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Exploring the risks, perceptions, and practices surrounding *Brucella melitensis* transmission among people, animals, and the shared environment among the Rendille and the Borana pastoralists in Marsabit County, Kenya

By

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Submitted in Partial Fulfillment of the Requirements for the

Master of Science degree of Global Health Equity

University of Global Health Equity
Capstone Practicum

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Date: 02 August 2021

DECLARATION

We, Valentine Ndacyayisenga and Yeukai Chikwenhere, hereby declare that the practicum capstone thesis has been written without any external unauthorized help, that it has been neither presented to any institution for evaluation nor previously published in its entirety or parts. Any parts, words, or ideas, of the thesis, however limited, which are quoted from or based on other sources, have been acknowledged as such without exception.

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DEDICATION

We would like to dedicate this project to our families, friends, and colleagues for their continuous support and encouragement throughout this journey.

ACKNOWLEDGMENT

We would like to express our deepest gratitude to all the people who participated in this research (UGHE faculty & Staff, Sauti Moja Team, Veterinarian International, the Rendille and Borana participants, and Marsabit County professionals). We thank the UGHE institutional review board for providing ethical approval to conduct our study.

Much appreciation to Dr. Janna Schurer, our supervisor for her tremendous support, for her constructive critiques, inspiration and for honing our research skills. Special thanks to Dr. Beth Miller and Veterinarian International for their mentorship and support in funding this project. Thanks to Bernard Ndambo and the Sauti Moja team for hosting and supporting us in the field. Our colleagues for feedback and encouragement as we progressed. To our mothers, your prayers and best wishes are highly appreciated. Above all, we thank God for His blessings and strength.

ABSTRACT

Introduction

Brucellosis is a zoonotic disease that is endemic in African countries including Kenya. It contributes to significant economic losses and poor quality of life. Previous studies have focused on knowledge, attitude, and practices regarding brucellosis transmission in East Africa, but few studies have been specifically linked to risks, practices, and perceptions of *B. melitensis* in animals and humans in arid/semi-arid (ASA) counties of Northern Kenya.

Methods

We conducted a phenomenological qualitative study in Marsabit county with the Rendille and Borana communities to understand the risks, perceptions, and practices associated with brucellosis. Eight Focus Group Discussions (FGDs), four in each community, were conducted, as well as an additional 12 Key Informant Interviews (KIIs) with human, animal, and environmental health professionals in the county.

Results

The study results revealed four key themes related to participants' risks, practices, and perceptions surrounding brucellosis transmission. The first theme, brucellosis-related practices, captured human, animal, and environmental practices related to brucellosis. These practices included food consumption patterns, management of livestock, and sanitation and hygiene practices. Secondly, brucellosis-related perceptions that influence practices captured participants' reasons for practices related to food consumption, livestock management as well as sanitation, and hygiene. The government capacity in brucellosis management theme encompassed the issues around policies, resources as well as opinions of government officials/technical officers on the communities. Lastly, the preferences for health communication theme captured the trusted communication channels and suggested strategies for health education and information programs

Conclusion

Both communities hold on to traditional beliefs and practices that increase the risk of transmission of brucellosis. Due to the animal and human restrictive mobility, and recurring hunger, brucellosis remains unprioritized; most of the attention and resources are dedicated to hunger issues hampering the implementation of zoonoses-related health programs like brucellosis. This study recommends focused community engagement and sensitization to address the low awareness and misconceptions among pastoralists. Sauti Moja and Veterinarians International should facilitate a forum to unify interested stakeholders in the county to lobby for funding to support animal and human health programs on Brucellosis and other zoonotic diseases.

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CHAPTER ONE: INTRODUCTION

1.1 Background

Brucellosis is a bacterial zoonotic disease that gravely obstructs livestock productivity and human health worldwide. The World Health Organization (WHO) classified it as one of the key neglected zoonotic diseases due to the burden of the disease particularly in low-and middle-income countries (Franc et al., 2018; WHO, 2014). Brucellosis can be transmitted to humans through direct contact with infected animals (Corbel, 2006), and consumption of animal products such as unpasteurized milk and raw meat (Blasco & Molina-Flores, 2011) or by inhaling airborne bacteria (Legesse et al., 2018). People infected with brucellosis typically present with an intermittent fever, often accompanied by anorexia and general body weakness, which may last for weeks or months if left untreated (Corbel, 2006). Brucellosis is generally misdiagnosed and underreported due to the difficulty in distinguishing some of its clinical signs and symptoms from other illnesses such as typhoid and malaria and limited diagnostic equipment. In animals, *Brucella. Spp* is transmitted between animals both vertically and horizontally and is highly contagious due to close contact among animals with possible cross-species transmission (Legesse et al., 2018, Franc et al., 2018; Díaz et al., 2011). Furthermore, the vast amount of the pathogen shed in the environment by infected animals promotes the transmission of the disease (Díaz et al., 2011, Corbel, 2006) Infected animals present with clinical signs such as reduced fertility, abortion, and low milk production. These have economic effects on livestock owners, the meat and milk industry, and human communities (Franc et al., 2018). *Brucella spp* can infect other domestic animals and wild animal species which can act as reservoirs for the disease for humans and other animals (Díaz et al., 2011).

The burden of human brucellosis remains a public health concern in low and middle-income countries. The disease is associated with permanent disabilities and result in prolonged health problems (James, 2013). Besides, it incurs extra medical expenses as well as reduced productive time (Zinsstag et al., 2007). In livestock, brucellosis results in diminished productivity, abortions, infertility, and weak offspring and is a major hindrance to trade and export (James, 2013, Xiao et al., 2011).

Globally, about 500,000 new brucellosis cases in humans are estimated to occur annually (Njeru et al., 2016) and are endemic in most of the African and Middle Eastern regions. Its prevalence is still unclear due to factors such as limited data, under-recognition by healthcare systems, and scarce laboratory diagnostic facilities (Nyerere et al., 2020, Mutua, 2017). In endemic countries, like Kenya, previous studies have indicated that human seroprevalence of brucellosis is positively correlated with livestock seroprevalence accentuating the role of domesticated animals as the source of human infection (Njenga et al., 2020). This is particularly in pastoral areas of Kenya due to close and frequent interactions between pastoralists and their livestock (Obonyo et al., 2015). Pastoral communities are reported to be at high risk of transmission of brucellosis due to their food consumption and livestock management practices.

1.2 Problem statement

Previous studies have focused on knowledge, attitude, and practices regarding brucellosis transmission in East Africa but there are no studies specific to risks, practices, and perceptions linked to *B. melitensis* in animals and humans among the Rendille and Borana communities in Marsabit county of Northern Kenya.

1.3 Study objectives

To explore risks, perceptions, and practices surrounding *Brucella melitensis* transmission among people, animals, and the shared environment among the Rendille and the Borana pastoralists in Marsabit county, Kenya.

1.4 The specific objectives include,

- To understand socio-economic, cultural, environmental, and animal factors relevant to *Brucella* transmission among the Rendille and the Borana pastoralists in Marsabit county, Kenya, by the end of July 2021.
- To identify trusted communication channels for health education campaigns among the Rendille and the Borana pastoralists in Marsabit county, Kenya, by the end of July 2021.

1.5 Organization of the report

The outline of the report comprises six chapters. The first chapter provides the background of the study, the problem statement, study objectives, and the overall organization of the study. Chapter two evaluates known information on brucellosis and the knowledge gap the study intends to address. Chapter three reveals the study design, setting, methods, and data collection procedures, and analysis. Chapter four highlights in detail the study results. Chapter five provides the discussion and study limitations. Lastly, chapter six presents the conclusion and recommendations of the study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Brucellosis background

Brucellosis is caused by gram-negative bacteria that belong to the genus *Brucella* (Blasco & Molina-Flores, 2011). These bacteria behave as discretionary intracellular pathogens of ruminants, Suidae, canids, and several wildlife species (Blasco & Molina-Flores, 2011). Five known Brucella species affect animals, these include *B. abortus, B. melitensis, B. suis, B. canis, and B. ovis*. *B. melitensis, B. abortus, and B. suis* are the principal cause of disease in domesticated animals along with infecting humans with *B. melitensis* being the most pathogenic in humans (Nyerere et al., 2020, Poester et al., 2013; Franc et al., 2018). *B. melitensis* is classified in the bacterial domain, kingdom Monera, Proteobacterium phylum, in the class of Alphaproteobacteria, Rhizobiales order, and Brucellaceae family (Nyerere et al., 2020, Poester et al., 2013).

2.2 Epidemiology

Brucellosis is a worldwide bacterial zoonotic disease affecting both animals and humans. Globally, about 500,000 new brucellosis cases in humans are estimated to occur annually (Njeru et al., 2016). Sub-Saharan Africa faces challenges with the assessment of the prevalence of brucellosis in humans and animals (Munyua et al., 2016). Even though brucellosis is reported to be endemic in Sub-Saharan African countries, the exact distribution remains unknown in those countries including Kenya (Kung'u & Master, 2020). Kenya is one of the Sub-Saharan countries that report cases of human brucellosis but brucellosis data about both animals and humans is limited (Spicic et al., 2021). Human brucellosis is common in pastoral communities and farmers due to close physical contact with livestock (Wakene & Mamo, 2017). A study that was conducted on human brucellosis surveillance through integrated disease surveillance reported 100,000 cases annually in Kenya, which translates to an annual incidence of 202/100,000 (Kung'u & Master, 2020).

Although there is limited data on brucellosis incidence, a 2015 study documented a high annual incidence of human brucellosis of 84 per 100,000 persons in a pastoralist community in Kenya. Brucellosis risk did not vary significantly across gender, location, or residence (Munyua et al., 2016). In 2012-2013, a study was conducted in Kajiado, Kiambu, and Marsabit counties in Kenya and it reported human seroprevalence to be highest, 46.5%, in Marsabit County. Human seroprevalence was three times higher in Marsabit compared with Kajiado and was six times higher in Kajiado compared with Kiambu (Osoro et al., 2015). A 2017 study conducted in East Africa reported the seroprevalence of human brucellosis among febrile patients of 31.8% and ranged between 13-16% among pastoral and agro-pastoral communities (Wakene & Mamo, 2017). However, several previous studies on human brucellosis seroprevalence in several counties in Kenya reported a range of 0.6% to 35.8% in humans (Djangwani et al., 2021, Kung'u & Master, 2020).

Regarding animals, in a study conducted about camels and human brucellosis in East Africa, the prevalence of camel brucellosis in Kenya was 15.36% (Wakene & Mamo, 2017). Another study conducted in Kajiado, Kiambu, and Marsabit counties in Kenya reported animal seroprevalence to be the highest in Marsabit county(Osoro et al., 2015). In livestock, seroprevalence was four times higher in Marsabit compared with Kajiado, which was about three times higher compared with Kiambu. Among the livestock species, camels and goats had the highest seroprevalence(Osoro et al., 2015). A 10 year assessment of brucellosis prevalence in Kenya reported a range of 0.0% to 20% of seroprevalence in goats across Marsabit, Kajiado, Baringo and Garissa counties (Djangwani et al., 2021, Kung'u & Master, 2020). A recent study reported a prevalence of 11.1% in camels in Marsabit county (Djangwani et al., 2021, Kung'u & Master, 2020). Goats and camels are usually infected with *B. melitensis*, although occasionally they can be seropositive to *B. abortus*. The highest incidence of *Brucella* in camels occurs when they are in contact with infected small ruminants (Gwida et al., 2012, Wernsry, 2014).

2.3 *Brucella* Transmission

2.3.1 Transmission to Humans

Humans are a dead-end host for *Brucella* species (El-Sayed & Awad, 2018, Ismail, 2015)**.** Brucellosis is transmitted to people through direct contact with infected animal tissues, consumption of infected food products, and airborne transmission in enclosed spaces like barns and abattoirs (Njeru et al., 2016, González-Espinoza et al., 2021)**.** Person-to-person transmission rarely occurs but it is possible through blood donation, bone marrow transplant, organ transplant, and tissue transplantation(Corbel, 2006; (El-Sayed & Awad, 2018, González-Espinoza et al., 2021)**.** Furthermore, vertical transmission from mother to child may also occur through breastfeeding (González-Espinoza et al., 2021).

Zoonotic infection occurs through direct contact of human mucosa and skin abrasions with infected animal tissues like blood, placental discharges, or aborted fetuses (Ismail, 2015), Kung'u & Master, 2020). Additionally, accidental inoculations with live cattle vaccines can lead to transmission to humans (Kung'u & Master, 2020). Therefore, an improved *Brucella* vaccine should not contain any live or infectious materials, as well as permit differentiation between vaccination and natural infection.

The environment plays a vital role in brucellosis transmission among humans. There are significant chances of heavy contamination with infected aborted fetuses or placental discharge of the yard, streets, markets, or general environment in communities (Corbel, 2006). *B. abortus* can survive on fetal tissues, soil, or vegetation for three to eleven weeks depending on the weather conditions (Aune et al., 2012). In winter, the bacteria can thrive in environments contaminated by aborted fetuses for over 60 days in winter, but only for a few hours when exposed to sunlight (El-Sayed &

Awad, 2018). Furthermore, wells and dams may be contaminated by runoff water or through the dumping of aborted infected fetuses in water bodies (El-Tras et al., 2010). Additionally, *Brucella spp.* survive in dung, slurry, milk, and cheese (Corbel, 2006).

Foodborne transmissions are common in communities that consume unpasteurized milk, drink raw blood, eat raw meat, or consume offal (Ismail, 2019; Kung'u, 2021). Urban populations are usually infected through the consumption of raw milk and or dairy products (Lucero et al., 2016). The cheese-making process can concentrate *Brucella* organisms which may remain infectious for several months. *Brucella* may survive for almost 2 months in soft cheese when produced under acidic conditions and temperatures between 11 and 14 °C or for two to three days at 37 °C, (El-Tras et al., 2010, Lucero et al., 2016)**.** The *Brucella* bacteria can survive in the air and be transmitted through aerosol inhalation, thus, the WHO includes it on the potential bioterrorism list (Corbel, 2006).

2.3.2 Transmission among animals

The transmission of *Brucella* in animals can occur either by direct or indirect contact with infected animals. Infected cattle are the main source of exposure of *B. abortus* while sheep and goats through aborted fetuses, placenta, and post-abortion uterine fluid, are mainly affected by *B. melitensis* (Gomo, 2015). Direct contact with sick or dead animals or ingestion of contaminated food and water is the most common route of infection among livestock (Djangwani et al., 2021, El-Sayed & Awad, 2018). Other modes of transmission include inhalation, skin contamination, conjunctival inoculation, use of pooled colostrum for feeding newborn calves, sexual contact, and artificial insemination (Corbel, 2006).

Sexual transmission is the main mode of passing the pathogen along with grazing on contaminated pastures (Corbel, 2006, (Wakene & Mamo, 2017). Sexual transmissions are common in ovine, swine, and canines (Gomo, 2015). This is facilitated through comingling of herds from different owners as well as crossbreeding with unscreened animals(Corbel, 2006). Livestock production systems in which different animals closely interact have higher chances of transmission.

2.4 Clinical presentation of brucellosis in humans

Human brucellosis typically presents as an acute or chronic illness characterized by fever, joint pains, night sweats, fatigue, headache, and weight loss persisting for weeks to months (Munyua et al., 2021). It appears in several organ systems, although undulant fever is most common. Besides the fever, acute symptoms include bones and joint pain which occurs in up to 40% of cases (Corbel, 2006, Mburu et al., 2021). Additionally, gastrointestinal (GI) symptoms, usually a result of foodborne cases, like nausea, vomiting, and abdominal pain occur (Kung'u & Master, 2020). Specific infections across several organs and parts of the body present as sacroiliitis, spondylitis, peripheral arthritis, osteomyelitis, bursitis, and tenosynovitis (Corbel, 2006). Hepatic lesions include scattered small foci of inflammation resembling viral hepatitis (Corbel, 2006).

There are also rare cases reported concerning brucellosis in humans. The *Brucella* organism has a special propensity for the reproductive organs, which in men could present as orchitis and epididymitis, while spontaneous abortion is the most common sign in women (Corbel, 2006, (Kung'u & Master, 2020). Infectious endocarditis is reported in 2% of cases yet is the most common cause of death from brucellosis. Brucellosis infection can invade the central nervous system, which results in neurological complications. This is prevalent in 5% of infection cases *of B. melitensis* causing a range of neurological complications including meningitis (Corbel, 2006). Skin lesions can include rashes, nodules, erythema, purpura, and petechiae (Corbel, 2006). Ophthalmic complications are very uncommon; however, uveitis is the most frequent manifestation (Potter, 2013)**.**

2.5 Clinical presentation of brucellosis in animals

Animal brucellosis typically causes abortions, stillbirths, decreased fertility, and milk production. They can present with clinical signs like carpal hygroma, orchitis, and abortions (Ducrotoy et al., 2017). A study reported that in 80% of infected animals, the bacteria reside in the mammary glands and secrete the pathogen into the milk (Seleem et al., 2010)**.** Infected cows are estimated to experience a 25% reduction in milk production (Seleem et al., 2010)**.** *B. melitensis* in goats and sheep manifests the same as cows, with late abortion, stillbirths, decreased fertility, low milk production, or epididymitis (Lilenbaum et al., 2007). In addition to abortion, and orchitis, sometimes pigs develop paralysis, abnormal gait, spondylitis, and blisters (Glynn & Lynn, 2008). The severity of the symptoms can vary across species and individuals and can be influenced by vaccination status, infectious dose, immune status, age, sex, management, and herd size and density (Potter, 2013)**.**

2.5 Diagnosis and treatment

2.5.1 Diagnosis in humans

Human brucellosis diagnosis cannot be made on clinical grounds alone due to the non-specific nature of the signs. Clinical history investigation should include profession, food ingested, contact with animals, and travel to endemic areas(Potter, 2013). A bacteriological test, preferably with a brucella culture isolated from blood, bone marrow, lymph nodes, or cerebrospinal fluids is best to identify the species. However, this requires a highly skilled technician and proper laboratory and diagnostic equipment which is expensive hence this test is unavailable in most of sub-Saharan Africa(M. Ducrotoy et al., 2017, Seleem et al., 2010). Serological tests in combination with clinical history are usually adequate for diagnosis when there is a high enough index of suspicion(Ducrotoy et al., 2017). The Rose Bengal Plate (RBP) serological test has a 99% sensitivity and is one of the simplest and effective tests utilized in testing for brucellosis (Poester et al., 2013). In brucellosis, agglutinating antibodies are progressively substituted by non-agglutinating antibodies henceforth

tests like the standard agglutination tests need to be complemented with the Coomb's test since it works by detecting agglutinating antibodies. The Coomb's test would be necessary to confirm the disease as it identifies incomplete antibodies. Several serological tests are used to diagnose human brucellosis including counterimmunoelectrophoresis (CIEP), latex agglutination, the indirect enzyme-linked immunosorbent assay (ELISA), through the identification of antibodies titers in the sample. Molecular diagnostic methods utilize molecular diagnosis using polymerase chain reaction-based assays that identify genomic components of the pathogen and confirm the presence of infection (M. Ducrotoy et al., 2017, Seleem et al., 2010).

With regards to the treatment of human brucellosis, doxycycline is the most effective antibiotic, dosed at 100 mg every 12 hours orally for six weeks, along with either streptomycin (1 g daily for two to three weeks) or rifampicin 600–900 mg daily for six weeks (Poester et al., 2013). There is compelling information that Tetracyclines are potent drugs for brucellosis treatment, and they are mostly used in Africa due to their affordability, availability, and scarce association with side effects (Potter, 2013, Solera, 2010).

2.5.2 Diagnosis in animals

Infected animals may have long incubation periods of *Brucella* and remain serologically negative for a good period. Therefore, diagnosis of brucellosis in animals should be carried out on a herd basis. The presence of the disease in a few animals is an indication of infection within the herd (Potter, 2013). Diagnostic tests can either indicate the presence of a pathogen or detect an immune response to it. A bacteriological test would be a definitive diagnosis however, not all infected animals give a positive culture. Similarly, with human diagnosis, the methods, skills, and facilities required are often unavailable. Consequently, serological tests become the means of diagnosis as they are most feasible and economically make sense (Corbel, 2006). The recommended test for screening in cattle is the RBT with enzyme-linked immunosorbent assay (ELISA) or complement fixation test (CFT) for confirmation of infection in individual animals. Surveillance screening of milk samples is done through the milk ring test or ELISA. Serological tests are utilized in camels and goats but a milk test for *B. melitensis* is not yet available (Ducrotoy et al., 2017)**.** The Rose Bengal test is used in small ruminants and camels but is less sensitive and requires the CFT to confirm the presence of incomplete antibodies(Poester et al., 2013). Additional serological tests that can be used in seroepidemiological surveys and monitoring include the card test, serum agglutination in the tube (SAT), indirect and competitive enzyme-linked immunosorbent assays, the fluorescence polarization test (FPA), and the lateral flow immunochromatography test (Corbel, 2006, (Gusi et al., 2019).

2.6 Brucellosis prevention

Successful prevention of domestic animal brucellosis is critical in preventing human brucellosis at the same time. The use of *B. abortus* strain 19 vaccines in cattle and *B. melitensis* strain Rev-1 vaccine in goats and sheep led to near-elimination of brucellosis in these animals in many countries (Young, 2002). In animals, some European countries have attained near-eradication of *Brucella* by use of vaccination, test and slaughter policy, and strict control of animal movement (Njeru et al., 2016). However, immunity through vaccination is not absolute hence vaccination alone will not eradicate brucellosis in animals (Corbel, 2006).

Although there are effective human treatments for brucellosis, prevention is more ideal. The prevention of human brucellosis is dependent on the successful elimination of livestock brucellosis. In humans, there is currently no approved vaccine for brucellosis readily available except in Russia and China (Seleem et al., 2010). Consequently, the focus is on effectively controlling the disease in the key livestock that transmits to animals like cattle, sheep, goats, and camels (Kung'u & Master, 2020). Two vaccines commonly used against bovine brucellosis are *B. abortus* strain 19 and strain RB51. *B. melitensis* strain Rev1 is the best vaccine available for control of ovine and caprine brucellosis though it is highly infectious to humans, but not very effective. Therefore, public health practitioners need to establish control or eradication strategies based on the specific context of the communities with regards to current socioeconomic status and infectious status (Blasco & Molina-Flores, 2011).

2.7 Brucellosis control

The control of animal brucellosis plays a vital role in reducing further transmission. In instances of abortion, the aborting animal should be isolated from other animals to prevent further transmission. It is also recommended to do a pre-purchase test of livestock followed by 30 days quarantine to ensure the purchase of brucellosis disease-free herds (Potter, 2013). This is useful in reducing the chances of spillover of the disease through domestic animals. Furthermore, regular milk testing in cattle, goats, sheep, camels, and other animals can be a great surveillance measure to detect the disease before it spreads to other animals. Brucellosis can be controlled by applying a slaughter policy to exterminate the already infected animals(Wakene & Mamo, 2017). Additionally, controlling the movement of animals suspected to contract the disease is a control measure that should be implemented to reduce brucellosis transmissions. In Indonesia and Thailand, there was a low rate of prevalence in stable animal populations, due to limited and controlled animal movement (Zamri-Saad & Kamarudin, 2016).

Regarding the environment, to reduce risks of environmental contamination, proper disposal of placentas or aborted animal tissues is recommended (Corbel, 2006). Animal slaughtering activities should also be performed in designated environments to minimize risks of contamination and

transmission to brucellosis hosts. The presence of virulent organisms including brucella in the environment is an important factor for brucellosis transmission (Zhang et al., 2014).

In humans, a collaborative approach that involves various sectors such as public health officials, food safety experts, veterinarians, medical personnel, academia, and communities is required to prevent human brucellosis. This is achieved through animal brucellosis control practices at public health and individual levels (Corbel, 2006). The Food and Agriculture Organization (FAO) recommends basing on prevalence estimates, socio-economic conditions, surveillance, and monitoring to control brucellosis (Njeru et al., 2016). There is a need to deliver public health education to communities on brucellosis prevention, use of protective personal equipment when assisting animals in delivery, and milk handling practices (Muturi et al., 2018). Besides, community awareness should be raised on food safety practices, food hygiene, and occupational hygiene, such as cooking meat thoroughly, boiling milk before consumption as well as avoiding contact with animals without protective equipment (Corbel, 2006). Although lack of knowledge acts as a barrier to infectious control, it is also an opportunity to strengthen education programs as a control solution (Onono et al., 2021). Lastly, veterinarians and physicians should be careful while dealing with infected animals and human patients respectively (Corbel, 2006). Kenya established a Zoonotic Disease Unit (ZDU) in 2011 to ensure collaborative control of zoonotic diseases, and brucellosis was prioritized among other diseases (Muturi et al., 2018). Therefore, that calls for a holistic One Health approach from public health, veterinary and medical authorities, and policymakers to ensure sustainable and effective brucellosis preventive measures. However, limited resources are allocated to brucellosis control due to undermined understanding of the impact it has on communities which mainly results from underreporting and poor diagnostic tools (Kung'u & Master, 2020).

2.8 Risks, practices, and perceptions relating to brucellosis

The main risk factors for human infection with *B. melitensis* are contact with sheep, goats, and camels, and consumption of raw foods of animal origin (milk and meat). Human brucellosis is common in areas where farmers or pastoralists live in close physical contact with their livestock and rely on animal products(Wakene & Mamo, 2017). Pastoralists incur the highest risk, both from daily contact with their livestock, and poor health services. In addition, pastoralists' frequent movement in search of water sources and pasture for their animals increases the chances of disease spread (Onono et al., 2019). Close physical contact exposes humans to the conjunctival or oronasal mucosa of infected animals. People such as veterinarians and laboratory staff, who work directly with infected animals or their products, are at high risk of brucellosis transmission. A study conducted in India revealed that 55.5% of veterinarians, who had no record of consuming unpasteurized animal products, tested positive for *Brucella* antibodies (El-adawy & Neubauer, 2021). This is suggestive of risk associated with the occupation and possible airborne *Brucella* transmission.

In animals, the risk for transmission is high in extensive types of livestock keeping that allows frequent and close contact among animals (Lopes et al., 2010). Frequent interactions between wildlife and livestock are also a risk factor amongst animals due to cross-contamination across the populations (Plumb et al., 2013). A study conducted in Kajiado county, Kenya reported that female animals born in contaminated environments are at a high risk of getting infected compared to those born in uninfected environments (Kung'u & Master, 2020).

Humans engage in practices that make them susceptible to zoonotic infections. Such practices include consumption of unpasteurized milk and raw meat which in turn results in the transmission of pathogens including *Brucella*. Pastoral communities commonly consume raw milk, meat, and blood as they have a dependence on their livestock as their source of food. Usually, they are situated in arid regions which do not support crop production. Consumption of infected animal products exposes them to a high risk of *Brucella* infections. A study in Ethiopia reported that the pastoral community drinks raw milk and eats raw meat like liver (Desta, 2015)**.** In Another study, women were said to drink blood from animals to replenish blood loss during childbirth (Njeru et al., 2016). Additionally, it is reported that pastoralists generally interact closely with their livestock to the extent of sleeping with them in the same house (Desta, 2015, Mutua, 2017). Usually, small ruminants such as lambs and kids sleep in the house with the keepers to protect them from bad weather, hyenas, or from getting stolen (Mutua, 2017).

Poor animal management practices predispose humans to infectious diseases from animals. Several studies have reported no use of protective gear among pastoralists when handling aborted products and assisting animals during parturition (Desta, 2015, Njeru et al., 2016, Mutua, 2017, Ntirandekura et al., 2018). This poses a high risk of infection from disease-causing microorganisms among this group of people. Another study reported that they also lend each other animals like sheep and goats for breeding purposes, and this gives room for the transfer of infection from one herd to another (Obonyo, Mark and Gufu, 2015). They would also introduce new animals to their herds without initial isolation for assessment of their health. Such husbandry practices are prone to expose healthy animals to infections and increase the risk of brucellosis transmission. Aborted products were reported to be thrown away for dogs to feed on. These were handled without protectives besides the possibility of *Brucella* cross-species contamination. High-risk behavioral practices towards zoonoses were reported for farmers and pastoralists in a study in Ethiopia (Alemayehu et al., 2021).

Brucellosis perceptions vary across locations and communities. In a study in Tanzania, participants perceived brucellosis as a zoonotic disease and it was referred to as a "disease of abortion" because, in livestock, abortion was a major sign. However, this information is not enough to differentiate brucellosis from other diseases that cause abortion (Ntirandekura et al., 2018). In the same study, some groups believed that brucellosis was caused by dry seasons due to high temperatures, whereas others believed the rainy season to cause brucellosis while another group said it was caused by other diseases like malaria, and foot and mouth disease (Ntirandekura et al., 2018). In

another study in Tanzania, pastoralists attributed livestock abortions which were mainly observed to trypanosomiasis because there were many Tsetse flies in the grazing areas (Mburu et al., 2021). Retained placenta, the birth of weak or still born calves, reduced milk production, and infertility were perceived to be the signs observed in livestock and the agro-pastoralists attributed a difficult birth process, body size, and supernatural forces to be the causes of those signs in livestock (Mburu et al., 2021). The agro-pastoralists attributed the same signs to similar incidences in humans especially in the cases of infertility and still births. Regarding the environment, the agro-pastoralists in Tanzania did not perceive livestock-wildlife interaction in grazing areas to be a potential route for brucellosis transmission (Mburu et al., 2021).

2.9 Brucellosis burden

Globally, brucellosis continues to be a public health concern especially in places where livestock is a major income-generating activity. Developing nations experience significant economic losses and reduced quality of life due to high brucellosis incidence (Kung'u & Master, 2020). It has detrimental impacts among wild and domestic animals as well as humans (Onono et al., 2019) and it is among the economically important zoonoses that are consistently ranked (McDermott et al., 2013). However, in low-income countries, brucellosis attracts less attention of health systems even though it has a high burden, thus the World Health Organization classified it as one of the top neglected zoonosis (Njeru et al., 2016). Underreporting and poor diagnostic tools in primary health centers result in a poor understanding of the true burden of brucellosis and lead to a false perception that it has a low impact on communities (Kung'u & Master, 2020). In Ethiopia, brucellosis is known to cause considerable economic losses across the country where it is prevalent (Ibrahim, 2009). The burden of the disease is attributable to humans, domestic and wild animals' diseases. In Sub Saharan Africa, brucellosis burden cuts across agriculture, public health, economic, and social development sectors (Njeru et al., 2016). Human brucellosis causes economic losses due to the cost of hospital treatment, the cost of drugs, and loss of work due to illness**.** Additionally, humans normally depend on both domestic and semi-domestic animals for meat sources, milk, hair, wool, and fertilizers to mention a few. Therefore, the suffering or death of animals due to brucellosis limits people's access to the resources (Solera, 2010).

With regards to the disease burden in animals, there are productivity losses even though they are not documented on *B. melitensis* particularly in Asia and Africa since it occurs periodically and in breaks rather than regular patterns. In addition to being sources of food and milk in Marsabit county, livestock such as camels, sheep, goats, and cattle are critical economic assets (Njanja et al., 2003)**.** Although there are no studies about the burden of camel and goat brucellosis to humans and animals in Kenya, cattle brucellosis contributes to economic losses, estimated at 237.5 million USD Purchasing Power Parity (PPP) per year. This is equivalent to 8.1 percent of the cattle value added (GDP), 22.55 percent of the Ministry of Agriculture, Livestock and Fisheries expenditure budget (The Monetary Impact of Zoonotic Diseases on Society Evidence from Three Zoonoses, (FAO, 2018). Additionally, in 2016, there was an estimate of 1.27 million cases and 12 004 deaths

due to brucellosis in Kenya (The Monetary Impact of Zoonotic Diseases on Society Evidence from Three Zoonoses (FAO, 2018). According to the World Bank, life expectancy in Kenya is 66.65 years, therefore 12 004 * (66.65 – 25) Years of Life Lost (YLL) are estimated to be lost due to brucellosis, and 96 percent of the fatalities are among livestock keepers(FAO, 2018).

2.10 Study justification

Brucellosis is endemic in Marsabit county, so pastoral communities are highly exposed to the infection. It is currently uncontrolled due to extensive livestock keeping associated with uncontrolled movements, inadequate veterinary support services, vaccines, and husbandry practices (Kahariri et al., 2021). Previous studies have focused on knowledge, attitude, and practices regarding brucellosis transmission in East Africa but no studies specific to risks, practices, and perceptions linked to *B. melitensis in* animals and humans in the Rendille and Borana communities of Marsabit County in Northern Kenya.

CHAPTER THREE: METHODS

3.1 Setting: Marsabit County, Kenya

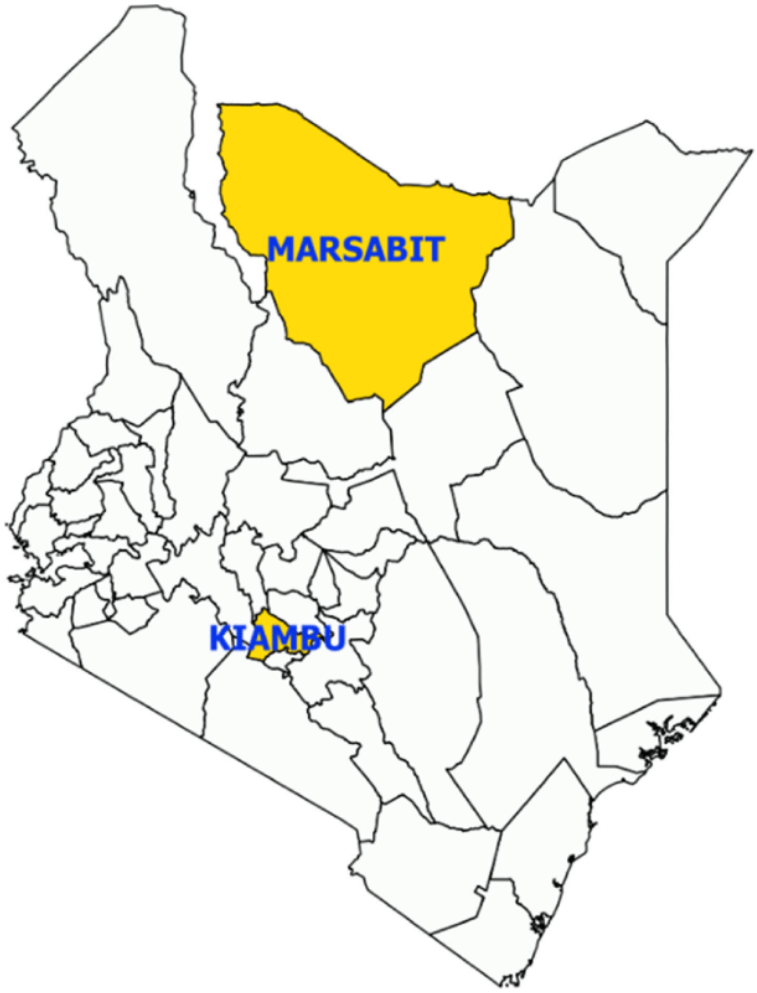

Figure 1: Map of Kenya (adopted from Njenga et al, 2020)

Marsabit County is in the Northern part of Kenya and occupies 66,000 Km^2 (Njanja et al., 2003). It is divided into 4 sub-counties, and 20 wards. Of the 343,000 estimated population in Marsabit county, 52% are male and 48% are female (UNICEF Marsabit). The county is populated by various ethnic communities including the Rendille, Gabbra, and Borana as well as the Samburu and Turkana. The pastoralists keep approximately 281,000 cattle, 673,000 small stock (298,000 sheep and 375,000 goats), 69,000 camels, 17,100 donkeys, and 77,950 chickens (Anon 2002) which are all kept on natural vegetation lying in agroecological zones (Njanja et al., 2003)(Njanja et al., 2003). Among the animals kept, camels are more important for economic growth, especially among pastoral and agro-pastoral livelihood groups as they are not only used for milk production but also as transport means and can withstand harsh conditions in arid areas. About 80% of the total surface area is arid and semiarid lands which provide subsistence economy to 25% of the

pastoral and agro-pastoral communities (Njanja et al., 2003). The county lies in an area that is only capable of supporting only livestock and wildlife. Men are traditionally responsible for taking care of animals whereas women take care of children and domestic chores across all communities mentioned**.**

3.2 Study Design description

This was a qualitative phenomenological study that used Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs).

3.3 Sample

The study targeted male and female Rendille and Borana livestock keepers/ owners of different ages in Marsabit county, Kenya. Eight FGDs of nine to ten participants each and twelve KIIs were conducted, a total of 80 FGD participants and 12 key informants.

The sample for this study was selected purposively to cover the pastoralist communities that own or herd camels and goats. For FGDs individuals were selected based on the cultural definition of age. For every FGD, the recruiters invited 10 participants. Of the four FGDs conducted in the Rendille community, two had 10 participants each whereas one had nine participants and the other had 12 participants. The additional people came to just sit and learn even when they knew they were not invited. For Rendille FGDs, we interviewed young adult male and female participants from age 20 to 35 years and elderly men and women of age > 45 years. The participation was 97.5% for this community. Of the four FGDs conducted in the Borana community, three had 10 participants each whereas one had nine participants. For Borana FGDs, we interviewed young adult male and female participants from age 18 years to 35 years and elderly men and women of age above 45 years. The participation was 97.5% for this community. For those who did not show up, nobody knew why they did not attend. The FGD participants were separated according to gender and age groups.

Key informants were selected from the county officials or community leaders responsible for human, animal, and environmental health. Two interviews were conducted with two government veterinarians from both Borana and Rendille communities. These two were mainly responsible for organizing and operating animal health and animal protection services and veterinary public health service with the respective communities. Two public health officers/WASH were interviewed from both Rendille and Borana communities. These were in charge of the overall health of the communities including education programs on health risks, hygiene, and sanitation practices. One community chief from Rendille and an assistant community chief from Borana were interviewed. These were the official first line of the central government and represented the government at the most local point and were responsible for duties such as local security, and community mobilization. The Kenya National Environmental Management Authority Representative was also

interviewed, and his role was to ensure that environmental regulations and standards related to pollution and waste management were followed across the county. Additionally, we interviewed a nurse whose responsibilities included treating patients and administrative roles at the county hospital. Lastly, two community elders from the Rendille and Borana communities were interviewed, and their roles were to oversee the well-being of the communities as well as advisors to the chiefs. All key informants were purposely selected based on how their roles were relevant to brucellosis diseases and as recommended by Sauti Moja and Veterinarians International.

3.3.1 Inclusion criteria for FGDs:

Community members who met the following criteria were included in the study.

- 18 years and older
- Goat and camel herders/managers /keepers

3.3.2 Exclusion criteria for FGDs:

Goats and camel herders with less than 6 months of experience were excluded from the study.

3.3.3 Inclusion criteria for key informants

- Experts and professionals who worked with the communities.

3.3.4 Exclusion criteria for key informants

- Leaders with less than 1 year of experience were excluded.

3.4 Data collection tools

The study tools were designed based on key literature, study aim as well as in consultation with our supervisor and preceptor organizations. The FGD guide with 23 questions and probes was used to explore the risks, perceptions, and practices around the transmission of brucellosis among the participants, their livestock, and their shared environment. The tools were initially developed in English then translated to Swahili by hired professional translators recommended by Sauti Moja. Another translator blinded from the study was asked to translate the guides back to English to validate the initial translation.

The guide was created in English and the interviews were conducted in English for all key informants except for one Borana community elder and one Rendille chief which were conducted in their local languages. The KII guides for community chiefs and elders were translated to Swahili by hired professional translators. To validate the translation, a second translator blinded to the study was assigned to translate them back to English. All the translated guides were pre-tested with local community members with the help of the local partner organization and adjusted accordingly to ensure validity. The KIIs allowed us to acquire expert information on the transmission of

brucellosis based on their professional background and receive recommendations on effective health education campaigns for the communities. The questions varied across different areas of expertise, and they ranged from four to 14 per key informants.

3.5 Data collectors

There were two primary researchers, two facilitators, and two translators. Both the facilitators and the translators were fluent in English and one of the local languages. Sauti Moja identified and recruited them with the support of the primary researchers. Both facilitators were Sauti Moja nutritionists, and the translators had attained at least secondary level education and were computer literate.

Before the commencement of data collection, the facilitators and translators were trained on qualitative research, the purpose of the study, group moderation, data collection, transcribing, and reporting, and the primary researchers tested the tools with the team. They were offered time to familiarize themselves with the FGD and KII guides and to ask questions. This helped them to understand the intended discussion points and the purpose of the study. Facilitators were responsible for the moderation of the FGDs while the primary researchers took notes with the assistance of the translators.

3.6 Data collection procedures

Study participants for FGDs were sought by the Sauti Moja team in collaboration with the local community leaders. All FGDs were conducted with the Rendille and Borana people in convenient locations identified by our partner organization. Before all FGD sessions, the purpose of the study and the consent process was explained to all participants, then written consents were provided by each participant. If participants could not write, they were asked to print their fingers on the form.

A trained facilitator moderated the discussions in the Rendille or Borana language utilizing a translated FGD guide and encouraged participants to contribute. All FGDs were audio-recorded with consent from study participants and handwritten notes were made by primary researchers throughout the sessions. Each discussion lasted approximately two to three hours. No stipend was provided to study participants.

A total of 12 key informants purposely selected based on their knowledge and experience provided an overview of the transmission of *Brucellosis melitensis* and the local communities' practices. The KIIs were conducted at their workplace or a venue that was convenient for them.

10 out of the 12 KIIs were conducted in English and the other two for the Rendille community chief and the Borana community elder were in their respective languages. Each KII lasted from 17 to 60 minutes. The English interviews were conducted by the primary researchers and recorded with the responder's consent to give room for more time for eye contact and taking notes between

the facilitator and the respondent during the interview. The two interviews in the local languages were conducted by the primary researchers and the translators. The primary researchers took handwritten notes throughout the interview sessions.

During data collection, COVID-19 prevention measures such as social distancing were followed as per the local regulations. The primary researchers also provided free face masks and hand sanitizers for the participants and data collectors to reduce the risk of COVD-19 transmission.

3.7 Measure/Domain

The domains for the measure of our study helped us understand the key areas below:

- Cultural practices and values identified by the communities related to the transmission of brucellosis.
- Environmental factors related to the transmission of disease.
- Animal factors were relevant to disease transmission.
- Communication strategies that are trusted by the communities for health education campaigns.

3.8 Data management

After every FGD or KII, the audio files were uploaded to a password-protected computer. The audio files were deleted from the recorder to ensure confidentiality. The audio-recorded data were transcribed in English into a Microsoft Word document throughout the data collection period.

All paper files like interview notes were kept in a cupboard that was locked and with access only to the research team. For interviews conducted in English, a second researcher listened to the recording and reviewed the transcript for accuracy. For interviews conducted in Rendille and Borana, a second native speaker listened to the audio and reviewed the transcript for accuracy, followed by the primary researchers reviewing the transcript.

3.9 Data analysis

The audio recorded were transcribed verbatim for both FGDs and the KIIs. All transcripts were cross-checked to ensure the completeness of data. Thematic data analysis was utilized to analyze the data, based on a codebook developed by the two primary researchers. Each primary researcher open-coded, independently, three out of 14 transcripts to initiate the process. The study utilized an integrated coding approach **(deductive and inductive**). The primary researchers developed a final codebook comprising 30 codes using inductive and deductive coding. The deductive approach involved the development of the initial codebook based on expected themes from the literature and the questions prepared. The inductive approach involved working back and forth between the codes that emerged during open reading and coding of the transcripts until comprehensive codes

were established. All codes were selected after exhaustive discussions and agreement between primary researchers. Conflicting codes were either removed or refined based on the study's aim and specific objectives. The translated interviews and FGD transcripts were uploaded into Dedoose Software for further independent coding using the initial codebook for easy organization, and analysis. Frequently used codes were determined by Dedoose code counts and identified dominant codes which were organized into five subsequent categories, after further discussion between primary researchers. These categories were then organized into four major themes which researchers felt captured study objectives and recurrent opinions among study participants. The results were presented concerning the overarching themes and subthemes accompanied by translated quotes from the transcripts. The participants' codes were replaced by a description of ethnic group, gender, and age group for the readers to easily follow while reading the report.

3.10 Ethical Protection Plan

3.10.1 Vulnerable populations

The study was in two communities of the Rendille and Borana groups and pregnant women, mothers with neonates, and people with disabilities were not part of the participants of the FGDs. Considerations were made concerning their comfort during the study.

3.10.2 Assessment of risks to participants

The discussions conducted asked questions related to practices and perceptions regarding a disease with a very low fatality rate henceforth, there was not any emotional or physical harm incited during the discussion or meetings

3.10.3 Medical or psychosocial support

There was no need for medical services or psychosocial support prompted by our study as the study took place in comfortable venues where participants were seated. A medical aid kit was available in case of minor emergencies.

3.10.4 Information and consent process

The study objective was explained to participants in their local languages (Rendille and Borana). Written consent to participate in the study was obtained from all individuals before the discussions and interviews began. Permission was asked verbally from participants to have the sessions recorded and they were informed that the recordings were for the researchers only. For anonymity and confidentiality in the information provided, participants' names were not used in the analysis, and they will be assured of that. Participants were informed that participation was voluntary and that they were free to withdraw anytime. Each focus group discussion was held within the village

or community where the participants came from and at a time and place of their choice. The key informant interviews were conducted at a time and place convenient to each person.

3.10.5 Protection of privacy and confidentiality

All digital copies of data were protected by a password in a computer and all paper files were kept in a cupboard that will be locked and with limited access only to the research team, where the key to the cupboard was kept by one of the primary researchers. Access to the cupboard was through the primary researcher.

3.10.6 De-identification of data

The participants were coded, and no names were collected. Any names mentioned within quotes were blocked out and replaced with the appropriate code.

3.10.7 Safekeeping of data

The transcripts were identified by codes and were accessible only to the team working on this research. After the data analysis, the data was stored in a restricted access local server that meets IRB requirements and is owned by UGHE. The notes and observation forms will be locked in a box UGHE library, in Butaro where they will be stored for ten years following the IRB regulations.

CHAPTER FOUR: RESULTS

4.1 Demographic description of the participants

For every FGD, the recruiters invited 10 participants. Of the four FGDs conducted in the Rendille community, two had 10 participants each whereas one had nine participants and the other had 12 participants. The additional people came to just sit and learn even when they knew they were not invited. For Rendille FGDs, we interviewed young adult male and female participants from age 20 years to 35 years and elderly men and women of age above 45 years. The participation rate was 97.5% for this community. Of the four FGDs conducted in the Borana community, three had 10 participants each whereas one had nine participants. For Borana FGDs, we interviewed young adult male and female participants from age 18 years to 35 years and elderly men and women of age above 45 years. The participation was 97.5% for this community. For those who did not show up, nobody knew why they did not come through. The age range differences between Rendille and Borana communities were due to their definition of young and elder based on local circumcision ceremonies as well as the ability to take responsibilities. Of the 12 key informants interviewed, only one participant was a woman, the Borana Community Chief. The key informants interviewed included one Rendille vet, one Borana vet, one Borana public health officer, one Rendille public health officer, one Rendille community chief, one Borana community chief. One Rendille community elder, one Borana community elder, one representative from Kenya National Environmental Management Authority (NEMA)who is from the Gabbra community, one Rendille conservationist, one Borana conservationist, and one human nurse clinician were also interviewed. The KIIs were selected from both communities except the human clinician and the NEMA representative who represented the county at large.

Analysis of the interview transcripts revealed four key themes related to participants' risks, practices, and perceptions surrounding brucellosis transmission.

1) Brucellosis-related practices

2) Brucellosis-related perceptions that influence practices

3) Government capacity in brucellosis management and,

4) Preferences for health communication

4.2 Theme one: Brucellosis related practices

This theme captured human, animal, and environmental practices related to brucellosis. These practices included food consumption patterns, management of livestock, and sanitation and hygiene practices.

4.2.1 Food consumption

Generally, the majority of the Rendille and Borana FGD participants acknowledged the consumption of animal source foods like raw milk, raw meat, and raw blood. Participants described the animal source products they consumed, how they were prepared, and when they would use those products.

The majority of the participants across all sexes and age groups in Rendille described that milk is mostly consumed raw, or sometimes mixed with raw blood to improve its taste. For meat, mostly men eat raw liver or roast it but leave the inside part red. For the Borana community, most young and elderly female participants said raw meat and raw blood are not usually consumed by everyone, but some male participants said otherwise. The Borana community said that the consumption of raw meat and blood was practiced by previous generations but currently, there are not many people who do it. Both communities stated that goat and cattle meat is the most consumed whereas camel's meat is rarely eaten. Additionally, the communities said they eat animal products mostly in the rainy season whereas other commercial foods such as ugali and rice are consumed in drought seasons. In both communities, goat meat was described as available in case of emergencies and slaughtered at different ceremonies like the birth of a child. The majority of the Rendille participants said that they consume the meat of dead animals even when they do not know the cause of death, whereas Borana people said they dispose of such meat instead of consuming it.

An elderly Borana female participant stated:

"If I add more, amongst the cows, goats, and camels, the helpful animals are goats. You can slaughter them at any time even for an emergency case."

A young Rendille male participant explained:

"When animals die, we normally eat without knowing even which disease has killed it and they at times transmit those diseases to us, we have seen this many times…."

An elderly Borana female participant stated:

"It's exactly that way. Just the way she had said, nowadays we do not drink their milk but previously we used to drink though at first, we milk them directly on the ground."

When asked about the food consumed, the young Rendille male participants stated:

"That depends because, for instance, during the rainy season we consume milk, blood, and raw meat also at times because our livestock provides us. We drink milk immediately, just drink. During the dry season, we consume other foodstuffs like ugali, rice, and many others that are nowadays

sold in the market. But in the past pastoralists depended on those mentioned foods that are milk, blood, and meat. But now, there are foodstuffs like ugali. When you go and look after goats, when they are tired and unable to move due to too much heat from the sun, you prepare that ugali, add milk, and eat."

A young Rendille male explained how animals source foods are prepared for consumption:

"For the meat, we roast them using fire outside or inside the house, and for the blood, we shoot the animal's neck using bow and arrow on the neck which was tighten using rope and collect the blood using a gourd and stir it properly and may take blood as it is, or we commonly mix it with milk and drink. We tend to take blood because it has more energy and builds the body, and you cannot get hungry that easily…"

4.2.2 Livestock management

The Borana and Rendille communities interacted with livestock for different reasons. Several activities were documented: housing their animals, milking, slaughtering of animals, health-seeking behaviors for their livestock, and grazing. Both communities across all ages and sexes shared similarities in the housing of their livestock. The proximity of sheds…. Participants stated that they have shed for goats closest to their compounds, followed by cattle and camel sheds which were farthest away.

A young Borana male participant stated:

"When I wake up in the morning, I open the doors of our livestock, we do milk to feed their young ones and the one who looks after the livestock drinks the raw milk and also carries, if he or she may drink while keeping the livestock. But during the heavy rain season, we take our cattle to the field early in the morning and bring them back before the sun starts being hot for milking, then the herdsman will prepare himself for the day's grazing."

A young Rendille male participant said:

"You put shoats [sheep and goats] nearer to where you sleep because they are the ones who are at risk from hyenas and next for cattle and the far end is for the camel. If you see you have overstayed in one place and feel like changing the kraals you construct new for both camels and if you see you have overstayed in one place and feel like changing the kraal you construct new for goats, mostly it is very rare for cows."

Generally, all participants were capable of milking the cows and goats including children. Both the Rendille and Borana men are mostly involved in activities such as milking camels, slaughtering, and treating sick animals. Although slaughtering was predominantly done by men, women also said they could do it. Participants shared how they traditionally treat their animals

through the use of herbs, hot *panga*[machete], and sucking of blood to prevent abortions. Additionally, they mentioned that they medicated their animals using drugs like oxytetracycline, and veterinarians were only involved when the owners fail to treat their livestock. For widows, they call male neighbors to assist them with treating their livestock. For grazing activities that were dependent on the seasons, participants highlighted that during drought seasons, they would migrate with their animals in search of pasture and water. Unlike the Borana community, the Rendille community expressed concerns of prolonged dry seasons, frequent lack of pasture and water.

When asked who milks camels, a young Rendille male participant said:

"*We as Rendille just believe it is our way of life, women can milk all the other livestock we have but not camel.*"

A young Rendille female participant explained:

"The solution to it and we cannot say it is the medication to it is that we put a panga(machete) to the fire and when it becomes reddish, we put it to that exact place we consider it affected and it mostly helps because at the end of the day the animal will get better and after sometimes it will be okay. We also put strings on fire and try to heal it."

A young Rendille female participant stated:

"During drought season cattle will go to the ''fora'' [grazing area with water and good pasture] and we are mostly left to manage the goats at home, for those who have no cattle they will most probably have goats to manage at home since goats are not driven to fora mostly."

However, some traditional practices were highlighted by the participants of how animals used to sleep in the house but there have been changes.

An elderly Borana male participant stated:

Yes, previously, it happened that way but nowadays there are changes. Those cows, goats, and camels have sheds separately and do not live in the house with humans. Many people have changed, it rarely happens recently, and people have constructed a shed for their livestock separately."

4.2.3 Sanitation and hygiene practices

The participants from both the Borana and the Rendille communities across all ages and sexes described their sanitation and hygiene practices related to cleaning activities, and waste disposal and management practices. Cleaning was highlighted for the utensils used for slaughtering. Male participants from the Rendille community mentioned the use of water to clean the knives used for slaughter and at times cloths to wipe the blood away. For milking utensils, mostly Rendille female

participants shared the use of smoke to clean the milk storage utensils. On the other hand, most male and female Borana participants pointed out the use of water and detergent to clean milk utensils and slaughtering tools.

An elderly Rendille male stated:

"We use anything to wipe off the blood from a knife when we do not have water."

A young Rendille female participant stated:

"You put the dry branches of those trees into the fire until they are charcoal-like, then you put them into a gourd and shake it well then you allow it to circulate and later you will clean it using a small cloth/ handkerchief like cloth then it is ready for use. When you start to use the cloth, handkerchief, it is clean, and it is used every day until it turns black. We do not wash it."

A young Borana male stated:

"We use water and detergents to clean it and some trees with a good smell are put on fire and its smoke is kept for milk to have a good smell."

Regarding livestock sheds cleaning, most participants from both communities stated that they mainly clean goat sheds while for camels and cows they do not. For cows, they said that they leave out the shed until the dung dries up and/or change when there is too much buildup of the dung in the kraals.

A young Rendille participant explained:

"For the cattle's kraals it does not need that regular cleaning but for shoats [sheep and goats] and camels you are at times forced to change the position of their kraals because of their wastes."

Regarding waste disposal for aborted animal products, most participants stated that they throw away into the open or feed to dogs.

A young Rendille female stated:

"At times we give that offal to dogs or cats depending on which ones are available and for some offal's we just place them next to the fire to dry or burn them and the dogs or cats will come from there."

A young Borana female participant stated:

"We drag it out of the shed and dispose of it outside so that wildlife will feed on it."

An elderly Borana female said:

"I will leave it that way but when I find them in front of the house, I will throw it away or give it to the dogs."

4.3 Theme two: Brucellosis-related perceptions that inform their practices

Participants shared several reasons for perceptions related to food consumption, livestock management as well as sanitation, and hygiene. The majority of these were based on their cultural and traditional beliefs and their personal experiences.

4.3.1 Perceptions related to food consumption practices

Most participants believed that boiling milk removed nutrients, altered the taste, or distorted the quality. Participants attributed it to various reasons like how it was a cultural way of doing it

An elderly female participant Borana stated:

"*It does not mean that we lack a source of heat to boil milk, we ignore it to preserve nutrients inside the milk."*

A Rendille Community Elder explained:

"There are no cultural rules that dictate that, but it is something we have just inherited from our forefathers, something you become so used to and do it every day."

A young Borana male participant stated:

"We consume it just the way it is. And if we boil it loses its taste, it is not as sweet as when it is consumed raw."

Consumption of blood was mostly mentioned as a healing practice for women who had given birth to replenish blood loss. Herders, mainly young men from both communities, that migrated with animals considered consumption of blood or as a mixture with milk to be more filling and provide more strength.

An elderly Borana Male participant said:

"It helps the body, haven't you heard that blood would replace blood, even doctors know this, and it also give strength."

An elderly Borana Male participant stated:

"The issue is people used to consume those products long ago, especially for blood when one is sick and suffering from blood deficiency syndromes. Traditional doctors advise them to take livestock blood, but nowadays it is a very rare case."

However, some participants from both Borana and Rendille communities mentioned that they usually boil milk for young children below 6 months old for health purposes. They said that children have weak immune systems and that is why they boil milk for them to prevent any diseases caused by raw milk.

A young female participant D from Borana said:

"We boil it for children so that it will not make them vomit when it's fresh and heavy since it might cause them to develop childhood disease. For adults, it is believed that when it is fresh, it will give them strength and that's why we drink the raw milk."

4.3.2 Perceptions related to livestock management

With regards to animal management perceptions, Borana and Rendille communities have different beliefs and perspectives on daily livestock management. When asked who milks animals between men and women, all participants said that women, men, and children milk goats and cattle whereas camels are milked by young and elderly men. The perspective behind this is related to the strength required and the position is taken when milking because camels are very tall and there is a particular way they are milked. Unlike some Borana female participants who said they could milk camels themselves, the Rendille community's beliefs did not allow women to milk camels.

An elderly Borana female participant said:

"Because women do not have strong masculine hands needed to drain enough milk and this should be timely otherwise camels will refuse to give you milk. And for your information camels have a lot of rituals, fragility and as such needs to be handled with a lot of care and caution"

A young Borana female participant said:

"*For Camels I do milking for myself."*

A young Rendille male participant said:

"We as Rendille just believe it is our way of life, women can milk all the other livestock we have but not camels."

Further discussions on livestock management revealed abortions, and stillbirths were frequently experienced by animals. When asked causes for that, most male and female participants from both communities stated that abortions and stillbirths were a result of their livestock being unhealthy, lacking enough pasture, chemicals or vaccines injected. Some participants shared that goats and camels mostly get abortions when bitten by insects like Tsetse flies and mosquitoes, and one participant stated that animals abort when they eat grass from where a rat lives. Regarding seasons variation, there was no distinct season at which abortions and stillbirth happen. Some participants from both communities mentioned that they occur during the rainy season while others said that they occur during the drought season.

A Rendille Community Chief said:

"On abortions, we believe that animals abort when they are generally unhealthy, we also believe that tsetse flies cause abortions when they feed on livestock especially camel and goats. Tsetse flies have got seasons and when they feed on goats and camel, they tend to bring abortions."

An elderly Borana male explained:

"This is because green pastures have nutrients which will add vitamins in the body of livestock, if those vitamins reduce in their body, they will get abortions."

A young Rendille female participant:

"The reason as to why we say that is because they are times that veterinarians will come and say that there is a disease that they want to prevent and request we vaccinate our animals and so after 2 to 3 weeks of vaccination we start witnessing abortions in expectant animals so that's why we have come to believe that drugs also cause abortions or at times they give birth to disable kids for shoats if they didn't abort."

An elderly Borana male participant said:

"For goats during short rainy seasons, some ticks feed on them hence they experience abortions. These insects suck blood from the livestock thereafter cause body changes as a result abortions, stillbirths and fever occur…."

An elderly Borana male participant said:
"Goats usually experience abortions during drought seasons, as well fever."

However, one key informant contradicted the general notion of vaccines or medicine being the cause of abortions but a means that has minimized such cases.

The Rendille community chief stated:

"It depends because for instance for the last five years we have not experience abortions as such, may be some few but in the past when we were children or warrior's abortion is so common during those days, the reason for the reduction of the rate of abortion is the availability of drugs to contain livestock diseases and address such issues."

4.3.3 Perceptions related to sanitation and hygiene

Sanitation and hygiene perceptions elaborated on their cleaning, and waste disposal practices. Participants mentioned limited or no access to water as a reason why they cleaned their milking and milk storage utensils with a piece of cloth and smoke. Slaughtering utensils were cleaned by wiping off the blood using a cloth. For animal sheds, only camel and goats' sheds were cleaned because these animals get uncomfortable when staying in dirty places whereas cows' sheds are not cleaned. An exception for cattle only occurred during the rainy season where they clean for calves because the cow dung becomes thick and difficult for them to move through.

A young Rendille male participant said:

"For cattle also when you see the cow dung is becoming too much you might decide to burn it but sometimes, you can get stuck when passing through it (cow dung) and now you realize you need to clean the area."

An elderly Rendille female explained:

"Maybe during the rainy season, we may clean where the calves sleep, during the rainy season cow dung becomes thick and unpassable at times."

A young Rendille women stated:

"We do not clean the iron sheet because of limited water, and you just hang it where animals sleep, knives you clean them if intestine and stomach stuff are there you clean or roast."

Additionally, participants highlighted that they use smoke to clean as it would help with preserving the milk as well as enhance the taste and smell.

An elderly Rendille female stated:

"There is a specific tree we use for cleaning so that milk won't go bad, you put little water into the gourd and rinse it then you put the dry branch of the tree into the fire and when it becomes reddish you put it into the guard and shake it well then leave it for smoke to circulate and later clean it using a cloth, that is for all the gourds"

A young Borana female explained:

"I use soap to clean the drum thoroughly, then heat some wood then place it under the tool to make it smell decent for milk preservation. Smoke is used for sweet smell and milk preservation."

4.3.4 Perceptions related to brucellosis

There were many perceptions related to human and animal brucellosis which were captured from both communities. Most participants referred to brucellosis as a milk disease, and it was given a local name *ndingandu* in Rendille and *dukub anani* in Borana.

Regarding human brucellosis, some participants from both communities said the disease was not there a long time ago when only animal source foods were consumed unlike nowadays where other foodstuffs with chemicals are consumed and they cause the disease. Additionally, they said milk does not cause brucellosis because they believe that medicine is given to animals when sick causes brucellosis in humans when they consume animal source foods. They also highlighted other sources of foods such as maize flour, rice, and others found on markets as possible causes of brucellosis in humans. Other participants said that animal diseases cannot be transmitted to humans.

An elderly Borana male participant stated:

"No, it was not there long ago, and I think this is the cause of this brucellosis, long ago we just use food of animal origin and from our foods but now we just buy foods with chemicals."

An elderly Rendille male stated:

"Though it is the doctors who say it, milk does not cause brucellosis according to us elderly people…."

Young Rendille male participant said:

"We do not know anything about this disease but am sure we don't take it from the milk of our animals but rather it is from the packed milk we buy from shops."

Participants from both communities had witnessed brucellosis in humans, and they said it had similar symptoms such as bone ache, joint pain, cannot walk, and fever, as those in animals. Two male participants said they had suffered from brucellosis.

A young Rendille male participant said:

"We know it as milk disease because of what we have heard but we do not know which milk causes it, we are just told it's milk disease..."

An elderly Borana male confessed:

"I have this disease. I feel bone ache, I can't walk, joint pains…"

An elderly Borana male stated:

"I heard human experience bone ache, joint pains, someone can't walk."

When young Borana women were asked what they know about brucellosis in humans, they stated:

"No, we have never heard. We only heard it's transmitted via air."

"We have heard of Brucellosis, but we have never heard it get transmitted from livestock to humans."

Regarding animal brucellosis, some participants acknowledged that livestock have the disease, and they mentioned some symptoms like joint pain, and fever. Although, the majority of the participants said they did not know its cause in livestock and how it is transmitted, some mentioned medicine as a major cause.
Other participants said that there was no brucellosis in animals even though they know other diseases that affect humans and look similar to those in animals.

An elderly Rendille female explained:

"It also affects livestock because it shows the same signs and symptoms just like in humans, though we might not call brucellosis the same name as with humans, it also infects them."

An elderly Rendille male participant said:

"We do not have brucellosis in animals but there are diseases with the same symptoms of brucellosis in human beings as in animals too and we believe that brucellosis in animals exists though we might not call it the same name in animals as in human beings."

A young Borana female participant said:

"We don't even know of animals with brucellosis, how it even looks so we don't know if it has a traditional drug for treatment."

4.4 Theme three: Government capacity in brucellosis management

The key informants described issues to do with policies, resources as well as their opinions on the communities based on their interactions with them. Subsequently, the following sub-themes emerged; brucellosis-related policies, government function, and capacity as well as perceptions on the communities.

4.4.1 Brucellosis related policies

The Borana public health officer mentioned he was unaware of any strategies/policies specific to brucellosis management. The human clinician responded by stating the process flow of work when he was asked about the presence of brucellosis management policies. When the national environmental management agency (NEMA) officer was asked about the presence of national environmental policies he responded by stating the presence of human and animal health policies in which environmental issues are stipulated and highlighted that there are challenges with dissemination from national to the county level.

A Borana public health officer said:

"No, I am not aware of any [policy] which is specific to brucellosis, and I also think brucellosis as a disease has not been considered to be a disease of public health importance because it does not kill quickly, and it is slow on the onset. So really, it has not been in the limelight in terms of health sector priority disease."

The human clinician and public health officer explained that there are no active structures or forums in place for coordinating brucellosis management, with mention of not so many collaborations/interactions unless it is an outbreak.

The human clinician explained:

"Most of the time, we don't have such forums. And most of the cases where we would meet those patients with those diseases, those zoonotic diseases. If it is an outbreak, like when we have a case of Rift Valley fever or something, that is when we work together with the veterinarians but because brucellosis seems as if it is an endemic thing and especially with the pastoralists, there are no many interactions and maybe it is an outbreak, like anthrax and this is Rift Valley fever when we come together from the health department, and also the vet."

When the Borana public health officer was asked how they communicate with veterinarians and community members on brucellosis, he explained:

"We do not have active forums through which we engage. But through their systems and their [veterinarians] surveillance system, they know that a disease like brucellosis is on increase. Of course, they now communicate to us that there is a new trend of brucellosis up-search in a very

locality, and we may need to intervene with temporary information like that, but on a day-to-day basis, there has not been an active surveillance and information sharing platform."

4.4.2 Government function and capacity

Most of the government roles captured were often focused on general contributions to either the health of animals or humans. They also stated minimal functions and resources dedicated to brucellosis management and collaborations across other departments.

The NEMA officer explained that they were aware of the One Health approach, and they have been part of the zoonotic disease unit. He further stated that their main role is not directly handling disease but enabling people to have a safe and clean healthy environment. Additionally, they collaborate in some instances with other stakeholders.

The NEMA Officer explained:

"Well, as an authority, we have embraced the concept of One Health whereby it encompasses a very good perspective of how to approach and handle the diseases or even health issues related cross-cutting between human, livestock and within this environment. So, we have been part and parcel of a zoonotic disease unit, set up by the county government, we remember and our role as an Environment Agency, especially as a national environment Management Authority, is to ensure that the citizens of this country are entitled to a safe clean and healthy environment."

The NEMA officer mentioned:

"Yeah, we have collaborated with the relevant department at the county level, which I told you is the Department of Agriculture, General Department of Agriculture, livestock, and fisheries, but specifically the veterinary unit."

The Borana public health officer stated they target all diseases that affect humans not only brucellosis.

The Borana public health officer stated:

"Eehh, generally we target all diseases that affect human beings because whatever human life is put at risk as public, that is our concern, not only brucellosis, but all diseases, but brucellosis being one of them."

Regarding animals, he highlighted that it is the veterinary department responsible for that and indicated that the challenge has been the creation of a platform for coordination between human and animal health experts.

The Borana public health officer stated:

"So now, the challenge has been now creating this linkage and the collaboration about how we can be able to share information to work together on diseases around zoonotic diseases. Then human health experts, animal health experts, how we can be able to create a platform sort of or a coordination mechanism through which we can be able to link up."

When the human clinician was asked what their role is concerning brucellosis, he stated:

"Yes, what we usually do. Of course, apart from the brucella agglutination tests, there are some other investigations that we usually do. They could be as for malaria parasites, maybe this person or patient could be having brucella this reactive, but the titers are below eighty. On that, simply we do not put the patient on treatment for brucellosis, maybe this patient needs some more investigation programs, then it shows you that it is possibly a blood infection, then we opt to do the blood infection treatment. And then we give a follow update like you repeat the brucellosis agglutination test after a month or something."

When the NEMA officer was asked if they have had any cases of brucellosis among co-workers and clients, he replied:

"We have not had it, so maybe an officer or any of our staff directly contracted this. But we have received reports here we have incidents records, any issues that have been within the society are normally booked here. And we will intervene, see how we can manage this situation, says cases have been reported, there are many times that they are like, some seasons, whereby we experience a lot of abortions in mostly small stocks, and also came up."

4.4.3 Perceptions and experiences in supporting communities

The opinions of the key informants on the communities varied depending on the level of interaction and the work done with them. The human clinician of the hospital county stated he has been working with the county for over 10years, while the Rendille community elder and chief mentioned they have been working in the community for 40years and nine years respectively. The Borana public health officer stated he has 13 years of experience with the community. The human clinician stated that he interacts with the communities when they come in for a consultation and they turn down his treatment to seek help elsewhere. The Borana public health officer shared how some members state that some sickness is caused by spiritual forces, and they seek help from traditional healers. The Rendille elder informed how the Rendille people are welcoming to people that want to work with them.

The human clinician stated:

"Yeah, you see down here. There is also a type of practice. You tell someone Yes. You have brucellosis. the person tells, okay. I do not need your treatment. They go to the traditional healer where there are some leaves, he or she will chew. And he or she is going to spit some saliva on your heart. And you believe that you have healed from brucellosis."

When the Borana public health officer was asked how he thinks the community perceives brucellosis, he said:

"Humm, there are, of course, traditional beliefs because in some instances it even contributes to some of the disabilities. Some even think now was some sort of cancer, some even on a personal level think it is not just a disease, there must be something that is hunting them or something like that or the family. Yeah. So, and that explains why they spend so much time going around the traditional healers before the hospital. Yes."

The Rendille community elder stated:

"One of the things you should know about the Rendille tribe is that they are not bad to foreigners, mmh as long as your intentions are not damaging the people and as long as somebody is coming to help a Rendille with an idea which can help that is something they like- so welcoming unless they're busy with their livestock they feel that you're wasting their time or they see that this person is coming to do his job and let me do my job, it's like you're somehow interrupting them with what they are doing unless it's somebody whom they know who's with you and explain to them that as to why you're there that's the time they can listen to you when you go all alone to them they will say what's this guy doing here he's just wasting his time with his questions."

Regarding waste disposal, one of the key informants highlighted the lack of designated areas and sanitation facilities for waste disposal which explained why communities threw aborted products out in the open. Some key informants also stated that the communities were not aware of the risks involved in handling aborted products with their bare hands and that explained why they continue to do it.

The Rendille Community Chief mentioned:

"There are no specific places designed for that, you just throw the aborted product away or leave it lying there and vultures will eat it or even dogs or even hyenas will feed on it…"

4.5 Theme four: Preferences for health communication

The Rendille and Borana FGD participants openly shared trusted communication channels for health information. They pointed out the use of a local radio station that communicates in the local languages and also stated that seminars from familiar organizations like Sauti Moja and Food for

Hungry (FH)were really helpful. Additionally, they highlighted their contribution towards making health education a success. Lastly, the community members from both communities suggested strategies to increase their presence, participation and improve their health outcomes as well as that for their livestock.

4.5.1 Preferences based on trusted communication channels

Both communities mentioned several trusted channels through which animals and human health information can be disseminated. Those channels include radio stations such as Jangwani and highlighted Sauti Moja, FH, veterinarians, and other NGOs. Veterinarians and Sauti Moja were mainly highlighted for animal health education while the rest of the channels were for human health. The young Rendille female participants also brought up Community Health Workers as important for human health education.

A young Rendille male participant explained:

"We also get information to local radio stations, and they spread further when infected with diseases and veterinarians will come in and offer help when they get such information, we also get information that certain disease is infecting certain locality and we avoid such a place."

Another young Rendille male participant added:

"We mostly get animals health information from the veterinarians because they will ask us to bring animals to the crusher for vaccination on a certain day or they at times tell people of a certain disease that is to come and educate us on preventive measures."

A young Rendille female participant said:

"If Sauti Moja could get a trained person who will come and train us on the causes and origin of brucellosis and how to prevent it then it will be good."

However, some participants do not like radio stations because they do not get opportunities to ask questions in the case, they do not have enough airtime to call. Others said that they might not get adequate and clear answers for questions, and therefore, they preferred in-person training sessions.

A young Borana female participant explained:

"We can't prefer this whenever it's done via radio, some of us might lack airtime or whatever we ask, we might not get an appropriate answer but when it's done face to face, it is negotiable and fruitful later."

Another young Borana female participant added:

"No, we don't prefer this because through radio we can't ask questions as we desire. But if someone is with you, you can do whatever you want. The most preferred ways for this health education are training."

The NEMA Officer shared the use of local radio stations as one of the channels through which they disseminated information to the communities. The human clinician highlighted the use of chief barazzas [When the chief meets with the community] as a platform to share health information and when they come through for consultation.

A NEMA representative mentioned:

"But in an event that we run out of our budget, we also explore options on information dissemination through radio talk shows, whereby we book specific radio, mostly local, radio, local radio stations, whereby there is that interaction mostly in the evening, we assign one of our officers to the stations, and then there is that open discussion? local communities call them from all the corners engaging with them."

The human clinician stated:

"Most of the modes of communication that we share is the use of the chief's barazzas or maybe when they come to the hospital before maybe you start dispensing the services, and you just brief them on maybe a certain topic."

4.5.2 Communities' commitment to supporting the success of health education campaigns

Both Borana and Rendille community participants freely shared their role in making community health education a success. The majority expressed their willingness to change their behaviors if trained on diseases and specifically brucellosis. Additionally, they mentioned that groups that were trained would help the rest of the community members by disseminating the learned information.

An elderly Rendille female participant said:

"Yes, we will change, so many things have changed in us, we never used to bath before but now we do almost daily courtesy of people coming to us in the villages sent by the government to teach us on hygiene, we nowadays take care of our children do not like before, so we expect some changes if we get such information."

A Borana young male participant stated:

"Many times, we teach others whatever we have learned, and they don't observe it around 80% as my colleague, I think whatever can make these people know is well is to have changes in the mobilization of this."

However, even though most of the participants said they will change if trained, there was one elderly female participant from Rendille who said that sometimes they get training on hygiene, but they ignore it because their source of water is not clean anyways. Additionally, another elderly Rendille male participant showed interest in learning what is in the milk that causes brucellosis, but he was still stuck on his belief that boiled milk is not milk.

An elderly Rendille female participant said:

"Some organizations that we can't even tell their names, they just pass by here as they go and say take clean water and maintain good hygiene, but we just listen and ignore because if you are told to drink clean water and the source of water in your area is a borehole that people take bath in sometimes is your only option. what will you do, you have no option but to take it?"

An elderly Rendille male participant stated:

"We want to know because you cannot tell us to leave milk and when you boil it, it does not have a taste and does not look like milk, so you should tell us or teach us how to prevent milk disease. Boiled milk is not milk, it is tasteless."

4.5.3 Community suggestions on strategies to make health education a success

Based on suggestions from and communities' roles and contributions toward educational strategies, the FGD participants and KIs suggested some strategies to ensure smooth and productive education campaigns as well as improving their health outcomes as well as their livestock. Suggestions included disseminating information during the rainy season when pastoralists are in their homes and not in the forests in search of pasture. They also suggested consistent training and training in local languages. The Borana young male participants also stressed separating men, women, and youth during training sessions to enable full participation and freedom to express themselves.

A Rendille Community Elder stated:

"Yeah anyone even those who are out and those at home as well, during the rainy season these guys come closer, they come home and during drought season they go far away from where the grass is, so these are times we get chances, when they are closer to us we do these training, when they are closer to us we talk to them, when they are not closer to us we don't talk to them because

animals can go anyplace as long as the vegetation is there and the grass is there they go there, and if water is there they go there too."

Elderly Borana male participant stated:

"I suggest if we get these training regularly, we shall remind them occasionally."

When asked why women, youth, and men must be separated during training, a young Borana male participant said:

"So that the communication will go well because even youths can talk to each other, women when they are together, they can pass the message to each other like elders or men. You see women when they are with men don't talk so much, they fear but when they are together without men, they can talk without fear same to children or youths."

CHAPTER FIVE: DISCUSSION

Cultural practices have been identified in several studies to promote the persistence of brucellosis in pastoral communities (Mutua, 2017). This study revealed cultural risks, misconceptions, and environmental interactions which increase the risk of brucellosis transmission among animals and humans in Rendille and Borana pastoral communities. Additionally, brucellosis was not considered a priority disease. Lastly, the communities expressed willingness to engage in discussions with experts on risk reduction and they were willing to receive information through particular channels.

5.1 Risky Behaviors for brucellosis transmission

The results of this study showed that the majority of the FGD participants engaged in cultural practices which expose them to brucellosis transmission. Several studies in Kenya and Tanzania show that pastoralist communities are likely to consume raw milk, blood, and meat which increase the risk of brucellosis transmission (Mburu et al., 2021, (Mutua, 2017, Ntirandekura et al., 2018, Munyua et al., 2016). Occasional consumption of raw goat, cattle, and camel milk, raw blood, and uncooked meat was practiced widely by the FGD participants and was attributed to cultural beliefs such as high nutrient content, blood replenishment, and energy respectively. Studies in Kiambu, Marsabit, and Garissa counties in Kenya mirrored our results, and one study by Njenga, found that pastoralists, believed that raw camel milk has better taste, medicinal value including aphrodisiac properties (Njenga et al., 2020); Obonyo, Mark, and Gufu, 2015). In line with that, a study conducted in Egypt concluded that long-standing cultural practices and a lack of understanding by the public on risks of consumption of raw milk prohibit people from adopting prevention practices (Franc et al., 2018). Although the animal source foods are rich in protein, and iron and contribute to the communities' nutritional supplements, they still pose risks for zoonotic diseases including brucellosis transmission if consumed raw (Azzarri et al., 2015).

According to our findings, raw blood was usually consumed by men while slaughtering or migrating with their livestock and women consumed it as a blood restoration after giving birth. Previous studies in Tanzania, Ethiopia, and Uganda indicated the same results where women consumed raw blood to replenish blood loss during childbirth. one conducted in northern Kenya noted that drinking blood was also meant to cure stomach ailments (Ng'ang'a et al., 2016; Ntirandekura et al., 2018, Desta, 2015). From the biomedical perspective, replenishment of blood is not achieved from drinking raw blood but utilization of iron supplementation among others for blood replenishment. This would make sense for an impoverished community that is situated far from medical centers to resort to the consumption of blood despite the risk associated with transmission of zoonoses such as brucellosis. However, there was no study to confirm the value of this practice. Drinking raw blood poses risks towards other zoonotic diseases including Rift Valley Fever (RVF) in Kenya transmission (Otieno et al., 2021).

Raw meat was generally consumed by men, where they only roasted the outer coating for the liver and ate the inside raw for energy and taste. A study conducted in Kajiado county, Kenya reported similar results where the Massai people consumed raw kidney and liver (Chege et al., 2015, Desta, 2015). This study revealed that young and elderly men were at higher risk as they were the ones mainly consuming raw meat. Animal source foods being the major constituent of diet limits the scope of food thus leading to food insecurity especially when animal production is limited. Considering other pastoral communities have been reported to not consume other animal source products like fish, chicken, and wild meat, food insecurity is exacerbated (Chege et al., 2015). Additionally, the pastoral communities in this study are situated in a semi-arid region where crop production is less practiced thus pushing people towards dependence on animal source foods.

In addition, respondents were culturally connected to their livestock, and close physical contact with them was not perceived as a threat that could cause disease. A study conducted in Northern Kenya and another in Mongolia showed that pastoral communities have a higher risk of contracting zoonoses than non-pastoralists due to their constant close interaction with livestock (Ng'ang'a et al., 2016, Racloz et al., 2013). Physical contact with livestock encompasses handling birth products while assisting livestock during parturition as well as handling infected aborted products without protectives. These are common practices among pastoral communities which increase the risk of transmission of brucellosis and other zoonotic diseases. A study in rural areas in Kajiado county, Kenya reported that Maasai handled infected aborted products without protective clothing, adding to their risk of brucellosis and other zoonoses (Onono et al., 2019). Traditionally, these communities have always lived closely and assisted with the parturition of their animals and never utilized protective clothing hence it's unlikely for them to consider it. The cost and availability of protectives may explain why they are never used as monetary circulation is rare in these communities. Their livestock is considered to be their banks and transactions for protectives may not be of value to them.

5.2 Misconceptions of brucellosis etiology and/or transmission

Pastoralism has had to adapt to colonialism, modernization, and climate change, which has increased their dependence on imported starches and fats. In this study, all FGD participants, community chiefs, and elders had some misconceptions on the causes, signs, and transmission pathways of brucellosis. Some participants mentioned processed food consumption, such as ugali, or rice, as the cause of human brucellosis and others believed the pasteurized milk, they purchased was the cause, unlike the fresh raw milk in their homes. A study in Kenya by Nyariki indicated that pastoralists were now transforming their activities such as diversification of livestock management and diet (Nyariki & Amwata, 2019). Greater reliance on purchased foods like rice and ugali has transformed their traditional animal-based diet, so they may speculate it is the cause of a new illness. On the other hand, a diversified diet is an opportunity to increase food security and reduce over-dependence on animal source foods which contribute to high risks of human brucellosis transmission.

The majority of the participants considered symptoms in humans and signs in animals to be the same. Both humans and animals were suspected of brucellosis if they have joint pains and difficulty in walking. The participants' perceptions were only limited to that in comparison to the additional medical symptoms of animal brucellosis such as abortions, low fertility, stillbirths, and low milk production (Obonyo, Mark and Gufu, 2015). Abortions were also reported to be a major recurring problem in livestock, but the sign was attributed to lack of good pasture, foot and mouth disease, vaccines, and Tsetse fly bite but never brucellosis as a cause. Several studies conducted in Kenya, Tanzania, and Ethiopia observed similar responses from their participants (Mburu et al., 2021, Asakura et al., 2018; Legesse et al., 2018). Over 50% of agropastoral studied in Tanzania did not know that brucellosis can also cause abortions while other participants attributed abortions to other factors like trypanosomiasis due to a large number of Tsetse flies in their grazing areas (Mburu et al., 2021). In Ethiopia, FGD participants related animal abortions to diseases like sheep and goat pox, bovine tuberculosis, malaria as well as foot and mouth disease (Legesse et al., 2018). Differing perspectives on disease etiology are a barrier to the implementation of prevention and control strategies. Another study in northern Kenya showed that when people's perspectives on the causes of diseases are contrary to the pathophysiological causes of the diseases, adherence to any preventive and control strategies for any disease is less effective (Ng'ang'a et al., 2016).

5.3 Brucellosis is not a priority

Public health officers and the human clinician possessed knowledge on the causes, symptoms, and transmission routes of brucellosis. However, the public health officials stated the disease as a disease of low public health concern because it has a low fatality rate among people, causes no disabilities, and takes a long time to present in patients. However, the non-specific clinical signs of brucellosis in humans lead to a low index of suspicion for health professionals, especially in under-resourced settings with inadequate testing facilities, resulting in misdiagnoses and underreporting (Legesse et al., 2018, Dean et al., 2012). The top three public health priorities highlighted were upper respiratory tract infections, waterborne diseases, and eye diseases, which all have multiple causes. However, the zoonotic disease prioritization study done in Kenya in 2011 ranks brucellosis in the top five (Munyua et al., 2021). With this categorization in place, it would be hoped that it is translated across the public health systems up to the county level to ensure that appropriate actions are put in place. The incapacitation and lack of prioritization of some diseases such as brucellosis can be attributed to the challenge with the ongoing devolution process of the Kenyan government. A World Bank report stated challenges thus far among county governments of lack of technical capacity, knowledge, and resources to effectively deliver on healthcare services (Bank, 2019).

5.4 Environmental risks for brucellosis transmission

Changing climatic conditions such as increasing drought and loss of pasture promoting both livestock movement and increased livestock-wildlife interactions, poor disposal of aborted tissues can contaminate the environment which also increases the risk of transmission. We learned that livestock from both communities shared grazing lands and water points with wildlife. One study in Kilombero district, Tanzania, reported similar findings where FGD participants observed that their livestock, especially cattle, routinely encountered wild animals such as puku antelopes, buffaloes, wild pigs, hippos, lions and even elephants. There was no consideration of this as a potential route of transmission of brucellosis and other zoonotic diseases as antelopes and buffaloes are known to shed brucella organisms in the environment (Mburu et al., 2021). Another study conducted on wildlife brucellosis reported that a large number of wildlife species were infected or have been found to show serological evidence of exposure to *Brucella spp* which could result in dilution or amplification of prevalence (Simpson et al., 2021). This resonates with some of our participants, particularly from the Rendille community whose communities were close to Marsabit National Park. Additionally, participants mentioned livestock migration in search of good pastures and water as a common practice, which (Obonyo, Mark, and Gufu, 2015) stated that it promotes contact from different herds and an increased risk of transmission (Obonyo, Mark and Gufu, 2015). The herd-to-herd contact and the herd to wildlife contact are reported to give way to spillover and cross-contamination of zoonotic diseases increasing the risk of transmission from wildlife to livestock or vice versa (Godfroid et al., 2013). Constant interaction at the livestock-wildlife interface led to the spread and maintenance of brucellosis in both animal and human populations (Mutua, 2017). The risk of transmission is complex and dependent on location, the population sizes of both wildlife and livestock, disease prevalence in wildlife, and susceptibility of livestock.

The majority of the participants threw aborted animal tissues away in the open or fed them to dogs although a few Borana participants mentioned that they buried aborted products. This aligns with a study in Maasai in Kajiado County where six groups said they fed them to dogs and two groups said they dispose of them by burying them(Mutua, 2017). *B. melitensis* was found in asymptomatic dogs so they may act as another brucella reservoir (Alamian & Dadar, 2020). As a result, herding dogs/companion animals should be included in brucellosis surveillance programs. Studies that were done in Ethiopia also noted improper disposal of aborted products and carcasses which increases the risk of disease transmission to human and livestock populations (Abd El-Wahab et al., 2019), Desta, 2015). *Brucella* species in aborted products, water, and manure can survive for periods of up to 150 to 250 days (Obonyo, Mark and Gufu, 2015), during which time it is infective to animals and people.

Changing climatic conditions may be increasing the risks of *Brucella* transmission. The rainy season was believed to influence the choice and availability of food where most participants consumed animal source foods (raw milk, blood, and meat) around this season hence increasing

chances for *Brucella* infection. A study conducted in Rendille pastoralists correlated our findings where it stated that seasonality influenced the nutritional status of most pastoral communities where milk production and calving are typically bountiful during rainy seasons and decrease during dry seasons (Nathan et al., 1996). During this season, animals would have good pasture, more milk production, and would be kept at home but with livestock overcrowding which increases transmission risks due to proximity. During the wet season when infected animals shed pathogens into the environment through birth fluids and tissues that contaminate pastures and the surroundings, this promotes in-herd transmission (Nyerere et al., 2020). Additionally, the survival of *Brucella* pathogens is reported to be favorable in wet seasons when the environment is cooler compared to hot dry seasons thus impacting the transmission rate(Shirima et al., 2014). However, participants from both communities had varying answers about seasonal trends of abortions, stillbirths, and fever in livestock; some said rainy season while others said drought season which made it hard to confirm the participants' perception of the exact season that might favor brucellosis transmission. This may be because there are other causes of abortion which occur at different times of the year. In Tanzania, three focus groups believed that brucellosis occurs in the dry season and two groups mentioned the rainy season (Ntirandekura et al., 2018). Studies in Cameroon, Mozambique, Ivory Coast, Burkina Faso, and Niger reported a lower brucellosis infection rate in hot and dry weather (Ducrotoy et al., 2017). However, most endemic areas like Marsabit have limited resources for brucellosis surveillance and diagnostic capacity and we did not find any studies to confirm these variations.

5.5 Open-mindedness

The Borana and Rendille participants demonstrated their openness and willingness to learn more about brucellosis in animals, humans, and how the environment contributes. Even though they mentioned that boiling milk kills nutrients, they had the curiosity to know exactly what is in the milk that causes brucellosis and indicated a willingness to learn and transform their practices. Additionally, they were also willing to teach each other amongst themselves to influence behavior change. This finding is contradictory to a study conducted in Turkana and Karamoja, Kenya, which attributed pastoralists' resistance to change to their traditions and dismal education programs (Report et al., 2016). Historically, blaming pastoralists for not behaving like the dominant culture has been the narrative about pastoralists (Report et al., 2016), and it might have contributed to ineffective relationships between these communities and the government.

The openness and willingness to learn of the communities are key factors for attracting development partners to work with them. The Ministry of health, the veterinary community, and the environmental conservancy sector should consider a collaborative effort to engage the community in animal, human, environmental health programs. In a study conducted among Borana pastoralists in Ethiopia, the participants acknowledged changes in their perception regarding the quality of milk and the associated health risks. These changes came about because of the

community's involvement in the existing health extension and livestock research activities in the area(Amenu et al., 2019).

5.6 Preferred communication channels

The FGD participants suggested radio Jangwani for information dissemination because they broadcast in local languages. A study in Garissa County recommended the use of local radios stations for targeted health education information (Obonyo, Mark and Gufu, 2015). Additionally, the study recommended the utilization of community health volunteers in control and prevention efforts which concurred with what the participants themselves suggested (Obonyo, Mark and Gufu, 2015). This is in line with some participants' suggestions to engage community health workers in health education campaigns.

The participants also preferred the rainy season for health awareness campaigns because everyone is in their homes with their livestock, unlike the drought season where most herders migrate in search of pasture and water. A study conducted in Ethiopia also confirms these seasonal migrations where it states that during the rainy season, animals trekked over short distances while during the dry seasons they have trekked over long distances and their location is not dependable (Africa, 2021).

5.7 Limitations of the study

Like all other studies, this study should be viewed considering several limitations. Firstly, language differences were a huge limitation for the primary researchers as it restricted them from conducting FGDs and missed opportunities to probe if the information got lost in the translation as well as objectively confirm the participants' responses. The primary researchers had to entirely depend on the facilitators and translators to make notes during the discussions which were then used for data quality check. Secondly, information collected from FGDs was based on what the participants told us and was not validated through direct observation of practices. While this may pose a risk of mismatch between the participants' real practices and what they said, the research team feels that the main issues have been explored and understood sufficiently considering the key informant interviews conducted for triangulation purposes. Thirdly, the translators/transcribers were inexperienced, so the quality of the transcribed interviews was in doubt. There is a possibility that some information may have been left out or misunderstood. However, a three-day training was done before data collection to improve facilitation and transcription skills, and the facilitators were given time to familiarize themselves with the tools. Also, the FGD facilitators conducted independent checks which were followed by group data quality checks with the primary researchers and transcribers to achieve consensus on the translation of culturally unique words and slang phrases. The data quality check with the facilitators and the transcribers confirmed the alignment of the content in the audios and the transcripts, but translation from an entirely different culture is inherently risky.

CHAPTER SIX: CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Both communities hold on to traditional beliefs and practices that increase the risk of transmission of brucellosis. Practices including consumption of raw animal products such as milk, sharing of grazing lands, and waste disposal pose high risks of brucellosis infection in animals and humans of all age groups. However, Rendille and Borana pastoralists currently do not perceive the aforementioned practices to be risky. This poses challenges to education and awareness programs. The changing climatic conditions such as drought and floods contribute to increased risk of brucellosis transmission thus increasing disease burden. Lastly, the interconnectedness of the communities, their livestock, and the shared environment contributes towards disease burden and should be addressed accordingly. The communities' interest in learning and preference for trusted intermediaries can aid the improvement of public health outreach at the local and national levels to prevent brucellosis and reduce its burden.

Restricted animal and human movement lead to over-utilization of natural resources, which has resulted in recurring hunger in the county. Most of the attention and resources are dedicated to address hunger issues, hampering the implementation of zoonoses related health programs such as brucellosis. This work is mostly conducted by NGOs, and they are more likely to be helpful considering they are more trusted by the communities. Additionally, government institutions have limited funding to sponsor awareness programs and to establish diagnostic centers. With devolution in progress, political will is yet to be established, and this further supports the role of NGOs as they will be considered neutral stakeholders thus better placed to support the county in zoonoses programs. Moreover, insecurities in the county due to tribal conflicts hinder health intervention programs and discourages government support. Therefore, the findings of this study show that practices and perceptions contribute to the increased risk of brucellosis transmission and have implications on the community's willingness to engage in protective practices.

6.2 Recommendations

This study recommends:

- Focused community engagement and sensitization to address the low awareness and misconceptions among pastoralists. Sauti Moja and Veterinarians International should set up education programs that create awareness and targeted training on the hazards of consuming raw milk, blood, and raw meat. The training sessions should be in person at the community level and scheduled during the rainy season and over the weekends. It is considered particularly important where cultural practices and beliefs clash with disease prevention strategies to adopt informal and participatory education as a tactic to explain transmission risks and promote acceptance of precise measures to limit the spread and re-emergence of the disease (Plumb et al., 2013). Specific tools like mobility and social

mapping may be helpful to get an in-depth of their seasonal movements and understanding of cultural landscapes and connection with local government services and facilities(Flanagan, 2015). Pictograms (picture books) containing food safety guidelines can also be used to teach the communities. Pictograms are non-verbal communication symbols that have commonly associated concepts and have been used to convey messages to people with short memory or literacy disabilities or who speak different languages (Hiranchiracheep & Yamazaki, 2018).

- Sauti Moja in collaboration with Veterinarians International can build on existing community-level programs to conduct educational programs on the risks of transmission of brucellosis. It would be less expensive to build on these, rather than designing something new and would improve trust, and chances of compliance to brucellosis-related training.
- Sauti Moja and Veterinarian International can share this study with stakeholders across human health, animal health, and environmental sectors to address brucellosis and zoonotic risks holistically. This could result in partnerships among the stakeholders. Such synergies have been documented to be essential for success in the case of brucellosis management in Mongolia where it fostered logistical cooperation in the form of joint transport, training, diagnostic analyses, and data-sharing (WHO, 2014).

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APPENDICES

Appendix 1: Participants Consent form

INFORMATION AND CONSENT FORM

Participant ID: _____

Project title: Risks, perceptions, and practices surrounding *Brucellosis melitensis* transmission among people, animals, and the shared environment among the Rendille and the Borana pastoralists in Marsabit County, Kenya.

Study population: The study will target two groups: Rendille and Borana Communities. The study participants from the Rendille community and the Borana community will be selected using convenience sampling. It will include both males and females, young and adults.

Version date:

Principal Investigators

Valentine Ndacyayisenga: MSc University of Global Health Equity, One Health track

Yeukai Chikwenhere**:** MSc University of Global Health Equity, One Health track

About this consent form

Dear participant.

You are being invited to participate in this study that regarding exploring potential risks and perceptions regarding the transmission of disease. You must understand and take into consideration the contents of this form since it contains important information to assist you in deciding whether to participate in this study. Please take your time in choosing whether to participate in this research and please feel free to ask any question about this research or this form. If you agree to participate, you will sign this form and be given a copy for your records.

Participation is voluntary

Participation in this research is entirely your choice. If you decide to participate, you are free to change your mind and leave the study at any time that suits you. You will not be penalized or lose any benefits otherwise entitled to you if you at point refuse to participate or stop your participation during the study.

What should you know about this research study?

The research study is being conducted by the researchers as part of their commitment to the University of Global Health Equity. Your participation is important as it will inform us of the perceptions and risks associated with the disease in question.

What is the purpose of this project?

The purpose of our study is to explore the risks, perceptions, and practices of transmission of *Brucella melitensis* in people and animals among the Rendille and Borana communities.

How many people will take part in this research?

Approximately 94 people will take part in this research.

What is the procedure for participation in this project?

Your participation will involve taking part in a group discussion in which a list of questions will be shared with groups of 8-10 people. The session will be recorded and is expected to last 90 minutes.

What are the possible risks or discomforts related to taking part in this project?

There are no possible risks or discomforts associated with our study. If you choose to participate, and however, happened to experience some emotional distress due to the nature of the discussion topic, we will share referral information with you at the end of the interview if you would like to seek help.

What are the possible benefits of taking part in this project?

If you choose to participate, you will be helping to develop context-specific recommendations to inform the creation of trusted communication strategies for future health education programs. This could potentially lead to improved health for your family, community, and animals.

What are my alternatives to participating in this study?

The alternative to participating in this research study is not to participate.

Will I be compensated for participating in this research?

There will not be any compensation available for this research, but a transport allowance will be provided for all participants.

What will I have to pay for if I participate in this research?

It will not cost you anything to participate in this research.

What happens if I am injured because of participating in this research study?

Physical accidents are not anticipated to happen during the study as there is no physical contact with the study participants.

Can my take part in the research end early?

You may decide not to continue in the research at any time without it being held against you. The person in charge of the research can remove you from the research at any time without your approval for any reason.

If I take part in this project, how will my privacy be protected? What happens to the information you collect?

The information collected will be kept anonymous and confidential. It will not include any of your names and will only be accessed by the project team. The results will be used for research purposes

only, not for your professional evaluation. We will not share your responses with anyone outside the research team at any time. All project data will be kept safe in locked storage or with computer and file passwords and will be destroyed after 10 years.

If I have any questions, concerns, or complaints about this project, who can I talk to?

The researchers for this study are Valentine Ndacyayisenga and Yeukai Chikwenhere and can be reached at the UGHE campus in Butaro, Rwanda; 0786768321, 0786824177; yeukai.chikwenhere@student.ughe.org and valentine.ndacyayisenga@student.ughe.org, If you have questions, concerns, or complaints.

- If you would like to talk to the project team.
- If you think the project has harmed you,
- If you wish to withdraw from the study."
- If you wish to withdraw from the study.

This research has been reviewed by the University of Global Health Equity and Kenyan Institutional Review Board. If you wish to speak with someone from the IRB, please contact the Kenyan approval board at customercare@nacosti.go.ke/infor@nacosti.go.ke, telephone: 0713788787/0735404245 or Whatsapp:0792746282 or Office of National Commission for Science Technology and Innovation off Waiyaki Way, Upper kabete, P O Box 30623, 00100 Kenya, for any of the following:

- If your questions, concerns, or complaints are not being answered by the research team.
- If you cannot reach the research team.
- If you want to talk to someone besides the research team.
- If you have questions about your rights as a research participant, or.
- If you want to get information or provide input about this research.

To contact the research team:
Yeukai Chikwenhere
yeukai.chikwenhere@student.ughe.org,
0786768321
Valentine Ndacyayisenga
Valentine.ndacyayisenga@student.ughe.org
0786824177

Statement of consent

Signing an X next to each statement and your fingerprint below indicates that:

- You have understood the content of this form.
- You have had the opportunity to ask questions and received satisfactory answers.
- If needed, you took time to discuss this information with others to help you decide whether to participate.
- You will receive a dated and signed copy of the form.

- You agree to participate in this research project.

☐ I consent to have the interview audio-recorded

_____ _____
Full name and signature of the witness Date and location

_____ _____
Full name and signature of the person requesting consent Date and location

I have read the information in this consent form including risks and possible benefits. All my questions about the research have been answered to my satisfaction. I understand that I am free to withdraw at any time without penalty or loss of benefits to which I am otherwise entitled.

I consent to participate in the study.

SIGNATURE (see next page**)**

Your signature below indicates your permission to take part in this research

_____
Name of participant

_____ _____
Signature of participant Date

_____ _____
Signature of the person obtaining consent Date

_____

Alternatively, if your respondent is illiterate, you could use the following for your statement of consent. Example: "Your signature below indicates you acknowledge that:

- You have understood the content of this form.
- You have had the opportunity to ask questions and received satisfactory answers.

- If needed, you took time to discuss this information with others to help you decide whether to participate.
- You will receive a dated and signed copy of the form.
- You agree to participate in this project.

Appendix 2: Translated participant consent form

Kiswahili version

UNIVERSITY OF
Global Health
EQUITY

Kitambulisho cha mshiriki: _____

Kichwa cha mradi: Hatari, maoni, na mazoea yanayozunguka usambazaji wa Brucellosis melitensis kati ya watu, wanyama, na mazingira ya pamoja kati ya wafugaji wa Rendille na Borana katika Kaunti ya Marsabit, Kenya.

Idadi ya watu wa utafiti: Utafiti utalenga vikundi viwili: Jamii za Rendille na Borana. Washiriki wa utafiti kutoka jamii ya Rendille na jamii ya Borana watachaguliwa kwa kutumia sampuli ya urahisi. Itajumuisha wanaume na wanawake, vijana na watu wazima.

Tarehe ya toleo:
Wachunguzi Wakuu:
Valentine Ndacyayisenga: Chuo Kikuu cha Global health Equity; One Health track
Yeukai Chikwenhere: Chuo Kikuu cha MSc cha Global health Equity; One Health track

Kuhusu fomu hii ya idhini
Mpendwa mshiriki,
Unaalikwa kushiriki katika utafiti huu kuhusu kuchunguza uwezekano wa hatari na maoni kuhusu maambukizi ya ugonjwa. Lazima uelewe na uzingatia yaliyomo katika fomu hii, kwani ina habari muhimu kukusaidia katika kuamua ikiwa utashiriki katika utafiti huu. Tafadhali chukua muda wako kuchagua ikiwa utashiriki katika utafiti huu, na tafadhali jisikie huru kuuliza swali lolote la utafiti huu au kuhusu fomu hii. Ikiwa unakubali kushiriki, utasaini fomu hii na utapewa nakala ya kumbukumbu zako.

Kushiriki ni hiari
Kushiriki katika utafiti huu ni chaguo lako kabisa. Ukiamua kushiriki, uko huru kubadilisha mawazo yako na kuacha masomo wakati wowote unaokufaa. Hautaadhibiwa au kupoteza faida zozote utakazopewa ikiwa utakataa kushiriki au kuacha kushiriki kwako wakati wa utafiti.
Je! Unapaswa kujua nini kuhusu utafiti huu?
Utafiti huu unafanywa na watafiti kama sehemu ya kujitolea kwao na Chuo Kikuu cha Global Health Equity. Ushiriki wako ni muhimu kwani utatujulisha juu ya maoni na hatari zinazohusiana na ugonjwa huu.

Madhumuni ya mradi huu ni nini?
Madhumuni ya utafiti wetu ni kuchunguza hatari, maoni, na mazoea ya kupitisha Brucella melitensis kwa watu na wanyama kati ya jamii za Rendille na Borana.

Ni watu wangapi watashiriki katika utafiti huu?
Takriban watu 94 watashiriki katika utafiti huu.

Je! Ni utaratibu gani wa kushiriki katika mradi huu?
Ushiriki wako utahusisha kushiriki katika majadiliano ya kikundi ambayo orodha ya maswali itashirikiwa kwa vikundi vya watu 8-10. Kikao hicho kitarekodiwa na kinatarajiwa kuchukua dakika 90.

Je! Ni hatari gani au shida zinazohusiana na kushiriki katika mradi huu?
Hakuna hatari zinazowezekana au usumbufu unaohusishwa na utafiti wetu. Ikiwa unachagua kushiriki, na hata hivyo, umepata shida ya kihemko kutokana na hali ya mada ya majadiliano, tutashiriki habari za rufaa na wewe mwishoni mwa mahojiano ikiwa ungependa kutafuta msaada.

Je! Ni faida gani zinazowezekana kushiriki katika mradi huu?
Ikiwa unachagua kushiriki, utasaidia kukuza mapendekezo maalum ya muktadha ili kuarifu kuunda mikakati ya mawasiliano inayoaminika kwa mipango ya masomo ya afya ya baadaye. Hii inaweza kusababisha afya bora kwa familia yako, jamii kijumla, na wanyama.

Je! Ni njia gani badala za kushiriki katika utafiti huu?
Njia badala ya kushiriki katika utafiti huu sio kushiriki.

Je! Nitalipwa fidia kwa kushiriki katika utafiti huu?
Hakutakuwa na fidia yoyote inayopatikana kwa utafiti huu, lakini posho ya usafirishaji itapewa kwa washiriki wote.
Je! Nitalazimika kulipia ikiwa nitashiriki katika utafiti huu?
Haitakugharimu chochote kushiriki katika utafiti huu.

Ni nini kinachotokea ikiwa nimeumia kwa sababu ya kushiriki katika utafiti huu?
Ajali za mwili hazitarajiwi kutokea wakati wa utafiti kwani hakuna mawasiliano ya mwili na washiriki wa utafiti.

Je! Kushiriki kwangu katika utafiti kunaweza kusimamishwa mapema?
Unaweza kuamua kutoendelea katika utafiti wakati wowote bila kushikiliwa dhidi yako. Mtu anayesimamia utafiti anaweza kukuondoa kutoka kwa utafiti wakati wowote bila idhini yako kwa sababu yoyote.

Ikiwa nitashiriki katika mradi huu, faragha yangu italindwaje? Ni nini hufanyika kwa habari unayokusanya?

Habari iliyokusanywa itawekwa bila kujulikana na kuwa siri. Haitajumuisha majina yako yoyote na itapatikana tu na timu ya mradi. Matokeo yatatumika kwa madhumuni ya utafiti tu, sio kwa tathmini yako ya kitaalam. Hatutashiriki majibu yako ya kibinafsi na mtu yeyote nje ya timu ya utafiti wakati wowote. Takwimu zote za mradi zitahifadhiwa salama katika hifadhi iliyofungwa au kwa nywila za kompyuta na faili na zitaharibiwa baada ya miaka 10.

Ikiwa nina maswali yoyote, wasiwasi, au malalamiko juu ya mradi huu, ninaweza kuzungumza na nani?

Watafiti wa utafiti huu ni Valentine Ndacyayisenga na Yeukai Chikwenhere na wanaweza kupatikana kwenya kampasi ya UGHE huko Butaro, Rwanda; 0786768321, 0786824177; yeukai.chikwenhere@student.ughe.org na valentine.ndacyayisenga@student.ughe.org, Ikiwa una maswali, wasiwasi, au malalamiko.

- Ikiwa ungependa kuzungumza na timu ya mradi.
- Ikiwa unafikiria mradi umekuumiza,
- Ikiwa unataka kujitoa kwenye utafiti."
- Ikiwa unataka kujitoa kwenye utafiti.

Utafiti huu umepitiwa na Chuo Kikuu cha Global Health Equity na Bodi za Ukaguzi wa Taasisi za Kenya. Ikiwa unataka kuzungumza na mtu kutoka IRB, tafadhali wasiliana na bodi ya idhini ya Kenya kwa customercare @ nacosti.go.ke / infor @ nacosti.go.ke, simu: 0713788787/0735404245 au Whatsapp: 0792746282 au Ofisi ya Tume ya Kitaifa ya Sayansi Teknolojia na Ubunifu iliyo na Njia ya Waiyaki, Juu kabete, SLP 30623, 00100 Kenya, kwa yoyote yafuatayo:

- Ikiwa maswali yako, wasiwasi, au malalamiko hayakujibiwa na timu ya utafiti.
- Ikiwa huwezi kufikia timu ya utafiti.
- Ikiwa unataka kuzungumza na mtu zaidi ya timu ya utafiti.
- Ikiwa una maswali juu ya haki zako kama mshiriki wa utafiti, au.
- Ikiwa unataka kupata habari au kutoa maoni kuhusu utafiti huu.

Kuwasiliana na timu ya utafiti:
Yeukai Chikwenhere
yeukai.chikwenhere@student.ughe.org,
0786768321
Valentine Ndacyayisenga
Valentine.ndacyayisenga@student.ughe.org
0786824177
Taarifa ya idhini
Kutia saini X karibu na kila taarifa na alama yako ya kidole hapa chini inaonyesha kuwa:

● Umeelewa yaliyomo kwenye fomu hii.
● Umepata nafasi ya kuuliza maswali na kupata majibu ambayo yalikuwa ya kuridhisha.
● Ikihitajika, ulichukua muda kujadili habari hii na wengine kukusaidia kuamua ikiwa utashiriki.
● Utapokea nakala ya tarehe na saini ya fomu.
● Unakubali kushiriki katika mradi huu wa utafiti.

Ninakubali kuwa na mahojiano ya sauti

_____ _____
Jina kamili na sahihi ya shahidi Tarehe na eneo

_____ _____
Jina kamili na saini ya mtu Tarehe na eneo
kuomba ridhaa

Appendix 3: Key Informants Consent form

INFORMATION AND CONSENT FORM
Participant ID: _____

Project title: Risks, perceptions, and practices surrounding *Brucellosis melitensis* transmission among people, animals, and the shared environment among the Rendille and the Borana pastoralists in Marsabit County, Kenya.
Study population: The study will target two groups: Rendille and Borana Communities. The study participants from the Rendille community and the Borana community will be selected using convenience sampling. It will include both males and females, young and adults. Key informants across the groups will be selected for interviews based on their areas of expertise and/or experience.
Principal Investigators
Valentine Ndacyayisenga: MSc University of Global Health Equity, One Health track
Yeukai Chikwenhere**:** MSc University of Global Health Equity, One Health track
About this consent form
Dear participant.
You are being invited to participate in this study regarding exploring potential risks and perceptions concerning the transmission of disease. You must understand and take into consideration the contents of this form since it contains important information to assist you in deciding whether to participate in this study. Please take your time in choosing whether to participate in this research and please feel free to ask any question about this research or this form. If you agree to participate, you will sign this form and be given a copy for your records.

Participation is voluntary

Participation in this research is entirely your choice. If you decide to participate, you are free to change your mind and leave the study at any time that suits you. You will not be penalized or lose any benefits otherwise entitled to you if you at point refuse to participate or stop your participation during the study.

What should you know about this research study?

The research study is being conducted by the researchers as part of their commitment to the University of Global Health Equity. Your participation is important as it will inform us of the perceptions, practices, and risks associated with the disease in question.

What is the purpose of this project?

The purpose of our study is to explore the risks, perceptions, and practices of transmission of *Brucella melitensis* in people and animals among the Rendille and Borana communities.

How many people will take part in this research?

Approximately 14 people will take part in this part of the research.

What is the procedure for participation in this project?

Your participation will involve a one-on-one interview in which a list of questions will be asked to you concerning your area of expertise or experience. The session will be recorded and is expected to last not more than 60 minutes.

What are the possible risks or discomforts related to taking part in this project?

There are no possible risks or discomforts associated with our study. If you choose to participate, and however, happened to experience some emotional distress due to the nature of the discussion topic, we will share referral information with you at the end of the interview if you would like to seek help.

What are the possible benefits of taking part in this project?

If you choose to participate, you will be helping to develop context-specific recommendations to inform the creation of trusted communication strategies for future health education programs. This could potentially lead to improved health for your family, community, animals, and the shared environment.

What are my alternatives to participating in this study?

The alternative to participating in this research study is not to participate.

Will I be compensated for participating in this research?

There will not be any compensation available for this research.

What will I have to pay for if I participate in this research?

It will not cost you anything to participate in this research.

What happens if I am injured because of participating in this research study?

Physical accidents are not anticipated to happen during the study as there is no physical contact with the study participants.

Can my take part in the research end early? You may decide not to continue in the research at any time without it being held against you. The person in charge of the research can remove you from the research at any time without your approval for any reason.

If I take part in this project, how will my privacy be protected? What happens to the information you collect?

The information collected will be kept anonymous and confidential. It will not include any of your names and will only be accessed by the project team. The results will be used for research purposes only, not for your professional evaluation. We will not share your responses with anyone outside the research team at any time. All project data will be kept safe in locked storage or with computer and file passwords and will be destroyed after 10 years.

If I have any questions, concerns, or complaints about this project, who can I talk to?

The researchers for this study are Valentine Ndacyayisenga and Yeukai Chikwenhere and can be reached at the UGHE campus in Butaro, Rwanda; 0786768321, 0786824177; yeukai.chikwenhere@student.ughe.org and valentine.ndacyayisenga@student.ughe.org, If you have questions, concerns, or complaints.

- If you would like to talk to the project team.
- If you think the project has harmed you,
- If you wish to withdraw from the study."
- If you wish to withdraw from the study.

This research has been reviewed by the University of Global Health Equity Institutional Review Board. If you wish to speak with someone from the IRB, please contact the IRB at irb@ughe.org, telephone: 0788316894 or Office of Human Research Administration (OHRA) at Kigali Heights Building, 5th floor, Kacyiru, Kigali, P.O. Box 6955, Rwanda, for any of the following:

- If your questions, concerns, or complaints are not being answered by the research team.
- If you cannot reach the research team.
- If you want to talk to someone besides the research team.
- If you have questions about your rights as a research participant, or.
- If you want to get information or provide input about this research.

To contact the research team:
Yeukai Chikwenhere
yeukai.chikwenhere@student.ughe.org,
0786768321
Valentine Ndacyayisenga
Valentine.ndacyayisenga@student.ughe.org
0786824177

Statement of consent

Signing an X next to each statement and your fingerprint below indicates that:

- You have understood the content of this form.
- You have had the opportunity to ask questions and received satisfactory answers.

- If needed, you took time to discuss this information with others to help you decide whether to participate.
- You will receive a dated and signed copy of the form.
- You agree to participate in this research project.

☐ I consent to have the interview audio-recorded

_____ _____

Full name and signature of the witness Date and location

_____ _____

Full name and signature of the person requesting consent Date and location

I have read the information in this consent form including risks and possible benefits. All my questions about the research have been answered to my satisfaction. I understand that I am free to withdraw at any time without penalty or loss of benefits to which I am otherwise entitled.

I consent to participate in the study.

SIGNATURE (see next page**)**

Your signature below indicates your permission to take part in this research

_____

Name of participant

_____ _____

Signature of participant Date

_____ _____

Signature of the person obtaining consent Date

_____

Appendix 4: Focus Group Discussion interview guide

To explore potential risks, perceptions, practices surrounding *Brucellosis melitensis* transmission among people, animals, and the shared environment among the Rendille and the Borana pastoralists in Marsabit county, Kenya.

Ice breaker [10 minutes]

Participants to share what gives them joy in their community/ Ask participants if they have a favorite animal amongst their livestock and to share their names if they have assigned one to them (This we hope will lighten the mood and have everyone relax before we start)

SECTION 1: RISKS

Human related

1. Tell us about your daily interaction with livestock
   Probes:
   - Which ones do you often interact with daily, and which ones are managed by your relatives or paid herders?
   - Which diseases normally affect your livestock?
   - Who takes care of sick animals?
2. What do you know about Brucellosis?
   Probes:
   - Have you ever had an animal with brucellosis?
   - How did you know?
   - What about your neighbors/family?
3. Would you like to share with us some of the ways you adopt to prevent brucellosis?

Animal-related

4. Describe an experience when your livestock had an abortion, stillbirth, or fever.
   Probes:
   - What had happened?
   - What did you do?
   - Who helped you (did you seek help from a Vet or neighbor?
   - Treat with medicine (describe) or supportive care?
   - Why do you think it got sick?

Environment-related

5. During which time of the year do you experience animal abortions, stillbirths, and fevers the most?
   Probes:

- Which time of the year does it occur --rainy or dry season?
- What do they do with the fetal and placental remains and the area where that happens?
- How do they clean up after assisting animals?
- Water accessibility and how far they get water from?
- Are abortions or fever more common now than when you were a child? Why? Why not?

6. Tell us about the grazing areas that you take your livestock to?
   Probes:
   - How does your livestock interact with any wildlife animals in the grazing or drinking areas?

SECTION 2: PERCEPTIONS

Human related

1. Some livestock owners believe that some diseases like malaria and Bovine TB can be transmitted from animals to humans through drinking raw milk. I would like to hear what you think about that, and if there are any diseases that you believe are transmitted that way?

2. Now, I would like to understand from the ways you think people can get Brucellosis from animals
   Probes:
   - Why do you think so?

Animal-related

3. You mentioned earlier what you think causes abortions and I wanted to share that I have heard people say drought or fly bites cause abortions/stillbirth/fever, what do you think about that?

Environment-related

4. I would like to know what your thoughts are regarding aborted products and excrement left lying around your grazing area or your surroundings?
   Probes:
   - Have you ever come across wildlife aborted birth membranes out in the field or grazing land and what do you think about that concerning the transmission of brucellosis and other diseases?

SECTION 3: PRACTICES

[Before the next question, we present each participant with a sheet of different types of food and an option to tick those that they are familiar with, collect the results and proceed with the next questions]. The purpose is to make sessions interactive, engaging and avoid interview fatigue.

Human related

1. What are the main sources of food here?
   Probes:
   - A report on Marsabit county says the main sources of food are milk, blood, and raw meat. Is that common? Would you tell us more about that?
   - What is the source and how do you prepare it for consumption?
   - What products do you consume from goats and camels?
   - How/when is it determined to kill an animal for consumption?
   - How do you involve veterinarians in the slaughter process?
2. How often do you consume milk?
   Probes:
   - Where does it come from? (species)
   - What milk do you prefer if you have a choice? Why?
3. Typically, who does the milking (for the milk you and your family consume)?
   Probes:
   - Self, a family member living with you; family member not living with you, neighbor, purchased?
4. What are the tools or utensils you use for milking?
   Probes:
   - How do you clean them?
   - Is there a specific environment where the milking is done?
   - How do you clean up the milking area?
5. How do you prepare the milk?
   Probes:
   - Who does it?
   - What is the source of heat you utilize for boiling if you heat it?
   - Do you ever add something to the milk before consumption, such as maize or millet (or other grain), blood, water, others?
   - When and why?
   - Would you like to share some of the things that may hinder you in preparing milk for consumption? (Ask about challenges to boiling (e.g., fuel) or taste (convincing children or family members)

Animal-related

6. Tell us where and how you keep your livestock?
   Probes:
   - If you can describe how that looks and where it is situated concerning where you sleep and cook?
   - How do you separate livestock in their closures?
   - Do you separate goats from camels, cattle, and other animals?

- If you do not, why, or why not?

7. How do you involve vets before while purchasing livestock animals?
   Probes:
   - Do you test if they are healthy before buying?
   - Do you isolate the purchased animals for a while before mixing with others?
   - If you do not, why, or why not?

Environment-related

8. Where are the animals slaughtered?
   Probes:
   - Describe how the slaughterhouse or areas look like?
   - Who does it?
   - What tools do you use?
   - How do you keep the area and the tools clean?
   - Do you wear any protective clothing during the process?
9. How do you dispose of dead animals from any cause?
   Probes:
   - How do you dispose of offal?
   - How do you utilize or handle the animal skin or hides from slaughtered animals?

SECTION 4: Health communication preference

tell us about how you normally learn about health information?

Probes:
- How do you get information about human health?
- How do you get information about animal health?
- Who do you trust to give you reliable advice?
- What are the most trustworthy sources?

1. What kind of information would you want to be included in health education on brucellosis?
   Probes:
   - What is the best way to learn about it?
   - Whom do you expect to get it from?
   - What would be your expectations and preferences?
2. What are the ways do you think this information can be disseminated to reach all the people?
   Probes:
   - What would be the community's contribution in making it a success?
3. What are the obstacles to reaching people?
   Probes:

- Do you think that people will change their behavior if it is risky? why? why not?
- What best motivates or encourages people to change their behaviors

Appendix 5: Translated FGD guide

Focus Group Discussion guide:

Kutadhmini hatari, maoni,vitendo na shughuli zinazo lingana na kusambazwa kwa ugonjwa wa maziwa kati ya watu, wanyama and mazingira kati ya jamii za Rendile na Borana gatuzi la Marsabit, Kenya.

Shughuli ya mwanzo:

- Wahusika kutoa maoni ya mambo yanayo wapa furaha
- Uliza wahusika kama kuna mnyama wanaompenda zaidi katika mifugo yao
- Uliza kama mifugo wako na majina na hayo majina ni yapi

SEHEMU YA KWANZA:
Kuhusiana na Binadamu:

1. Tueleze shughuli zako za kilasiku kuhusiana na mifugo?
    a. Ni mifugo gani unaohusika nao kila siku, ni wagani wanochungwa na jamii yako na ni wagani wanaochungwa na wafugaji wa kulipwa?
    b. Ni magonjwa gani yanoawakabili mifugo yako kwa kawaida?
    c. Ni nani anayechunga mifugo wakigonjeka?
2. Je wajua ugonjwa wa maziwa?
    a. Je kuna mifugo wako waliogonjeka uganjwa wa maziwa?
    b. Ulijua ajekwamba wamegonjeka ugonjwa wa maziwa?
    c. Je jamii yako na majirani wanjua kuhusu uganjwa wa maziwa?
3. Unaweza kutueleza njia unazotumia ilikukinga mifugo wako kutokana na ugojwa wa maziwa?

Kuhusiana na Wanyama:

4. Tueleze mazoea yako mifugo wako wakiwa na mimba tasa, joto na kuavya mimba
    a. Nini kilichotendeka?
    b. Ulifanya nini?
    c. Nani alikusaidia katika mambo haya?
    d. Ulipata madawa?
    e. Unadhani kwanii mifugo yako ilipata haya matatizo?

Kuhusiana na Mizingira:

5. Ni wakati upi wa mwaka unapokumbana na haya magonjwa ya joto, kuavya mimba na mimba tasa?
    a. Ni wakati wa mvua ama kiangazi?
    b. Unashughulika vipi na mabaki ya uzazi, unayaweka wapi?
    c. Unajiosha vipi ukimaliza kumsahidia mfugo wakati wa kuavya mimba?
    d. Je haya magonjwa ya mimba tasa, kuavya mimba na joto yamezidi sasa kulinganishwa na ukiwa mtoto?
6. Tueleze mambo kuhusiana na pahali unapo wapeleka mifugo kupata lishe na maji ya kunywa?
    a. Mifugo wako wanategamana aje na wanyamapori kwenye sehemu za lishe na maji?

SEHEMU YA PILI: MAONO

Kuhusiana na Binadamu:

1. Kuna wakulima wa mifugo wanaoamini kwamba magonjwa kama malaria na homa ya mabavu ya wanyama, yanaweza kuambukizwa kutoka wanyama hadi binadamu kwa kukunywa maziwa yasiyochemshwa. Je wewe unaona vipi hii kauli?Na je unadhani kuna majongwa mengini yanayoabukizanwa kutoka wanyama hadi biandamu kwa maziwa?
2. Nigelitaka unieleze vile unavyodhani watu wanaweza pata ugonjwa wa maziwa kutokana na mifugo?
    a. Mbona unadhani hivi?

Kuhusiana na mifugo:

3. Awali ulinieleza maoni yako kulingana na kuavya mimba kwa mifugo. Nigetaka kukueleza kwamba watu wengine wamesema kwamba ukame na kushambuliwa na nzi kunasababisha kuavya kwa mimba, mimba tasa na joto kwa mifugo. Je maoni yako ni yapi?

Kuhusu Mazingara:

4. Nigelitaka kujua maoni yakokuhusu uchafu ya miba tasa na kuavya mimba kuachwa kwenye sehemu za lishe na vile huu uchafukama unadhani unachangia kuenezwa kwa ugonjwa wa maziwa na magonjwa mengine.
    a. Umewahi pata mizoga ya wanyamapori kwenye eneo la malisho na unadhani hii mizoga na uchafu wa mimba tasa huchangia kuenea kwa ugonjwa wa maziwa na magojwa mengine?

SEHEMU YA TATU: MAZOEA

Kuhusiana na Binadamu:

1. Nini haswa vyanzo vya chakula?
    a. Kuna repoti ya gatuzi la Marsabit inayosema kwamba vyanzo vikuu vya chakula ni maziwa,damu na nyama mbichi. Hivi vyakula ni vya kawaida? Unawezatueleza zaidi?
    b. Ni vitu gani unavyokula kutoka mbuzi na ngamia?

c. Ni lini unaamua kwamba mfugo unaweza kuwa chakula?
d. Mnapo chinja wanyama je mnahusisha watu wasiokula nyama?

2. Ni mara ngapi unakunywa maziwa? Unauzoefu wa kunywa maziwa?
    a. Haya maziwa unayatoa wapi?
    b. Unayapenda maziwa ngani? Na kwasababu gani?
3. Kwa kawaida nani anakamua maziwa?
    a. Je ni wewe, mtu wa familia mnaye ishi naye, mtu wa familia asiyeishi na nyi , au unanunua maziwa?
4. Ni vifaa vipi unavyotumia kukamua?
    a. Unahakikisha usafi wa vyombo hivi vipi?
    b. Kuna sehemu uliyotenga maalum kwa kukamua?
    c. Unahakikisha usafi wa eneo la kukamua ki vipi?
5. Unayatengeneza mazi vipi?
    a. Nani anayetengeneza maziwa?
    b. Unatoa wapi moto wa kuyachemsha maziwa?
    c. Unaongezea chochote maziwa yako kabla ya kuyatumia kama vile mahindi, wimbi damu maji au chochote kingine?
    d. Kama ndiyo, unaogeza lini na mbona?
    e. Je kuna jambo ama mambo ungetaka kutuambia yanayo kuzuia kutayarisha maziwa ya kutumia (Changamoto unazo kabiliana nazo)

Kuhusiana na mifugo:

6. Tueleze ni wapi na vipi unavyo waweka mifugo wako.
    a. Unaweza fafanua jinsi sehemu inavyokaa, sehemu iko wapi kulingana na unapopikia na kulala
    b. Unawagawana aje mifugo wako kwa mizizi yao
    c. Unawatofautisha ngamia,ng'ombe namifugo wengine?
    d. Kuna sababu za kutofautishana hawa mifugo?
7. Unawahusisha daktari wa mifugo unaponunua mifugo?
    a. Unaangalia kama mifugo wana afya njema kabla kununua?
    b. Unawatenga mifugo unaowanunua ama unawachanganya pamoja na wale wakitambo?
    c. Kuna sababu gani kwa kufanya hivi?

Kuhusiana na Mazingira:

8. Mifugo yako inachinjwa wapi?
    a. Nani anachinja mifugo?
    b. Kuna mavaazi rasmi kwa wanaochinja mifugo?
9. Unawazika aje mizoga ya mifugo waliokufa?
    a. Je unatupa matumbo ya mifugo waliokufa kivipi?
    b. Unatumia aje ngozi ya mifugo?

SEHEMU YA 4: MAZUNGUMZO YA AFYA

1. Tueleze jinsi unavyo pokea maaelezo ya kiafya?
    a. Unapataje habari za kiafya ya wanadamu
    b. Unapataje habari za kiafya ya mifugo
    c. Unauhakika na habari hizi unazozipata za kiafya?
    d. Kulingana na wewe ni vyanzo vya habari unavyoamini zaidi?
2. Ni ujumbe upi ungalitaka kupewa unapata ujumbe wa ugonjwa wa maziwa?
    a. Ni njia gani ungependa kujulishwa juu ya ugonjwa wa maziwa?
    b. Ungelitaka nani akupee huu ujumbe wa ugonjwa wa maziwa?
    c. Matarajio yako kwa ujumbe huu ni yapi?
3. Je unaweza kutueleza vile huu ujumbe wa ugonjwa wa maziwa unaweza sambazwakwa njamii yote?
    a. Je jamii inaweza husishwa kivipi kwenye kusambazaa ujumbe huu?
4. Je nipingamizi zipi unazoziona kufikisha huu ujumbe wa afya juu ya ugnjwa wa maziwa kwa jamii?
    a. Undhani watu wata badilisha mienedo na mazoea yao wakiupata huu ujumbe wa afya?
    b. Ni jambo gani ama mambo gani yanayowafanya watu kubadilisha tabia kulingana na ugojwa wa maziwa?

Appendix 6: Key Informant Interview guide

To explore potential risks, perceptions, practices surrounding *Brucellosis melitensis* transmission among people, animals, and the shared environment among the Rendille and the Borana pastoralists in Marsabit county, Kenya.

Thank you for agreeing to an interview today.

My name is ___ and my colleague and I are researchers from the University of Global Health Equity. We are conducting a project trying to explore potential risks, perceptions, practices surrounding *Brucellosis melitensis* transmission among people, animals, and the shared environment.

As a leader in this county, your views and experiences are extremely valuable to us, and we appreciate your contribution to this research. There are no right or wrong answers, so please feel free to share your thoughts with us. Your participation today is entirely voluntary. We will not use your name in any documents that arise from the research. I would like to record notes during our interview. The reason for this is so that we do not miss anything that you say, and so we can capture your views correctly. The notes will be kept confidential and only used for this research project to inform future public animal and human health interventions.

The interview will last about 45 minutes. Do you have any questions before we begin?

A key informant interview guide
Public Health officers (PHO and Vets)

1. Please describe the work of the organization.
2. Can you tell me a bit about your role in the organization and the community?
3. Are there any policies with regards to brucellosis management in humans or animals (surveillance, diagnosis, treatment, vaccination)?
   Probe (if there are any policies):
   - Are there dedicated facilities and resources for brucellosis management?
4. What do you know about Brucellosis?
5. How does your work relate to the challenges of brucellosis in (animals for vets, or in humans for Public health officers)?
6. How has human or animal brucellosis impacted the community?
7. What are the risk factors associated with brucellosis transmission that you have seen in your line of work with the community?
8. How does the community perceive brucellosis transmission?
9. What are the main challenges **(socio-economic; environmental; cultural)** to improving human/livestock health in the County?
   Probes:
   - What additional information is needed to design a good plan?

- What are the most important elements of such a plan?
- Do you think that the local population wants to improve their animal and human health? Why? Why not?

10. What are the activities or interventions (current and previous) in place to reduce brucellosis in the County?
    Probes:
    - By whom?
    - Did/Do you have a role?
    - Was/ Is it effective?
11. How do you communicate about brucellosis with Vets/PHO and with the communities?
12. How do local people understand infectious disease transmission?
13. How do local people conduct their cleaning activities?
    Probes:
    - How do they accomplish it?
14. Is there anything you would like to share that we did not ask you about?

Physician at a clinic

1. How many brucella cases do you see?
   Probes:
   - How they are distinguished from malaria, and
   - How are they diagnosed and treated?
2. What do you think are the major risk factors to Brucellosis transmission among your/the community members?

WASH officers (WO)

1. Please describe the work of the organization.
2. Can you tell me a bit about your role in the organization and the community?
3. What water source do people and livestock in the community use primarily for drinking, cooking, cleaning, and bathing?
4. How does your work relate to infectious disease management?
5. How do local people understand infectious disease transmission?
6. What are some of the practices and behaviors regarding cleaning activities with these communities?
   Probes:
   - How do they accomplish it?
7. Tell us about any programs or projects regarding animal and human waste management and hygiene practices in the community?
   Probes:
   - Do you perceive waste disposal as a problem?
   - Are there specific hygiene practices implemented regarding the disposal of aborted products from animals (livestock/wildlife)?

8. Is there anything you would like to share that we did not ask you about?

Community Elders

1. How long have you lived in the community?
2. Can you tell us about your role as an Elder?
3. In all your years in the community, have there been any programs to educate the community about Brucellosis in animals and humans?
   Probes:
   - By whom?
   - Did you have a role?
   - How do you think they were effective?
4. Would you like to share with us how you receive the following officers: public health officers; Veterinary officers; WASH officers and representatives from environmental management agencies?
5. Is there anything you would like to share that we did not ask you about?

Community Chiefs (CC),

1. How long have you lived in the community?
2. How long have you been a leader in the community?
3. Can you tell us about your role as a community leader?
   Probes:
   - How does your work address the challenges of Brucellosis?
4. How do you think Brucellosis has impacted the community?
   Probes:
   - Animal health
   - Human health
   - Environment
5. What are the community perceptions about abortions, fever, and stillbirths in livestock (camels, goats, etc.)?
   Probes:
   - Have they changed in recent years?
   - Why or Why not?
6. Are there any designated waste disposal areas (for aborted products or animal excrement) within your community?
   Probes:
   - If yes, tell us more about them.
7. There is a report on Marsabit County, and it says the main sources of food are raw milk, blood, and raw meat. Is that common?
   Probes:
   - Would you tell us more about that?

- Why do you think community members consume unpasteurized milk and drink raw blood?
- Are there any cultural practices or beliefs that influence this?

8. In all your years of experience, have there been any programs to educate the community about animal health and human health?
   Probes:
   - By whom?
   - Did you have a role?
   - How do you think they were effective?
9. In all your years of experience, have there been any programs to educate the community about Brucellosis in animals and humans?
   Probes:
   - By whom?
   - Did you have a role?
   - How do you think they were effective?
10. Would you like to share with us how you receive the following officers: public health officers; Veterinary officers; WASH officers and representatives from environmental management agencies?
11. Is there anything you would like to share that we did not ask you about?

Kenya Wildlife Service

1. Please describe the work of your organization.
2. Can you tell me about your role in the organization and the community?
3. How does your work relate to infectious disease management?
4. Our focus is on brucellosis transmission among humans and animals. One of the risks for animal brucellosis transmission is contact between livestock and wildlife, how do you think your work could contribute to minimizing this risk of transmission?
   Probes:
   - How do you minimize frequent interactions between wildlife and livestock?

A representative from Kenya National Environmental Management Authority (NEMA)

1. Please describe the work of your organization.
2. Can you tell me about your role in the organization and the community?
3. How does your work relate to infectious disease management?
4. Our focus is on brucellosis transmission among humans and animals. One of the major risks in contact with contaminated animal products like aborted products, how do you think your work could contribute to minimizing this risk of transmission?
5. Are there any national environmental policies with regards to the following?
   - Animal wastes management and,
   - Co-mingling, and how do they translate in this community?

6. Tell us about whether you do a regular environmental impact assessment to assess the impact of livestock production on the environment in the county?
   Probes:
   - If they do, what indicators do they use?
   - Can we see the last report, or can we find it on the internet?
   - If they do not, why not?
7. Is there anything you would like to share that we did not ask you about?

Appendix 7: IRB approval letter

University of Global Health Equity Institutional Review Board
Academic Ethics Review

Notification of Approval

Ref: UGHE-IRB/2021/033

May 4, 2021

Protocol Title:	Risks, perceptions, and practices surrounding Brucella melitensis transmission among people, animals, and the shared environment among the Rendille and the Borana pastoralists in Marsabit County.
Principal Investigator(s):	Valentine Ndacyayisenga, Yeukai Chikwenhere
Protocol #:	140
Funding Source:	UGHE
Initial IRB Review Date:	April 20, 2021
Initial Review Type:	Full review
Additional Review Dates:	May 04, 2021
IRB Review Action:	**Approved**
Effective Date:	May 4, 2021
Expiration Date:	May 3, 2022

Dear Valentine Ndacyayisenga, Yeukai Chikwenhere

On May 4, 2021, the University of Global Health Equity Institutional Review Board (UGHE IRB) approved this resubmission with modifications review. **Please note that the approval for this protocol will lapse after one (1) year and must be renewed according to the procedures of the UGHE IRB.**

The IRB reminds you that you are responsible for fulfilling the following requirements:

- Changes, amendments, and addenda to the protocol or consent form (if applicable) must be submitted to the committee for review and approval, prior to activation of the changes.
- Only approved consent forms are to be used for the enrollment of participants.
- All consent forms signed by subjects must be retained on file, and are submitted to inspection, along with other project materials, during routine onsite visits or audits.
- Failure to submit an application for continuing review will result in the suspension or termination of the study.
- The UGHE IRB must be notified at the closure of the study.

Please contact the UGHE IRB via email at irb@ughe.org with any questions.

Sincerely,

Daniel Seifu, IRB Chair