Health challenges, mortality patterns, and factors affecting survivability of indigenous and crossbred goat strains managed on station in the central zone of Tanzania

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SUMMARY

The study was designed to assess health challenges, mortality patterns, and factors influencing the survivability of Gogo white × Boer crossbred and pure Gogo white goats raised on the station at the Tanzania Livestock Research Institute (TALIRI), Kongwa, Dodoma, Tanzania. Secondary data on mortality, diseases, and causes of goat mortality were collected spanning 10 years (2011–2021). A total of 658 goats (312 males and 346 females) were included in the study, comprising 452 Gogo white × Boer crosses and 206 pure Gogo white goats. Data were analyzed using SPSS version 20. The results revealed that the main cause of death was pneumonia (24.0%), followed by diarrhea (15.3%), poor nutrition (14.7%), and predation (13.3%). The overall average mortality rate for the entire study period was 22.80%. Additionally, the results showed that season significantly affected survivability, whereby kids born during the dry season had markedly reduced survivability by 3.78 folds at 95% CI of 2.54–5.62 compared to those born during wet season. Moreover, the year of birth significantly influenced survivability by 3.278-fold at 95% CI of 2.18-4.93. The study identified pneumonia, diarrhea, poor nutrition, and predation as the primary causes of mortality at TALIRI Kongwa. Crossbred goats (Gogo × Boer) were found to be more vulnerable to death compared to the local Gogo white breed. Furthermore, survivability was significantly affected by birth type (single or twin), season, and year of birth. The study recommends that improved management practices and better healthcare services should be addressed to reduce mortality rates and enhance the economic viability of goat production at the TALIRI Kongwa farm.

Keywords: Health challenges; Goat kids; Management practices; Survivability; Mortality

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INTRODUCTION

In Tanzania, approximately 30% of agricultural households engage in goat farming. Goats play a crucial role in supporting the livelihoods of agro-pastoral and pastoral communities, particularly in ensuring food security due to their high reproductive capacity and minimal investment (Magonka 2024). Goat farming predominantly involves the Small East African (SEA) goat breed, which is distributed in all

agro-ecological zones in Tanzania. The indigenous strains of SEA goats identified in the country include Gogo white, Ujiji, Sukuma, Maasai, Pare, Sonjo, Newala, and others (Hyera and Nguluma, 2017). Despite their potential, studies have indicated that indigenous goats generally exhibit lower productivity compared to crossbred types; thus, efforts have been undertaken to improve the productivity of SEA goats, especially for meat, by crossbreeding with other breeds, such as Boer from South Africa. According to Ngongolo and Mmbaga (2022), crossbred goats tend to outperform indigenous goats in terms of productivity. However, high mortality, poor nutrition, and disease prevalence are some of the major challenges limiting production of crossbred goats in central semi-arid areas of Tanzania. Several studies have identified health challenges hindering the performance of crossbred goats (Abebe, 2022; Guliye et al., 2019; Bhatti et al., 2020; Zeleke et al., 2022; Tajonar et al., 2022). For instance, according to Abede (2022), disease and parasite incidences and poor veterinary services are major reasons for poor performance of crossbred goats. A study conducted by Guliye *et al.* (2019) evaluated the health challenges of crossbred goats and found that crossbred goats were more susceptible to respiratory diseases compared to purebred goats. Therefore, despite the significance of crossbred goats, their performance can be affected by different health issues.

In addition, limited availability and poor-quality feed resources is another key challenge affecting the performance of crossbred goats. Inadequate access to nutritious feed negatively impacts their growth and productivity (Nchimbi-Msolla et al., 2018). Many farmers rely on crop residues and byproducts, especially during dry seasons, but these feeds, such as maize stover, rice straw, and wheat straw, are high in fiber, low in protein, and poorly digestible (Mtenga et al., 2020). Additionally, crossbred goats often experience mineral deficiencies, including calcium, phosphorus, selenium, and copper (Mlay et al., 2020). Limited access to quality mineral and protein supplements further hinders efforts to meet nutritional needs and achieve optimal goat performance (Mwacharo et al., 2019).

Moreover, the welfare challenges, such as housing limitations, poor management practices, mechanical injuries, and social interactions, significantly impact a goat's performance, productivity, and overall well-being. Likewise, insufficient space can lead to overcrowding, restricted movement, and increased aggression among goats (Mekonnen *et al.*, 2018). Aggression and social stress among goats can lead to reduced feed intake, reduced growth, and poor reproductive performance between crossbred goats. According to Msalya *et al.* (2020), inadequate housing conditions, poor sanitation, and improper handling practices contribute to stress, injuries, and increased vulnerability of goats to diseases. Generally, welfare challenges impose stress and aggression on goats, thereby reducing their production performance. In order to improve welfare, goats should be free from hunger, thirst, bad handling, stress, and overcrowding at all times. These challenges not only reduce herd replacement rates but also result in substantial economic losses to smallholder farmers.

Despite the presence of various studies on challenges facing goat production (Tsegaye *et al.*, 2013; Ershaduzzaman *et al.*, 2007; Gamit *et al.*, 2020; Shija *et al.*, 2014; Slayi *et al.*, 2014), there is a paucity of information regarding the performance of goats in the central zone of Tanzania. Thus, this study explored the challenges facing the production of pure Gogo white and Gogo white x Boer crossbred goats, mortality patterns, and the factors influencing the mortality rates in these two goat breeds/genotypes at TALIRI Kongwa. The information obtained from this study will provide valuable insights for crossbred goats in the tropics.

METHODOLOGY

Study Area

The study was carried out at the Tanzania Livestock Research Institute (TALIRI) located in Kongwa District, within the Dodoma Region of central Tanzania. Geographically, Kongwa is situated at approximately 06°11′34″ South latitude and 36°24′26″ East longitude. The district spans an area of 4,041 km² and is subdivided administratively into three divisions, 22 wards, 87 villages, and 383 hamlets. The region experiences a semi-arid climate, with an average annual rainfall of approximately 700 mm, predominantly occurring between November and April. The mean annual temperature is around 26.5°C. The Indigenous ethnic groups of the area include the Gogo, Kaguru, and Rangi communities, with livestock keeping, particularly of cattle, goats, sheep, and donkeys, being the primary economic activity.

Study design and Source of data

The retrospective longitudinal study design was used in this study, whereby 10-year (2011–2021) secondary data collected at TALIRI, Kongwa were used. The mortality and health challenges parameters facing Gogo and Gogo x Boer crossbred goats were collected and analyzed. During this period, both pure Gogo white goats and their first-generation (F1) crossbreeds with Boer goats were managed under a semi-intensive management system, with supplemental feeding provided during the dry season. The dataset comprised health and mortality records from 658 goats (312 males and 346 females). Out of this, 452 goats were Gogo x Boer crosses (209 males and 243 females), and 206 were Gogo goats (103 males and 103 females).

The health and mortality challenges data were collected at the TALIRI Kongwa goat breeding program. For each individual goat, factors such as sex, birth type, year of birth, and season were recorded.

Data analysis

MS Excel (2024) was used to organize the data, which was then analyzed using the Statistical Package for Social Sciences (SPSS). Descriptive statistics were employed to determine the frequencies of death causes, annual mortality rates, and overall mortality for the entire study period. The mortality data were further categorized by sex and breed. The frequency data for causes of death and mortality rates were then exported to an Excel sheet. Additionally, inferential statistics were performed using a binary logistic regression model to assess the effects of sex, birth type, season, and year of birth (as independent variables) on goat survivability (alive or dead. The binary logistic regression model equation is:

$$\frac{\text{Prob(alive)}}{\text{Prob(dead)}} = e^{\beta_0+\beta_t X_1+\cdots\beta_i X_i} \qquad (1)$$

Where, *e* raised to the power of the coefficient represents the factor by which the odds change when the i^{th} independent variable increases by one unit. If the coefficient is positive, E (β_i) >1, indicates an increase in odds. However, if the coefficient is negative, E (β_i) < 1, it indicates that the odds are decreasing. When the coefficient is zero, β_i =0, E (β_i) = 1, it shows that there is no change in odds. A binary logistic regression model was fitted with survivability (0 = dead, 1 = alive) as the dependent variable.

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RESULTS AND DISCUSSION

Cause of death in two breeds of goats

The causes of death are presented in Figure 1. The main cause of goat death was pneumonia (24.0%), followed by diarrhea (15.3%), poor nutrition (14.7%), and predation, such as eagle attacks and dog and hyena attacks (13.3%). Other causes were traumatic injuries, brain cysts, being born weak, PPR, dip wash, bloat, abscesses, worm infestation, and umbilical hernia. Worm infestation and umbilical hernia were the least causative agents of deaths in goats, with 0.7%. The high prevalence of diseases might be influenced by various factors such as season of birth (wet vs dry), sex of animal, breed, and year of birth. Another plausible reason might be due to the aridity of the Kongwa district, an environment that is favorable for the growth of disease agents, particularly during the rainy seasons (Marufu *et al.,* 2010).

On the other hand, predation was highly influenced by the season, whereby during the dry season, the incidence of attacks by predators was reported to increase (personal communication with the farm manager). This result is in agreement with Tsegaye *et al.* (2013), whose findings reported that the main causes of mortality in goats were diseases, predation, accidents, and poisoning, with an index of 0.30, 0.13, 0.10, and 0.01, respectively. Moreover, the current study is comparable to that of Enwelu et al. (2015), who found that high mortality in goats and sheep was caused by diseases (mean = 1.44) and poor feeding (mean = 1.03) among the Aguata community in Nigeria. Furthermore, the findings presented in Fig. 1 are consistent with those of Ngongolo and Mmbaga (2022), who reported that pneumonia (64.10%) was the leading cause of goat mortality, followed by diarrhea (22.44%) in the Mpwapwa District, Dodoma, Tanzania. Similarly, Shija et al. (2014) found comparable results, indicating that respiratory diseases, poisoning, and bloating were the major causes of death among dairy goats in the Mvomero and Kongwa districts of central Tanzania.

Effect of Year on mortality rates

Mortality rates of goats over the study period and mortality rates by breed, sex, and year of birth of goats are presented in Fig. 2 and Table 1, respectively. Higher mortality was experienced in the years 2017 and 2019, followed by 2020 and 2018. The year 2014 recorded the lowest mortality. The overall average mortality for the entire study period was 22.80% (2.2% per year). This result concurs with that reported by Ershaduzzaman *et al*. (2007), who reported the mortality rate in Black Bengal goat weaners to be 22.1% over a study period of one year. A similar level was also reported by Tifashe *et al*. (2017) in sheep (22.27%) in the Wolaita, Soddo, and Zuria districts in Ethiopia. However, the rate of mortality in the current study was relatively higher than that reported by Ngongolo and Mmbaga (2022), who reported a mortality rate of 9.48% in ten years of data (2010-2020) for two breeds of goats (Blended and Local goats) in Mpwapwa district, Dodoma central Tanzania. To the contrary, Shija *et al.* (2014) reported a lower mortality rate of 15.5% in dairy goats in the Kongwa and Mvomero districts of central Tanzania. The mortality rates were influenced by feed availability, drought, extreme weather conditions, endo- and ectoparasites, and diseases.

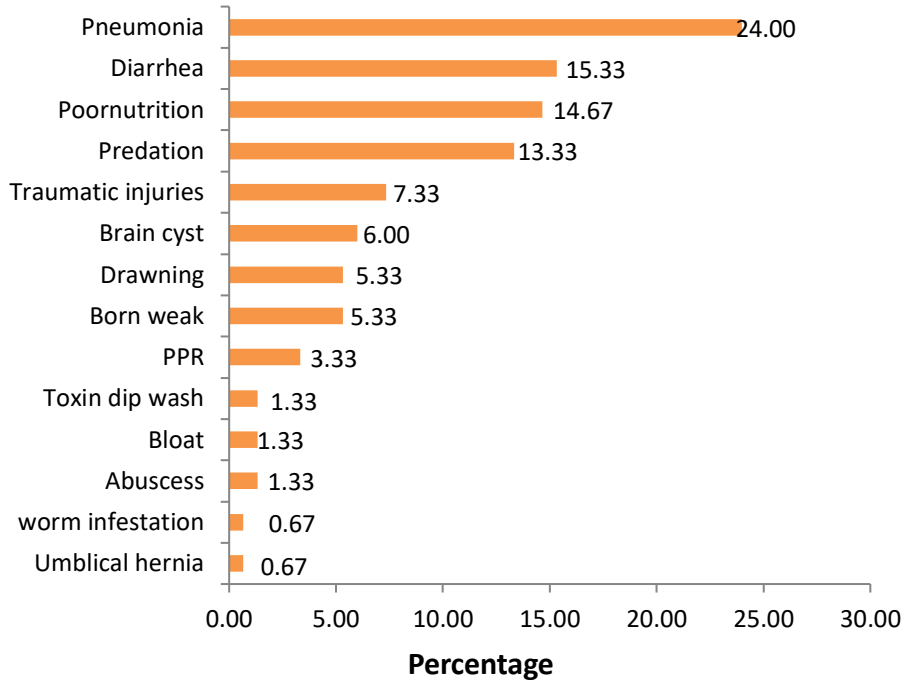

Figure 1: Frequency of the cause of death in two breeds of goats (Gogo and Gogo x Boer) at TALIRI Kongwa

Effect of Breed, Sex, and season on Mortality rates

Data for the current study shows that a total of 658 goats were born over 10 years from 2011 to 2021. Among them, 31.3% (206 goats, 103 males and 103 females) were the Gogo white breed/strain, while 68.7% (452 goats; 209 males and 243 females) were Gogo white x Boer crossbreeds. During the same study period, 150 goats died, with Gogo white goats accounting for 18.7% (28 deaths) and Gogo white x Boer crossbreeds up to 81.3% (122 deaths) (Table 1). The observed difference in mortality rate between Gogo white and Gogo x Boer crossbreds might be explained by the fact that indigenous goats are more resistant to harsh environments and diseases than crossbred goats and thus less susceptible to diseases and other environmental constraints. Thus, even though crossbreds have advantages in terms of growth performance, susceptibility to environmental constraints and disease susceptibility are the major drawbacks of crossbred goats compared to their counterpart indigenous goats. Moreover, this result is in line with Smith & Khumalo (2015), who reported that indigenous goats in South Africa showed genetic resistance to heartwater. All Saanens succumbed, and only one indigenous goat and two crossbreds died in a year. In addition, the current finding conforms with Habtegiorgis *et al*. (2024), who found that farmers in Southern Ethiopia perceived crossbred kids as more susceptible to disease and drought compared to indigenous kids. However, this result contradicts Ngongolo and Mmbaga (2022), who reported no consistent death trends between indigenous goats and crossbred goats (blended goats) in different years of their study period.

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The observed disparity in mortality between sexes highlights potential differences in vulnerability based on sex and calls for further investigation into management and biological factors influencing survivability in young goats. Results showed that out of 150 deaths, 56.7% (85 deaths) were females and 43.3% (65 deaths) were males. This might be attributed to the fact that in many cases, female kids are often retained for future breeding or milk production, while males may be sold or culled early. This longer retention period increases the likelihood of female kids being exposed to disease or management-related stressors for longer durations, which could elevate their mortality risk. Moreover, competition, especially during lactation, and competition at the weaning stage for feed may impact weaker or less dominant individuals more severely. If female kids are slightly smaller or less aggressive feeders than males, they may be at a disadvantage in accessing adequate nutrition, leading to weakened immunity and higher disease susceptibility. This result aligns with Toviesi et al. (2020), who found that female kids accounted for a higher pre-weaning mortality (74.1%) for days 1-10 compared to males. However, this finding contradicts Chauhan et al. (2019), whose finding found that male Sirohi goat kids in India had a higher hazard of death compared with female kids.

Moreover, of 150 deaths, 124 deaths (82.7%) were single births, and 26 (17.3%) deaths were twin births. It is generally believed that kids born as twins or multiples are at a higher risk of mortality due to shared intrauterine resources, lower birth weights, and increased vulnerability to stress and disease (Alphonsus et al., 2018; Yilmaz et al., 2011). However, in this study, a surprising pattern was observed whereby single-born kids accounted for the majority of mortalities (82.7%), significantly higher than their twin-born counterparts (17.3%). This might be explained by the population structure of the herd, as the majority of births were singletons (singles), so the higher number of deaths among single-born kids could simply reflect their numerical dominance.

Furthermore, data for the current study show that a total of 60 kids (40%) died in the wet season and 90 (60%) died during the dry season over 10 years (Table 1). The higher mortality during the dry season is likely linked to nutritional stress, which is one of the most prominent challenges faced by goat herds during this period. In many production systems, forage availability and quality decline significantly in the dry season due to reduced rainfall and pasture growth. This leads to nutritional deficiencies in both does and kids, affecting growth, immunity, and survival rates.

Under nutritional stress, does may produce less milk or milk of lower nutritional quality, which directly impacts kid survival, particularly in the pre-weaning period. Furthermore, weaner kids, who are transitioning to solid feed, may struggle to find sufficient nutrients during the dry months, making them more vulnerable to diseases and weight loss. In addition to nutritional limitations, the high temperatures and water scarcity typical of the dry season can cause heat stress in young kids. Heat stress is known to affect metabolic processes, immune function, and overall resilience. Without adequate shelter or access to water, kids may experience dehydration and thermal discomfort, further contributing to mortality risks (Maloiy et al., 2008). This study is similar to Cooke et al. (2024), who found that from the end of the wet season to the end of the dry season, forage quality declines, with crude protein levels decreasing and fiber content increasing, which in turn results in poorer nutrition, hence negatively impacting the growth, health, and survival of goats.

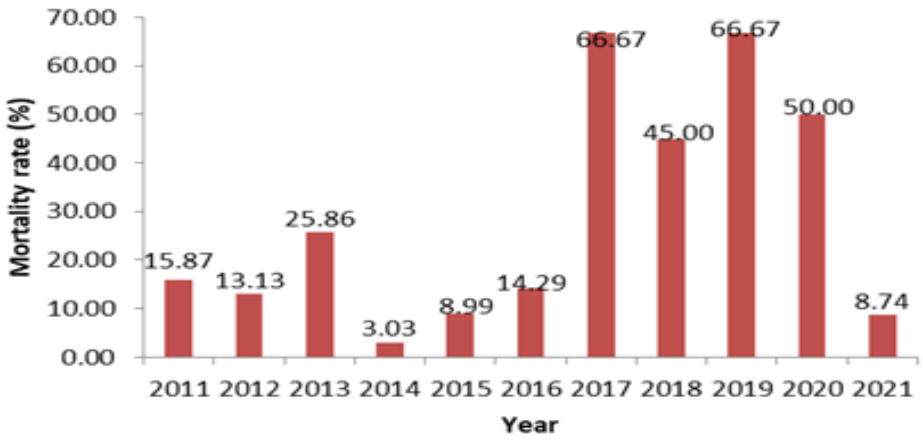

Figure 2: Yearly mortality rate (2011-2021)

Key factors affecting the survivability of goats

The binary logistic regression results are presented in Table 2. In sex, female was the reference, whereas in season, the dry period was the reference category. In the year of birth, participants were grouped into two categories: group 1 was 2011-2017, and the second group was 2018-2021; thus, the years 2011-2017 were the reference category in this study. The analysis revealed that season, and year of birth had statistically significant effects on goat survivability ($p < 0.05$), whereas the effect of sex was not significant ($p > 0.05$). The results showed that season significantly affected survivability, while kids born during the dry season had markedly reduced survivability by 3.78 folds at 95% CI of 2.54–5.62 compared to those born during wet season. Furthermore, the year of birth significantly influenced survivability by 3.278-fold at 95% CI of 2.18-4.93. Similar findings were reported by Honhold (2001) and Majumdar et al. (1980), who also observed no significant differences in mortality rates between male and female goats. However, in contrast to the current study, Ershaduzzaman et al. (2007) found sex to be a significant factor influencing kids' mortality in Bangladesh, whereby the mortality rate of approximately 29% was recorded for kids aged 0–3 months. In this study, female kids exhibited higher mortality than their male counterparts.

Season significantly affected both mortality and survivability, with kids born in the wet season showing a 3.781 times higher likelihood of survival compared to those born in the dry season. This may be due to feed and water scarcity during the dry season, which limits milk production and results in higher kid mortality from malnutrition and starvation. Additionally, heat stress during the dry period may further reduce survivability. These findings are in agreement with Ershaduzzaman et al. (2007), who observed higher mortality rates among Black Bengal goat kids during the hot months (July–October) at the Bangladesh Livestock Research Institute (BLRI). Similarly, Chowdhury et al. (2002) reported that growing goats (aged 3–12 months) suffered nearly 40% mortality during the hot and wet season (July–October). The present study also aligns with Tifashe et al. (2017), who found that goat mortality was highest in autumn (46.7%), followed by spring (26.7%), and lowest in summer (6.7%) in southern Ethiopia. However, the current findings contradict those of Awemu et al. (1999), who reported higher mortality during the wet season.

Table 1. Distribution of goat mortality by breed, sex, season, and year of birth at TALIRI Kongwa (2011–2021)

			Year of birth											
Parameters		**Value**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Total**
Breed	GB	Count (%)	10(100)	12(92.3)	9(60)	2(100)	0(0)	1(100)	6(100)	17(94.4)	23(95.8)	33(75)	9(100)	122(81.7)
	GG	Count (%)	0(0)	1(7.7)	6(40)	0(0)	8(100)	0(0)	0(0)	1(5.6)	1(4.2)	11(25)	0(0)	28(18.7)
Sex	F	Count (%)	4(40)	5(38.5)	7(46.7)	0(0)	1(12.5)	0(0)	3(50)	9(50)	14(58.3)	36(81.8)	6(66.7)	85(56.7)
	M	Count (%)	6(60)	8(61.5)	8(53.3)	2(100)	7(87.5)	1(100)	3(50)	9(50)	10(41.7)	8(18.2)	3(33.3)	65(43.3)
Season	Wet	Count (%)	4(40)	11(84.6)	4(26.7)	0(0)	8(100)	1(100)	2(33.3)	2(11.1)	0(0)	21(47.7)	7(77.8)	60(40)
	Dry	Count (%)	6(60)	2(15.4)	11(73.3)	2(100)	0(0)	0(0)	4(66.7)	16(88.9)	24(100)	23(52.3)	2(22.2)	90(60)

Notes: GB=Gogo x Boer goat, GG=Gogo goat, F=Female, M=Male

Year of birth significantly influenced mortality as well, with the years 2018-2021 showing a higher rate of survival of kids by 3.275 odds higher than the years 2011-2017. These variations may be due to factors such as feed availability, drought conditions, or disease outbreaks in these years. Moreover, a change in managerial practices might be the plausible cause of such variations between those year groups. This finding conforms to that of Datta *et al. (*2024) and Chauhan et al. (2019), who found year of birth to be among the significant factors influencing kids' survival.

Table 2: Binary logistic regression results of survivability of goats by sex and birth type, season, and year of birth.

Parameters	Coefficient (B)	S. E	Wald	Sig.	Odd ratio (Exp(B)	95% C.I for EXP(B)	
						Lower	Upper
Sex	0.352	0.204	2.965	0.085	1.422	.952	2.123
Season	1.330	0.202	43.207	0.0001*	3.781	2.543	5.620
Year of birth	1.186	0.209	32.359	0.0001*	3.275	2.176	4.928
Constant	-3.168	0.325	94.832	0.0001*	0.042		

*Notes: S.E = standard error of the mean; * = there is significant difference at $p < 0.05$; C.I. = confidence interval*

CONCLUSION AND RECOMMENDATIONS

The study identified pneumonia, diarrhea, poor nutrition, and predation as the primary causes of mortality at TALIRI Kongwa. The study revealed that Crossbred goats (Gogo × Boer) were found to be more vulnerable to death compared to the local Gogo white breed. Furthermore, survivability was significantly affected by factors such as season, and year of birth. Hence, it is recommended that improved management practices and enhanced health care services be implemented to lower mortality rates and improve the economic sustainability of goat production**.**

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COMPETING INTERESTS

The authors declare no conflicts of interest.

AUTHORS' CONTRIBUTIONS

Saita Issono Olekimosa: Conceptualization, Methodology, Data curation, Resources, Investigation, Formal Analysis, Writing – original draft, Funding acquisition

Said Hemed Mbaga: Conceptualization, Supervision, Validation, Writing—Review & editing

Athumani Shabani Nguluma: Conceptualization, Supervision, Validation, Writing – review & editing

Salum Omary Kuwi: Formal Analysis, Investigation, Resources, Project administration, Data curation

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