households and their livelihoods^[3]. Many livestock produced by smallholder farmers fail to achieve their full productivity potential as a result of disease-related deaths or the negative impact of production-limiting diseases

and disorders^[14]. The risks associated with animal diseases are believed to be higher for the smallholder sector compared to the commercial sector. This discrepancy is in part due to poor infrastructure and limited resources in the smallholder sector, which make the provision of veterinary services particularly challenging in smallholder areas^[15]. Effective delivery of veterinary services becomes crucial in improving livestock productivity, protecting livelihood assets, ensuring food safety, and promoting the well-being of humans^[16]. Enhancing access to veterinary services for smallholder farmers has shown promising results in improving their livelihoods^[17].

According to the World Organisation for Animal Health (WOAH), Veterinary Services are defined as arrangements for providing animal health care and welfare measures^[18]. The WOAH has set standards and recommendations for the provision of veterinary services, emphasizing the need for appropriately staffed systems, competent personnel, functional structures, and supportive legislative frameworks^[18]. Veterinary services encompass curative and preventive services, the production and supply of pharmaceuticals, public health protection, and extension services^[19].

Curative veterinary services refer to the diagnosis and treatment of animal diseases, and the management of production-limiting disorders^[20]. Preventive veterinary services encompass interventions aimed at preventing disease transmission or occurrence, including vaccination, pest control, and sanitary measures^[20]. The production and supply of pharmaceuticals refer to the availability of veterinary vaccines, medicines, and biological products used for preventive and curative purposes^[21]. Human health protection, also known as veterinary public health, involves sanitary measures to protect humans from diseases originating from animals or animal-sourced food, such as presale antemortem inspection of livestock at markets and meat inspection at abattoirs^[20]. Veterinary extension services, also known as promotive veterinary services, include all management measures that are specifically designed for the purposes of fostering an increase in animal productivity and its general health. They aim to enhance livestock productivity and health through management measures and decentralized extension services^[19].

Establishment and growth of Veterinary Services in Zimbabwe

The origin and development of veterinary services in Zimbabwe have been shaped by historical and contemporary factors, including colonial influences, post-independence reforms, and external pressures such as Structural Adjustment Programmes (SAPs) and the Land Reform Programme^[22]. During the colonial era, the veterinary services in Zimbabwe were primarily focused on controlling diseases such as Rinderpest. However, these services were centralized around the settlers, and the provision of veterinary care was racially biased, with limited access for native Africans. Livestock disease control was used as a means of social control, reinforcing the alleged superiority of European settlers^[22].

After independence, the government recognized the need to restructure the veterinary services to ensure equitable access for smallholder farmers. Efforts were made to decentralize the services and provide necessary resources. The establishment of veterinary training institutions, such as the Faculty of Veterinary Science at the University of Zimbabwe and the Mazowe Veterinary

Institute (now Mazowe Veterinary College), aimed to train veterinarians, government veterinary extension workers, and animal health inspectors. Animal Health Management Centres (AHMCs) staffed by Veterinary Extension Workers (VEWs) were established to provide preventive, curative, and promotive veterinary services to smallholder farming areas. Provincial and district veterinary offices were also opened to improve service delivery^[23].

Up until the year 2000, disease control measures were implemented, including strict dipping regimes, livestock vaccinations, and movement control, which were supported by a robust legal framework. The DVS received substantial budgetary support from the European Union (EU) and achieved significant success in exporting beef. The aim was to have a qualified veterinarian heading every district, and while progress has been made in this regard, dwindling resources have hindered the effective execution of field operations^[23]. In the late 1980s, Zimbabwe, like many other African countries, adopted SAPs under pressure from the World Bank. These programs favoured market principles over free public services. The expectation was that the private sector would provide veterinary services, but in most cases, the market approach did not meet expectations. Institutional arrangements were put in place, including the commercialisation of some services and the establishment of Community Animal Health Worker (CAHW) systems.

The post-independence development of Zimbabwe's veterinary services is also closely linked to the Land Reform Programme of the 1990s. This program aimed to address historical land inequalities by acquiring white-owned farms and redistributing land to indigenous Zimbabweans. However, the land reform had negative impacts on veterinary control measures. Uncontrolled livestock movement, vandalism of veterinary fences, and inadequate infrastructure and personnel in newly resettled areas disrupted disease prevention protocols, leading to the occurrence and spread of animal diseases^{[24][22]}.

While efforts have been made to improve veterinary services in Zimbabwe, challenges remain, particularly in terms of resource allocation. The increase in the number of veterinary staff has not been matched with the provision of requisite resources such as transportation and pharmaceuticals, limiting the effectiveness of field operations. Furthermore, the adoption of SAPs and the Land Reform Programme has presented additional obstacles to the provision of veterinary services^[6] (Centre for Public Impact, 2017).

Main actors in the provision of veterinary services in the smallholder sector

The provision of veterinary services in the smallholder sector in Zimbabwe involves multiple actors, including the public sector, private sector, community animal health workers (CAHWs), and ethnoveterinary practitioners^{[4][25]}. However, the dominance of non-veterinarians and the limited involvement of veterinarians have posed challenges to the quality and sustainability of veterinary services. The dip tank is the smallest governance unit of the veterinary services. The dip tank provides the infrastructure for cattle dipping, vaccinations, treatment, and inspection. A dip attendant mans the dip tank and works under the supervision of a Veterinary Extension Worker who is based at the Animal Health Management Centre (AHMC) located within the ward or in a neighbouring ward. Each AHMC may serve 2-6 dip tank areas depending on the settlement pattern. The services provided are primarily preventive and

promotive (extension) and, to some extent, curative. The Veterinary Extension Workers are backstopped by and report to the Government Veterinarians who are based at the district centres.

Historically, the provision of veterinary services in Zimbabwe was primarily the responsibility of the Government Services, mainly focused on protecting large-scale, commercial farming areas, with hardly any presence in the smallholder agriculture sector^[22]. The public sector, through the DVS, has been the main provider of veterinary services to smallholder farmers. This dominance can be attributed to the perception that smallholder farmers are unable to afford private services, leading to the provision of free services by the public sector. However, this approach is known to have crowded out other service providers and suppressed the participation of the private sector in the smallholder sector^[26].

The private sector has the potential to play a crucial role in providing veterinary services to smallholder farmers. However, there are several challenges inhibiting private-sector investment in this sector. These challenges include low productivity in the sector, high transactional costs such as transport, and inadequate infrastructure to promote business development. The aggregate demand for private veterinary services is often lower than is required for profitable operations, and the high transaction costs associated with service provision in remote areas make the services expensive for farmers^[26]. Despite these challenges, the private sector can contribute by supplying veterinary drugs and equipment to improve the availability of veterinary inputs in the smallholder sector.

Community Animal Health Workers (CAHWs) have emerged as important actors in the provision of primary animal health services at the local level. CAHWs are lead farmers who are selected by their communities to undergo training so that they can provide primary animal health care services at the community level^[27]. They can bridge the gap between state veterinary authorities and livestock farmers and form an integral part of an integrated veterinary services provision system. In Zimbabwe, a significant number of CAHWs have been trained under donor-funded programs and have been involved in activities such as Newcastle Disease vaccination.

While community animal health programs have shown potential for providing cost-effective veterinary services to rural communities, their long-term sustainability beyond project funding has been a concern. However, studies have indicated that the demand for CAHW services is high among smallholder farmers, surpassing the demand for DVS services^[4]. CAHWs' residency in the communities they serve enables them to provide timely and accessible services. Critics argue that the dominance of non-veterinarians in veterinary service delivery has led to a decline in service quality, which can have implications for food security^{[28][29]}.

Ethnoveterinary practitioners have also emerged as significant actors in providing primary veterinary services in the smallholder sector in Zimbabwe. Smallholder farmers often resort to indigenous practices due to the unavailability and high cost of conventional veterinary medicines^[25]. These practices are seen as cheap, locally available, and sustainable alternatives to conventional medicines. However, there is a need for scientific validation and documentation of the effectiveness and potential side effects of ethnoveterinary practices^[30].

Overall, the provision of veterinary services in the smallholder sector in Zimbabwe involves a mix of actors, including the public sector, private sector, CAHWs, and ethnoveterinary practitioners; however, there is no evidence of collaboration among the service providers. While each actor has its strengths and limitations, collaboration and coordination among these actors can lead to improved veterinary service delivery, better access to veterinary inputs, and enhanced livestock health management in smallholder farming areas.

Supply of veterinary pharmaceuticals to smallholder farmers

The availability, access, and proper use of veterinary pharmaceuticals are critical for the success of veterinary interventions in the smallholder sector in Zimbabwe. However, smallholder farmers in Sub-Saharan Africa, including Zimbabwe, face significant challenges in accessing veterinary medicines^[31]. Previously, smallholder farmers in Zimbabwe used to obtain veterinary drugs from Animal Health and Management Centres (AHMCs), but hyperinflation and the disbanding of the drug revolving fund system within the DVS have disrupted this supply chain (DVS, personal communication). As a result, farmers now have to travel to nearby towns or service centers, incurring high transport costs, to obtain the necessary drugs.

This scarcity of veterinary medicines has created opportunities for opportunistic individuals who take advantage of the unavailability of drugs and the lack of information among the farmers. As noted by ^[31], the supply of veterinary drugs in sub-Saharan Africa has been taken over by private non-professional actors. These individuals sometimes sell falsified, substandard, or improperly stored drugs, leading to improper use and potential risks to animal health and antimicrobial resistance. Farmers have reported purchasing veterinary drugs from roadside markets known as "baccosi," where sellers often have limited knowledge of the drugs and do not provide appropriate instructions for use.

Studies conducted in other countries have also highlighted similar challenges. ^[32] found that farmers in Cameroon administered subtherapeutic doses of veterinary drugs due to a lack of knowledge, which increases the risk of antimicrobial resistance. ^[33] observed that a significant percentage of veterinary products available in South Kivu, Congo, were not up to standard. The sale of counterfeit and substandard veterinary products not only leads to treatment failures but also erodes farmers' confidence and contributes to the development of resistance among disease-causing microbes.

To address these challenges, an effective veterinary system should ensure the availability of quality veterinary drugs and take measures to penalize the sale of substandard drugs^[33]. Additionally, addressing the limited knowledge among smallholder farmers regarding the proper use of veterinary drugs is crucial. Cases of farmers failing to comply with recommended treatment protocols due to limited knowledge have been identified as a major cause of treatment failures^[32] ^[34].

Promoting public-private partnerships has the potential to enhance the availability and access to veterinary drugs for smallholder farmers in Zimbabwe. Collaboration between the public and private sectors can help establish sustainable supply chains, improve drug quality control, and provide educational initiatives to enhance farmers' knowledge about proper drug usage.

Human health protection in the smallholder sector

In the smallholder sector, livestock is slaughtered for various purposes, including home consumption, sale, or as part of celebrations and ceremonies. However, the slaughtering practices often do not take place at registered hygienic slaughter facilities and are not subject to inspection^[35]. Additionally, there are instances where animals that have died from diseases or unknown causes are processed for human consumption. This situation presents a significant challenge in terms of zoonotic disease transmission, posing risks to human health.

Although government veterinary technical staff and environmental health technicians under the Ministry of Health can conduct inspections upon request, the reality on the ground indicates that farmers rarely seek these services. This lack of awareness or limited access to service providers due to geographical distance hinders the implementation of proper inspections and monitoring of meat safety. It is crucial to intensify awareness-raising efforts to educate smallholder farmers about the dangers associated with consuming uninspected meat and the importance of safeguarding public health^[36].

Zoonotic diseases are infectious diseases that can be transmitted between animals and humans. By consuming meat from animals that have not undergone proper inspection and slaughter procedures, individuals increase their risk of contracting zoonotic infections. Some common examples of zoonotic diseases include anthrax, brucellosis, salmonellosis, and cysticercosis. To mitigate these risks and protect public health, several strategies can be implemented. These include:

- Strengthening extension services: Government veterinary and health departments should collaborate to provide outreach services to smallholder farmers. This involves conducting training programs and awareness campaigns to educate farmers about the importance of proper slaughtering practices, meat inspection, and zoonotic disease prevention^[37].
- Enhancing collaboration between veterinary and health sectors: Government agencies responsible for veterinary services and public health should work together to develop integrated surveillance and response systems for zoonotic diseases. This collaboration can help identify potential disease outbreaks and implement timely interventions to protect both animal and human health^[37].
- Strengthening disease surveillance and reporting: Encouraging farmers to report any suspicious animal illnesses or deaths to veterinary authorities can aid in the early detection and prevention of potential zoonotic disease outbreaks. This information can also guide targeted interventions and awareness campaigns^[38].
- Promoting good animal husbandry practices: ^[39] suggest that educating smallholder farmers about proper animal husbandry practices, such as disease prevention, vaccination, and regular veterinary care, can contribute to overall livestock health and reduce the risk of zoonotic disease transmission.

State of veterinary services provision in the smallholder sector

It is widely recognized that the provision of veterinary services to smallholder farmers in Sub-Saharan Africa and other developing nations is a significant challenge^[40], and Zimbabwe is no exception. In Zimbabwe, veterinary services for smallholder farmers are generally provided for free or are highly subsidized by the state through the DVS. However, the public veterinary services in

Zimbabwe have faced documented challenges, leading to the need for reforms. These challenges include insufficient professional and technical staff, limited resources, and inadequate investment in the sector^[41].

Studies conducted elsewhere have also highlighted the limited access to veterinary services for smallholder livestock owners, as officials often prioritize farmers with better resources who can provide incentives^[20]. Findings indicated that a reduction in resource allocation to public veterinary services resulted in decreased coverage and delivery of services to smallholder farmers^[20].

The performance evaluation reports of Veterinary Services (PVS) conducted by the WOA in 2009 and 2014 concluded that veterinary services in Zimbabwe fell short of optimal levels, leading to the failure of previously successful animal disease control programs^[41]. The reports highlighted inadequate supervision of field operations by veterinarians and a lack of trained paraprofessionals to support them^[41]. The existing arrangements for providing veterinary services were deemed grossly inadequate.

The increased number of animal disease outbreaks and the high mortality rates reported in Zimbabwe in recent times further demonstrate the lack of capacity to prevent and control livestock diseases in the smallholder sector^[13]. Animal disease outbreaks have had a significant negative impact on the economy, particularly in the drier areas of the country where livestock is crucial for rural livelihoods^[4].

Addressing the challenges in veterinary service provision requires strategic management and organization of the veterinary services system, as identified in the WOA report^[41]. The report emphasizes the need for a strategic review of the veterinary services system and the allocation of adequate resources to effectively deliver critical disease prevention and control programs.

Conclusion

The literature review highlights the inadequacy of current veterinary services for smallholder farmers in Zimbabwe, leading to significant livestock losses. To protect their livelihoods, smallholder communities urgently require a viable and sustainable animal disease control service. ^[4] suggest promoting the CAHW system to supplement the services offered by the DVS and enhance accessibility and cost-effectiveness for smallholder farmers. An integrated veterinary system that fosters collaboration and synergies between veterinarians and paraprofessionals, as well as incorporating community participation, may be effective in delivering quality veterinary services.

The lack of legal recognition and clear role definition for non-veterinarians within the veterinary structure contributes to controversies surrounding their involvement. It is crucial to establish a legal framework that recognizes the responsibilities and minimal training requirements for paravets, thus ensuring their incorporation into the veterinary system. Such a framework would enhance the governance and regulation of veterinary services, particularly for smallholder farmers. Furthermore, collaboration and referral networks between veterinarians and paraprofessionals, both from the public and private sectors, can address structural shortcomings in the livestock sector. This collaborative approach would improve disease surveillance, detection, reporting, and the prudent use of antimicrobial agents.

To ensure the success of involving multiple players in enhancing veterinary services, it is essential to consider the demand for services from livestock farmers. Consultation with farmers and obtaining their input regarding structural changes in the provision of veterinary services is vital. Their decision-making regarding the health of their livestock needs to be considered, ensuring that the services provided are perceived as valuable and outweigh the associated costs.

Improving the access of smallholder farmers to effective veterinary services is essential for enhancing livestock productivity, protecting livelihoods, and promoting human health. Public-private partnerships and a decentralized approach to extension services can play a vital role in improving service delivery and disease prevention measures, leading to improved livestock production and overall well-being. This study concluded, therefore, that the most ideal model arrangement for the provision of veterinary services to the smallholder sector is an integrated arrangement bringing together CAHWs, government veterinary services, and private sector drug supply companies, with DVS playing the central coordinating role. Under this arrangement, the CAHWs will be the frontline cadre for providing primary animal health care, local-level surveillance, and disease reporting, as well as the first responder working directly under the supervision of the government veterinary extension worker. The private sector, through a public-private partnership arrangement, assumes the role of supplying veterinary drugs and dipping chemicals. DVS takes the overall responsibility for animal disease control through coordinating the private sector, CAHWs, and any other stakeholder involved in animal health services, providing preventive and curative services, as well as administering the provisions of the policies and regulations governing animal health issues. This conclusion is in tandem with the findings of^[28], which determined that a collaborative relationship among service providers resulted in an improvement in animal disease surveillance, detection and reporting of diseases, and proper use of veterinary drugs. Moreover, the disjointed and isolated nature of various actors supporting the livestock sector in Zimbabwe presents a structural shortcoming. To overcome this, the establishment of collaboration and referral networks between veterinarians and paraprofessionals, emphasizing the potential synergies and improved quality of veterinary services, is recommended.

By implementing a comprehensive and inclusive veterinary governance structure, Zimbabwe can establish a sustainable, practical, and cost-effective veterinary services delivery system for low-income smallholder farmers. This would involve promoting collaboration, legal recognition, clear role definition, and consultation with farmers to meet their needs effectively and efficiently.

Statements and Declarations

Author Contributions

Conceptualization: L. Maposa, E. C. Garwe; Methodology: L. Maposa, E. C. Garwe; Investigation: L. Maposa, E. C. Garwe, G. G. Nyamushamba; Resources: L. Maposa, E. C. Garwe, G. G. Nyamushamba; Writing – Original Draft: L. Maposa; Writing – Review & Editing: E. C. Garwe, G. G. Nyamushamba; Supervision: E. C. Garwe; Project Administration: L. Maposa.

Data Availability

The data supporting the findings of this review are available within the cited references. Further inquiries can be directed to the corresponding author.

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