NATIONAL STRATEGY FOR THE PREVENTION AND CONTROL OF BRUCELLOSIS IN HUMANS AND ANIMALS IN KENYA (2021-2040)

REPUBLIC OF KENYA
ZDU ZOONOTIC DISEASE UNIT

NATIONAL STRATEGY FOR THE PREVENTION AND CONTROL OF BRUCELLOSIS IN HUMANS AND ANIMALS IN KENYA

(2021-2040)

Ministry of Agriculture, Livestock, Fisheries and Co-operatives
and
Ministry of Health

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List of Abbreviations

ACDC	Africa Centers for Disease Control
AFI	Acute Febrile Illness
AMR	Antimicrobial Resistance
AU-IBR	African Union Inter-African Bureau for Animal Resources .
BCC	Behavioral Change Communication.
BOD	Burden of Disease
CoG	Council of Governors
COHUs	County One Health Units
CHI	Cost of illness
CHVs	Community Health Volunteers
CVL	Central Veterinary Laboratory
CVO	Chief Veterinary Officer
CZC	County Zoonotic Committee
DALY	Disability Adjusted Life Years
DVS	Directorate of Veterinary Services
EAC	East African Community
EDP	Extremely Dangerous Pathogen
FELTP	Field Epidemiology and Laboratory Training Programme
GHSA	Global health security agenda
IEC	Information Education and Communication
IDSR	Integrated Disease Surveillance and Response
IHR	International health regulations
ILRI	International Livestock Research Institute
IGAD	Intergovernmental Authority on Development
JEE	Joint External Evaluation
KABS	Kenya Animal Brucellosis Study
KALRO	Kenya Agricultural and Livestock Research Organization
KEMRI	Kenya Medical Research Institute
KAPs	Knowledge, Attitude and Practices
KEVEVAPI	Kenya Veterinary Vaccines Production Institute
KLWSS	Kenya Livestock, Wildlife Syndromic Surveillance System
KMA	Kenya Medical Association
KMPDB	Kenya Medical Practitioners and Dentists Board
KNBS	Kenya National Bureau of Statistics
KPIs	Key Performance Indicators
KVA	Kenya Veterinary Association
KVB	Kenya Veterinary Board
KWS	Kenya Wildlife Service
MALF	Ministry of Agriculture, Livestock and Fisheries
M&E	Monitoring and Evaluation
MOH	Ministry of Health
MOU	Memorandum of Understanding
NACOSTI	National Commission for Science, Technology and Innovation
NAPHS	National Action Plan For Health Security
NBPCC	National Brucellosis Prevention and Control Committee
NGO	Non-Governmental Organization
NPHL	National Public Health Laboratories
NZD	Neglected Zoonotic Disease
OH	One Health
OHCEA	One Health Central and East Africa
OHF	One Health Framework
OIE	World Organization for Animal Health
PCP	Progressive Control Pathway
PPE	Personal Protective Equipment
PVS	Performance of Veterinary Services
RBT	Rose Bengal Test
RVIL	Regional Veterinary Investigation Laboratories
SCZC	Sub county Zoonotic Committee
SME	Subject Matter Experts
SOPs	Standard Operating Procedures
SWOT	Strengths, Weaknesses, Opportunities and Threats.
UHC	Universal Health Care
UON	University of Nairobi
VBM	Valuable Biological Materials
VEES	Veterinary Epidemiology and Economics Section
WHO	World Health Organization
WTP	Willingness to Pay
ZDHA	Zoonotic Disease and Animal Health
ZDU	Zoonotic Disease Unit
ZRM	Zonal Risk Mapping
ZTWG	Zoonotic Technical Working Group

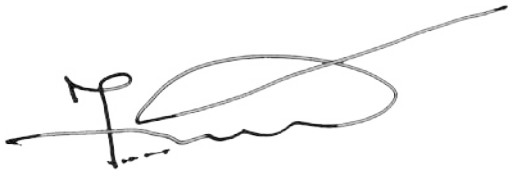
Foreword

This document describes Kenya's strategic plan for the prevention and control of human and animal Brucellosis with possible elimination by 2040. Brucellosis is a disease that affects animals and humans leading to significant livestock production losses and negative public health impacts. Brucellosis is among the top five priority zoonotic diseases in Kenya and is endemic in most pastoral communities. However, there is limited data on its geographical distribution, economic impact, burden estimates and costs of intervention.

Kenya's national Brucellosis prevention and control strategy highlights the challenges for effective control of Brucellosis that include: lack of legal framework in control of zoonotic diseases, inadequate funding and evidence-based research for supporting cost-effective control plans. The successful implementation of this strategy requires a multisectoral Integrated One-Health Framework (OHF) that leverages on the existing collaboration between human and animal health sectors for joint risk assessment, surveillance, management, and communication. This strategy outlines the epidemiological status of the disease while focusing on diagnosis and surveillance, preparedness and response, disease burden, socioeconomic and public health impacts, and prevention and control of Brucellosis at the national and subnational levels in Kenya.

This strategy will guide systematic risk reduction and cost-effective control of Brucellosis through sustained livestock vaccinations, improved rapid diagnostics, enhanced joint animal-human surveillance, standardized human treatment regimens, environmental disinfection, and elimination of infected animals and enhancing of public knowledge. The strategy will adopt a four-phased risk-based pathway that will substantially reduce the overall prevalence and incidence of Brucellosis by at least 95% for the country to move from an endemic state to a disease-free status. We are optimistic that each of our partners will join hands and play their role in achieving a Brucellosis free Kenya by 2040.

Hon. Peter Munya, EGH
Cabinet Secretary
Ministry of Agriculture, Livestock, Fisheries and Co-operatives



Sen. Mutahi Kagwe, EGH
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Ministry of Health

Acknowledgements

This national strategy for the prevention and control of brucellosis in humans and animals in Kenya was developed through a wider consultative process with subject matter experts from human and animal health, researchers, and policy formulators at the national and subnational levels. The development of this plan is in line with the priorities outlined in the National Action Plan for Health Security (NAPHS). These priorities were derived from the Joint External Evaluation (JEE) conducted in 2017 and Performance of Veterinary Services (PVS) conducted in 2019.

The Zoonotic Disease Unit (ZDU) coordinated this consultative process by anchoring on the existing multisectoral Zoonotic Technical Working Group (ZTWG), drawing membership from the Ministry of Agriculture, Livestock, Fisheries and Cooperatives (MALF), the Ministry of Health (MOH), Kenya Wildlife Service (KWS), universities and research organizations. The Zoonotic Disease Unit (ZDU) led the drafting process.

To prepare this national strategy, the Food and Agricultural Organization (FAO-Kenya) provided technical and financial support through the USAID Global Health Security Agenda (GHSA) initiative. We appreciate this support. We acknowledge the institutions listed below whose representatives participated in developing and validating this strategy. A complete list of contributors and organizations has been provided in Appendix 4.

- Food and Agriculture Organization (FAO)
- United States Agency for International Development (USAID)
- County Governments
- Field Epidemiology and Laboratory Training Program (FELTP)
- International Livestock Research Institute (ILRI)
- Kenya Medical Research Institute (KEMRI)
- Centers for Disease Control and Prevention-Kenya (CDC-K)
- Kenya Veterinary Association (KVA)
- Kenya Veterinary Vaccines Production Institute (KEVEVAPI)
- Kenya Wildlife Service (KWS)
- Neglected Tropical Diseases Programme
- University of Liverpool- HORN project
- University of Nairobi (UoN)
- Washington State University (WSU)
- Zoonotic Disease Unit (ZDU)

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Principal Secretary
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Executive Summary

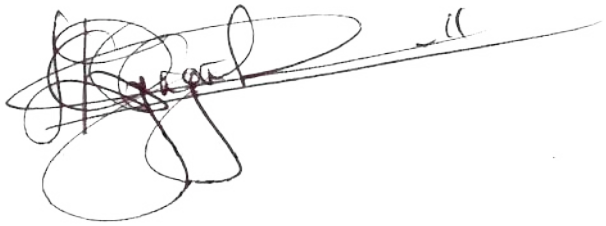
Brucellosis is a priority zoonotic disease that causes significant losses in livestock production, negative socioeconomic impacts on livestock trade and a threat to public health in Kenya. It is mainly transmitted from infected animals to humans through contact or consumption of contaminated products like milk. Poor handling and disposal of livestock afterbirths, animal carcasses and internal organs at slaughter leads to environmental contamination and increased risk of infection in livestock and further spread to the human population. The need for developing this prevention and control blueprint for Brucellosis is based on the gaps identified during the Joint External Evaluation (JEE) in the implementation of International Health Regulations (IHR, 2005) and strengthening of the Global Health Security Agenda (GHSA).

The successful control of Brucellosis requires multisectoral coordination efforts in food safety and hygiene, livestock health, public health and consumer education. The pasteurization of milk for direct human consumption is one of the most important methods in preventing transmission of the disease from animals to humans. Whereas it is recognized that eradicating brucellosis in animals through vaccination or culling of infected animals is not feasible in Kenya, the focus to prevent human infection should be on risk communication and community engagement through education campaigns that raise awareness and improve food safety and occupational hygiene.

The strategy envisages a Brucellosis free country by the implementation of one health approach that are focused on eliminating brucellosis in humans and animals, with the main goal being the reduction of both the burden and socioeconomic impacts of Brucellosis by 80% in human and animal populations by the year 2040. This will be achieved by harmonizing one health policy and institutional frameworks, advocacy and awareness creation, targeted livestock vaccinations, standardization of human and animal testing, integrated surveillance, implementation and applied research, enforcement of biosecurity and biosafety and resource mobilization.

The pre-implementation phase of this strategy will require the establishment of intersectoral national and subnational committees. The national brucellosis prevention and control committee (NBPCC) will cascade its coordination functions to the subnational coordinating committees established as the County Zoonotic Committees (CZC) and Sub-County Zoonotic Committees (SCZC). This strategy will be implemented through a stepwise approach in four phases that will involve the i) establishment of disease burden and building of capacity for surveillance, diagnosis, prevention and control, ii) reduction of animal brucellosis prevalence and incidence of human brucellosis by 50%, iii)reduction of animal Brucellosis prevalence and incidence of human brucellosis by 80% and iv) reduction of animal brucellosis prevalence and incidence of human Brucellosis by more than 95% in bovine and more than 99% in humans.

The control and elimination of an endemic disease like Brucellosis is both time and resource consuming, hence the need for implementation of a multisectoral one health approach that is cost effective and timely to minimize the impacts of brucellosis on human and animal health in Kenya.



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Chapter One: Introduction

1.1 Background

Brucellosis is one of the most widespread zoonotic diseases in the world with significant impacts on public health, socioeconomic status and international trade. The disease affects a broad range of species including livestock, wildlife and humans. It is endemic in most developing countries with about 500,000 new cases of human brucellosis occurring globally each year and up to 10% of the population in some countries being infected (Godfroid, 2017). Prevalence of the disease in Sub-Saharan Africa ranges from 5-55% in humans and 8-46% in domestic animals (Dean, A.S., 2012; Smits and Cutler, 2005; Mangen *et al.,* 2002).

Aetiology

Brucellosis is caused by infection from various *Brucella* spp., which are gram-negative facultative intracellular coccobacilli (short-rod bacteria) in the *Brucella* genus (Adone 2013). It has twelve species based with varying host preference and pathogenicity. The disease in cattle is caused almost exclusively by *Brucella abortus*, although *B. suis* or *B. melitensis* are occasionally incriminated. There is a zoonotic potential of animal variants including but not limited to, *Brucella melitensis* (goats and sheep), *Brucella abortus* (cattle), *Brucella suis* (swine) and *Brucella canis* (dogs). (Figure 1)

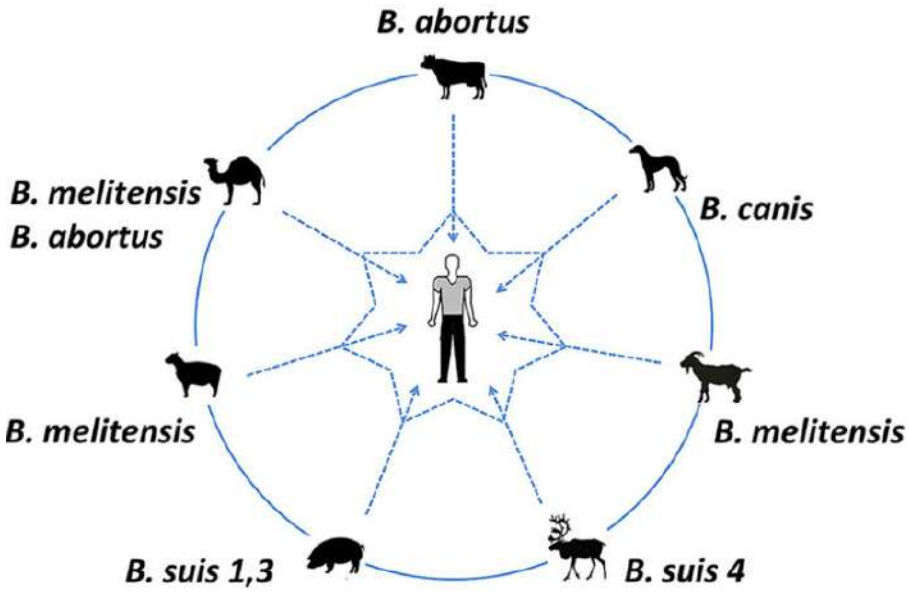


Figure 1: *Brucella* species affecting human and animal hosts.

Transmission in Animals

Brucella penetrates the nasal, oral and conjunctival membranes, where it establishes itself and replicates to cause bacteremia that may last several weeks or resolve by itself, it may recur for about two weeks in about 5-10% of affected animals. *Brucella* spp. infects the host primarily by attaching and penetrating mucosal epithelial cells with an initial adaptation phase followed by a replication phase whose incubation lasts 30 to 60 days or at times 5 to 60 days. It can evade the body's immune system and mounting a widespread systemic infection that is responsible for replication in the lymphatic system and other organs such as the liver, kidneys, breast tissues or joints (Assenga *et al.,* 2015). Bulls once infected become permanent carriers and act as a reservoir of infection (OIE 2019)

Transmission in Humans

Humans are mainly infected through consumption of raw (unpasteurized) milk, other dairy products, eating of undercooked meat and meat products. The bacteria is mainly excreted through milk (Babaoglu *et al.,* 2018). Other routes of infection are direct contact with infected aborted fetuses, uterine contents and discharges. There is a possibility of person-to-person transmission through close contact, blood transfusion, sexual intercourse, and bone marrow/organ transplantation (OIE 2019). Accidental exposures to live attenuated vaccine strains of *Brucella* spp. via needle stick injury, spray exposure to the conjunctiva and open wounds have been reported in veterinarians. Personnel administering *Brucella* vaccines (RB51, S19, and Rev-1) during vaccinations should wear proper personal protective equipment (PPE) (CDC 2017). There is a high risk of occupational exposure and risk of infection to laboratory workers involved in diagnosis and vaccine production. Accidental exposures can also occur via the respiratory tract and the conjunctiva. Aerosol infections can occur, especially in abattoirs (Harding AL 2006) (Figure 2).

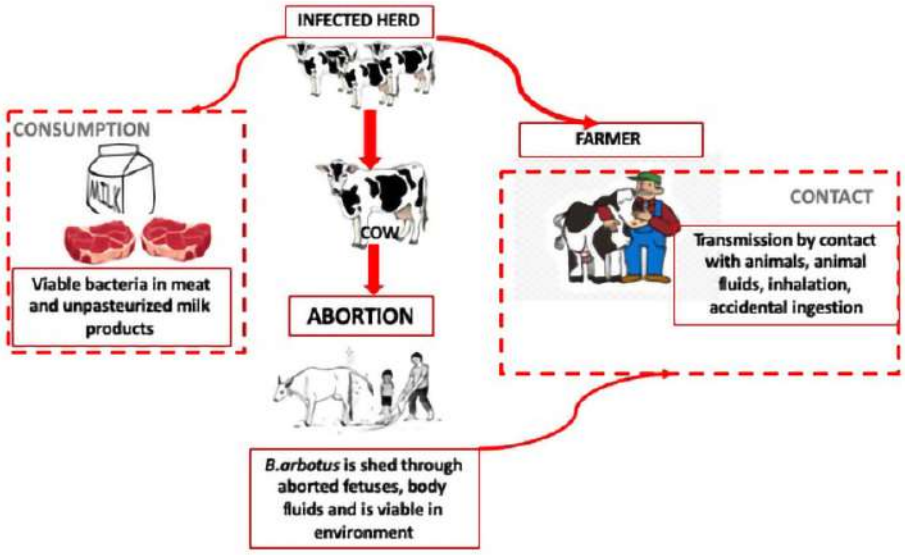


Figure 2: Transmission pathways for Brucellosis

The disease is insidious, severely debilitating and often recurrent with acute or sub-acute febrile stages being frequently confused with other acute febrile illnesses like Malaria. As a result, it is frequently misdiagnosed contributing to the tendency for over-prescription of antibiotics and the risk of emergence of anti-microbial resistance (AMR). It requires long periods of therapy with two or more antimicrobial drugs and delay in treatment can lead to long-term complications. It leads to loss of workdays due to lethargy and hospitalization of infected persons, loss of income, and increased household healthcare costs (Franc *et al.*, 2018)

1.2 Rationale and Justification

Despite the socio-economic importance of brucellosis, it is a neglected disease with no safe vaccine for human and no effective treatment in animals. The disease is preventable through vaccination in domestic animals and in humans through biosafety and biosecurity measures. However, weak epidemiological surveillance systems, inadequate policy and institutional frameworks, inadequate knowledge on various aspects of the disease, and limited technical capacities hinder prevention and control of the disease.

In Kenya, brucellosis is among the top five priority zoonotic diseases with a seroprevalence of up to 44% in humans, which is strongly associated with livestock raising (Kahariri, 2018; Muturi *et al.,* 2018; Osoro *et al.,* 2015). The country's One Health strategic plan for the prevention and control of zoonotic diseases (2021–2025) and the National Action Plan for Health Security (NAPHS) identify the disease as a priority.

The National Brucellosis Prevention and Control Strategic Plan aims to eliminate brucellosis in Kenya by 2040 using a progressive approach informed by global and regional guidelines (OIE, WHO and FAO, AU-IBAR). It aligns to the Kenya Constitution 2010, Kenya's Vision 2030 and relevant sectoral policies and strategies. Its implementation will contribute towards the Kenya Big Four Agenda especially the attainment of universal health coverage, food security and nutrition and trade and manufacturing.

Chapter Two: Situational Analysis

2.1 Country Profile

Kenya lies on the East Coast of Africa, between latitudes 5° N and 5°S and longitudes 34°E and 43°E. It borders Ethiopia to the North, South Sudan to the Northwest, Uganda to the West, Tanzania to the South and the Indian Ocean and Somalia to the East. The country's total area is about 587,000 km2 of which over 80% is Arid or Semi-arid land (ASAL). The country's population is 47,564,296 according to the 2019 census with a growth rate estimated at 1.57% (KNB, 2019, KDP, 2019).

Kenya's real Gross Domestic Product (GDP) in 2018 was Ksh 4,794.8 billion, with a growth rate of 6.3% (KNBS, 2019). Agriculture was the dominant industry of the country accounting for 34.2% of the total GDP, 12.1% of wage employment and 47.7% of export earnings. According to the same survey, animal production contributed 4.1% to GDP, which was about 12% of Agricultural GDP. About 60% of the country's livestock is raised in the ASALS where it employs nearly 90% of the population (MALF, 2019). Wildlife is the backbone of Kenya's tourism sector and over 70% of the wild animals interact freely with livestock in community lands.

2.2 Epidemiological Situation

Brucellosis is caused by infection from any of several species of bacteria belonging to the genus *Brucella* that affect livestock, humans and wildlife (Corbel, 2006).The disease affects a wide range of livestock including cattle, camels, sheep, goat, pigs, equine and dog. Four free-ranging wildlife species namely, Bison (*Bison bison*) and elk (*Cervus Canadensis*) in the USA, African buffalo (*Syncerus caffer*) in Africa and the Alpine ibex (*Cabra ibex*) in the French Alps are also affected. New species of *Brucella* have been identified in other wildlife including marine mammals and monkeys (Godfroid, 2017).

Brucella spp are gram-negative facultative intracellular coccobacilli (short-rod bacteria) in the *Brucella* genus (Adone,2013),which has at least twelve species based on varying host preference and pathogenicity. Brucellosis is endemic in Sub-Saharan Africa including Kenya especially in areas where extensive pastoral production systems are practiced. *Brucella abortus* is the most widespread cause of infection in animals and mostly affects cattle. *B.melitensis* mostly affects sheep and goats and is reported as the most common cause of the disease in humans. *Brucella* suis which mostly affects pigs has a limited occurrence than both *B.abortus* and *B.melitensis* although it can cause human infection similar in severity to *B.melitensis*. *Brucella canis* has a widespread source of infection to dogs with no known case of human infection.

The first animal clinical case of brucellosis in Kenya was detected in 1916 while the first laboratory case was confirmed in 1931 (Njeru *et al.,* 2016). More recent human and animal seroprevalence studies of brucellosis have been conducted in Central, Rift Valley, Coast, Nairobi, North-Eastern, Eastern, Western and Nyanza regions (Osoro *et al.,* 2015). A comprehensive systematic review indicated the widespread occurrence of the disease in Kenya where it has been for about 100 yrs. and has affected humans, sheep, cattle, goats, pigs, camels and wildlife (Njeru *et al.,* 2016).

2.2.1 Prevalence and Burden of Human Brucellosis

In 2012, a national survey to document major diseases that lead to outpatient morbidity in patients below 5 years of age was conducted by the Kenya National Bureau of Statistics (KNBS, 2012). Brucellosis was reported across all counties except Kwale, Nyeri, Tana River and Lamu. The highest burden among ten top counties was reported in Uasin Gishu, Nakuru, Nairobi and Kajiado (KNBS, 2012). (Figure 3)

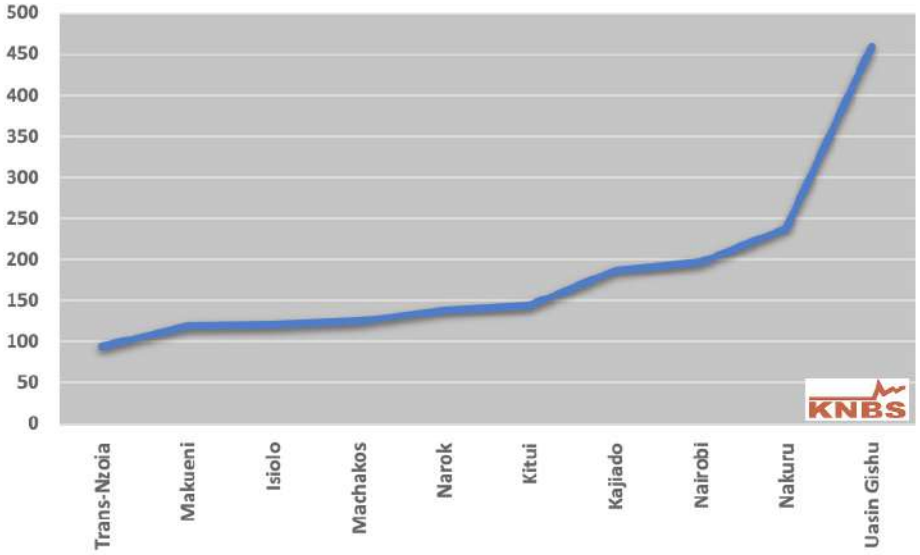


Figure 3: Outpatient Morbidity due to Brucellosis in patients below 5 yrs in selected counties.

Several human-animal linked sero-epidemiological studies conducted among pastoral communities of Narok, Kajiado, Marsabit, Turkana, Machakos and Garissa counties have indicated a high prevalence of human brucellosis (Njeru et al., 2016). A comparative human-animal linked prevalence study revealed a human household prevalence of 5.7% (25/433) and 31.8% (87/274), while the animal seroprevalence was 1.2% and 3.4% in Kiambu and Kajiado counties respectively (Ogola *et al.,* 2014).

In 2015, a seroprevalence survey of brucellosis conducted in Busia, Kiambu, Nairobi and Nakuru counties also indicated a strong association between human and animal sero-positivity. High risk was associated with owning livestock, contact with hides and skins and consumption of animal products (Osoro *et al.,* 2015).

A risk factor analysis for human brucellosis conducted among a pastoralist community in Kajiado county revealed that consumption of un-boiled raw milk increased the risk of infection by seven times while assisting animals in birthing increased the risk by four times (Muturi *et al.,*2018). Seroprevalence and risk factors of brucellosis in humans and animals evaluated in Marsabit county revealed a seroprevalence of 44% (332/775) in humans, with 73% (166/277) of households having at least one member testing positive for *Brucella* antibodies (Kahariri,2018).

The prevalence of human brucellosis is distributed countrywide with an observed increase from 2013 -2018 (Figure 4).Surveillance efforts by the MOH indicated that livestock keeping, lack of information on brucellosis and poor personal hygiene were mainly responsible for infections in human. Counties in the Rift Valley regions of Kenya (Nandi, Uasin Gishu and Nakuru) had the highest burden of infections. Counties where pastoralism was practiced e.g. West Pokot had reported low numbers of infection. This underestimate could be due to inadequate diagnostic capacity and failure to capture cases that do not seek medical attention for various reasons e.g. insecurity, inaccessibility of health facilities and culture. The true public health burden of brucellosis in Kenya may be underestimated hence the need to improve on capacity building and standardization of diagnostics.

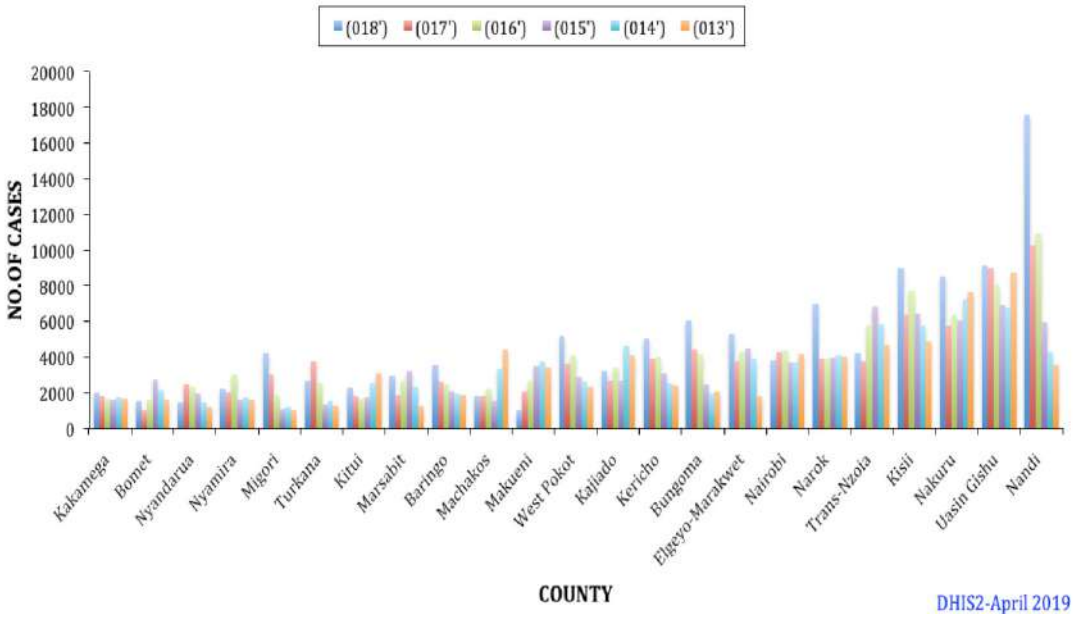


Figure 4: Burden of human brucellosis in selected counties in Kenya (2013-2018).

2.2.2 Prevalence of Animal Brucellosis

Brucellosis cases are mostly reported in pastoral communities and the prevalence is higher in arid and semi-arid counties of Kenya (Njeru *et al.,* 2016). Seroprevalence studies conducted in pastoral counties of Kajiado, Turkana, Samburu and Marsabit reported a brucellosis prevalence of 9.9% to 15% (Osoro et al., 2015). Kiambu an agro-based county where smallholder intensive system is practiced reported a prevalence of 2.5% in cattle (Ogola *et al.,* 2014).

A brucellosis seroprevalence and risk factor study conducted in Garissa in sheep and goats, revealed an overall seroprevalence at individual animal-level to be 20.0% (95% CI: 18.2% - 22.0%). In goats, the seroprevalence was 24.3% (95% CI: 21.8%-27.1%) while in sheep it was 12.5% (95% CI: 10.2%-15.2) (Obonyo.,2018). In Marsabit an overall seroprevalence of 13.6% (734/5444) was detected in all animals with a herd prevalence of 68.2% (189/277) where at least one animal had a positive brucellosis test per herd . The species seroprevalence was 16.09% (goat), 11.89% (sheep), 11.24% (cattle) and 11.14% (camels) (Kahariri, 2018).

A seroprevalence survey conducted in cattle in Narok County detected a 12.44% seropositivity in 225 cattle. Seroprevalence was higher in livestock closer to Maasai Mara with cattle in the village Mara Rianta having an odds ratio of 7.03 compared to Endoinyo Narasha further away. This suggests that closer contact with wildlife may increase the circulation of brucellosis (Enstrom *et al.,* 2017).

2.3 Surveillance and Diagnosis

2.3.1 Integrated Surveillance of Brucellosis

An effective surveillance system for the control and eradication of brucellosis highly depends on the collaboration between animal and human healthcare providers. In Kenya, the Zoonotic Disease Unit (ZDU) provides an ideal platform for coordinating joint surveillance activities that involves joint protocols, data sharing and communication of surveillance information across sectors. Reliable sources of surveillance data for livestock brucellosis in Kenya include; livestock keepers, animal health practitioners, diagnostic laboratories, slaughterhouses, case investigations and targeted active surveys.

The surveillance system gathers data from the lowest levels in villages and health facilities. Animal cases are subsequently detected by routine passive surveillance and clinical observation by animal health workers who report to the county veterinary authority. This is mirrored in the human health sector with the intersection being County One Health Units (COHUs) which are gradually being established on pilot basis. The county veterinary authority and COHU's transmit the information to the national surveillance platforms.

There are seven regional veterinary investigative laboratories and a central veterinary laboratory (CVL) involved in the diagnosis of animal brucellosis. The regional veterinary investigation laboratories (RVILs) are; Kericho, Eldoret, Garissa, Karatina, Nakuru and Mariakani and the central veterinary laboratory (CVL) in Kabete, Nairobi. The faculty of veterinary medicine of the University of Nairobi also tests *Brucella* samples. These laboratories submit monthly surveillance reports to the Veterinary Epidemiology and Economics Unit (VEES) at the Directorate of Veterinary Services (DVS).

The National Public Health Laboratory (NPHL) receives samples from other counties for confirmatory diagnosis of human brucellosis and then reports to the Director of Medical Services. The DVS and DMS report directly to OIE and WHO respectively. FAO supports some of the surveillance activities. There have been attempts to establish syndromic and active surveillance systems that can rapidly detect brucellosis cases. For example, the Kenya Livestock and Wildlife Syndromic Surveillance (KLWSS) is a near real-time electronic surveillance and reporting system that captures abortions in livestock and wildlife in suspected brucellosis cases. ZDU led the Kenya Animal Brucellosis study (KABS), a small-scale human-animal risk surveillance project that was conducted in Kajiado county in 2015. KABS had a two-pronged approach that hospital-based screening of febrile patients and animal surveillance based on brucellosis clinical syndromes. (Figure 5)

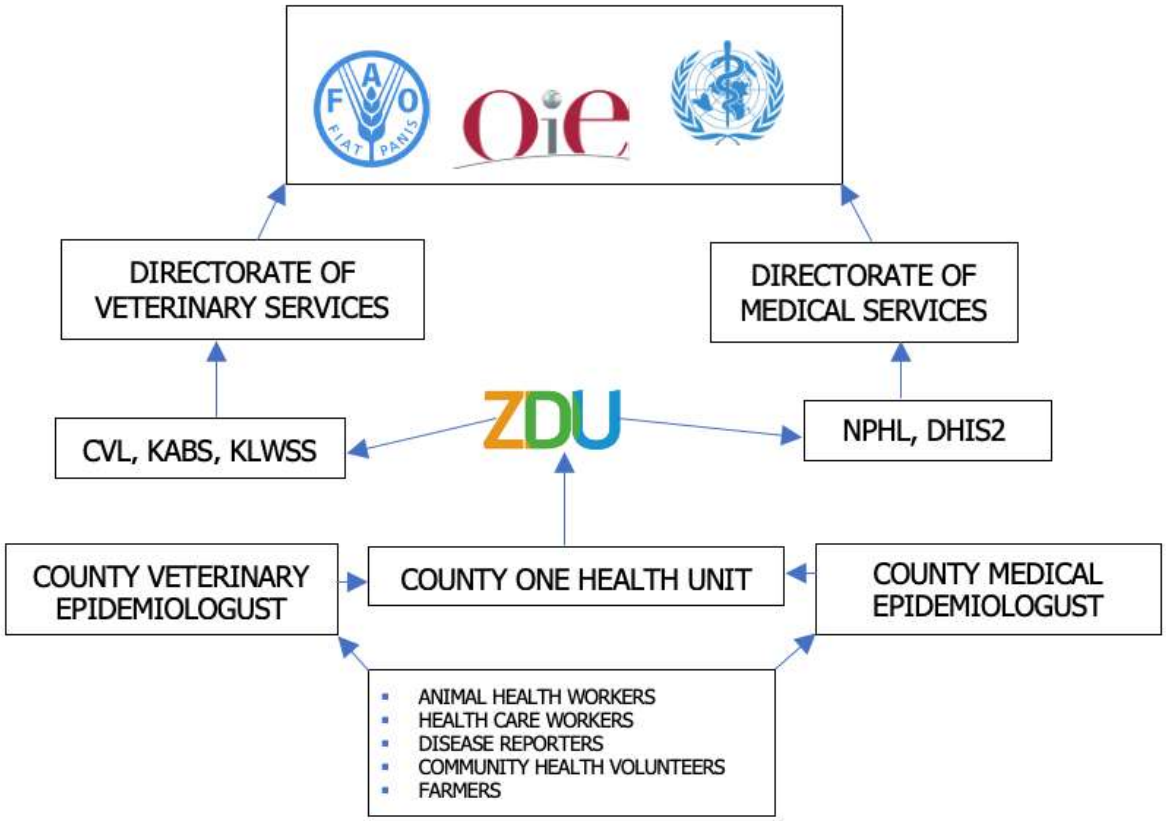


Figure 5: Integrated Surveillance System for Brucellosis in Kenya.

2.4 Diagnosis of Brucellosis

In Kenya, RBT is highly recommended for both human and animal routine screening and presumptive diagnosis in resource limited laboratories or smaller health facilities due to the low cost and ease of testing. They are, however opportunities to invest in rapid cutting edge diagnosis that are highly sensitive and specific for characterization of the circulating serovars, Realtime PCR has successfully been used for research purposes, while GeneXpert algorithms used for testing Multidrug resistance tuberculosis (MDRTB) can be adopted for testing the genetic diversity and emergence of AMR since similar drugs are used for treatment of brucellosis.

Animal Diagnosis

Suspected cases of Brucellosis should be based on positive serological results or observed clinical signs. Infections during pregnancy cause placentitis, which may lead to fetal deaths, stillbirths, retained placentas, and abortion. Pregnancies carried to term may yield calves that are infected. In males, the testis, seminal vesicles and epididymis are mainly affected and a large percentage of the organism is shed in the semen. Infected bulls that are used for mating often transmit the disease to the females. Chronic infections can lead to infertility due to epididymitis and orchitis. The most visible sign is fluid accumulations in the knee joint (hygromas) due to arthritis.

Figure 6: Clinical animal Diagnosis, Knee joint hygromas in a buffalo and goat

Several laboratory and field tests are routinely used. These include:

- Microscopic examination of smears stained with the Stamp's modification of the Ziehl-Neelsen
- Serological tests: Buffered *Brucella* antigen tests, the card agglutination test (CAT), Rose Bengal plate agglutination tests (RBT) and the complement fixation test (CFT). Indirect or competitive enzyme-linked immunosorbent assays (ELISAs).
- A brucellin allergic skin test for unvaccinated sheep and
- Milk Ring Test (MRT) for infected dairy animals and for surveillance of brucellosis-free herds.
- PCR : Real-time PCR is employed at the CVL and other research laboratories for surveillance and confirmatory diagnosis.
- Lateral flow immunochromatography assay (LFA) is highly recommended as suitable for laboratories in resource-limited areas. The low cost of RBT and ability to diagnose human brucellosis makes it most suitable in routine diagnosis and surveillance (Gusi *et al.,* 2019)

Human Diagnosis

Brucellosis is an acute or sub-acute febrile illness that is often confused with other acute febrile illness like Malaria, Dengue, Chikungunya, typhoid fever and should be considered by clinicians. It may present with non-specific signs such as malaise, anorexia and prostration that resembles "chronic fatigue syndrome" which may persist for weeks to months if untreated (Corbel 2006). During pregnancy there is a high risk of causing spontaneous abortion, particularly during the first and second trimesters (CDC 2017). During clinical examination, there is need for history of exposure/contact with animals to be documented to correlate the human and animal cases.

A presumptive diagnosis can be determined by serum agglutination tests SAT, SAT[3]160 in one or more specimens obtained after the onset of symptoms i.e. *Brucella* total antibody titer of greater than or equal to 1:160 by (SAT), the detection of *Brucella* DNA in a clinical specimen by Realtime PCR is also recommended.

The Rose Bengal (RBT) screening test may be routinely used in small private clinics and major health facilities.Other tests include:

- ELISA tests that detect antibodies of IgM, IgG, and IgA classes
- Complement fixation test (CFT)
- Coombs, fluorescent antib ody test (FAT).
- Rapid tests : IgM/IgG lateral flow immunochromatography assay (LFA)

Case Definition for Livestock Brucellosis

A suspected case of brucellosis infection in livestock will be considered based on a positive serological result or observed clinical signs of any of the following: abortion, retained placenta, stillborn, epididymitis, orchitis, reproductive failure and arthritis (hygroma). However, a confirmed case will be based on positive laboratory diagnosis of the disease as per OIE guidelines.

Case Definition for Human Brucellosis

The recommended WHO case definition for human brucellosis is:

- Clinical: An illness characterized by acute or insidious onset, continued, intermittent or irregular fever of variable duration, profuse sweating, particularly at night, fatigue, anorexia, weight loss, headache, arthralgia, and generalized aching. Local infection of organs may occur

- Suspected: A case that is compatible with the clinical description and is epidemiologically linked to suspected or confirmed animal cases or contaminated foods of animal origin.

- Probable: A suspected case that has symptoms compatible with disease and is positive in the Rose Bengal test, but negative in blood culture and showing low titres in the confirmatory tests.

- Confirmed: A suspected or probable case that is laboratory confirmed.

The susceptibility and severity of the disease depend on sex, age, history of previous vaccination, immune status of the animal and management practices of the farm (He 2012).
All case definitions may require modification depending on the availability of medical services and laboratory resources.

2.4.1. Prevention

Pasteurization: all milk for human consumption should be boiled or pasteurized at high temperatures to kill *Brucella*. If pasteurization facilities are not available, the milk should be heated to a minimum temperature of 80–85 °C and held at that level for at least 30 minutes.

Culling: Isolation and slaughtering of sick animals is highly recommended and compensation should be considered in different settings. Test and slaughter may be considered depending on the ability of farmers to meet costs or compensation mechanisms.

Disposal and destruction : aborted fetuses, placentae and contaminated litter should be collected in leak-proof containers and disposed of preferably by incineration. The destruction of *Brucella* organisms can be hastened by addition of calcium cyanamide or xylene (this should be performed only by qualified personnel to minimize environmental contamination)

Biosafety and Personal Safety: Each laboratory should have written procedures addressing the use of equipment (especially equipment that may generate aerosols); disinfection of equipment and contaminated materials, handling and processing samples; spill containment and cleanup; and waste handling. There is a potential risk of occupational exposure and infection in laboratory workers culturing bacteria or manufacturing live attenuated vaccines.

Laboratory acquired infections can be prevented by performing *Brucella* culture at Biosafety level 2, When other potentially high-tittered materials such as membranes, fetal tissues and fluids Biosafety level 3 is recommended. All persons involved in high-risk procedures, including contact with suspected animal brucellosis cases, should wear adequate protective clothing as part of standard personal protective equipment (PPE). Eye protection is important to prevent conjunctival contamination and infection.

Livestock Vaccination

In Kenya two types of livestock vaccines are imported and licensed by KEVEVAPI;

Brucella arbotus S19 is recommended for cattle. A single *Brucella abortus* S19 vaccination of heifers between 5-8 months of age provides lifelong immunity. Live vaccine should be used with care in adult animals because it can cause abortion in in-calf females and inflammation of the testes in adult males. Vaccination is likely to reduce the number of infected animals in a herd by over 90% if carried out over a period of 5 years.

Brucella melitensis Rev.1 is effective against the brucellosis of sheep and goats caused by *B. melitensis,* the commonest source of human infection. Rev-1 has also been found to be protective against natural infections in goats and sheep for at least 4.5 years after vaccination Adverse effects of strain persistence and secretion in milk have been encountered with this vaccine strain, it is also contraindicated in pregnant animals. Immunization with this strain can stimulate strong anti-O antigen antibody titers interfering with the serological diagnosis to distinguish between vaccinated animals and natural infection by both *B. melitensis* and *B. ovis* (Yang *et al*. 2013). Vaccination cannot eradicate Brucellosis but it is a first step in control and possible eradication. There is a high risk of human infection by the live vaccine to veterinarians and other medical staff performing immunizations in cattle. Caution should be taken in case accidental exposure occurs (CDC 2012). There are no commercial vaccines for other susceptible animals like camels and pigs. There is need to ensure high quality of vaccines and procurement procedures should factor in the targeted animal populations.

Quarantine and Movement Control

Movement and sale of unauthorized animals from endemic areas to non-endemic areas should be prohibited. Additionally, imports of animals to brucellosis free zones should be restricted to disease free animals. Animal identification is a key tool for Brucellosis control. It is recommended that, animals that have been vaccinated against brucellosis and other diseases should be marked differently (branding, tagging, tattooing, RFID) to establish of their status.

Environmental and Sanitary Measures

Humans handling infected fetuses, placenta and animals should use protective gloves to minimize infection. Accidental infection can occur when contaminated hands touch the mouth, nose and eyes of the handler, in this case thorough disinfection is highly recommended.

Other recommended prevention methods in animals are:

- Isolation of all animals that have aborted until all the discharges have stopped
- Burning or burying all contaminated materials such as fetuses, foetal membranes
- Cleaning and Disinfection of all cattle premises, which may be contaminated with fetuses and foetal membranes.
- Humans should avoid drinking raw milk and un-pasteurized milk products or coming in contact with aborted fetuses.

2.5 Socioeconomic and Public Health Impacts

Brucellosis causes a significant burden on human health due to costs incurred in diagnosis and treatment (Franc et al. 2018). The acute and chronic symptoms of the disease can cause significant lethargy, loss of man-hours and workdays and hence loss of income. It limits the socioeconomic growth of affected individuals, communities and a country at a larger scale leading to increased poverty rates. In Livestock, the disease leads to short and long-term impacts that are mainly characterized by production and reproductive losses especially in endemic pastoralist areas. Effective control of brucellosis has measurable economic costs due to the requirement of livestock vaccination, isolation, depopulation and human treatment.

In Kenya, there is lack of national estimates of the burden of brucellosis in human and livestock populations and overall underestimation of true prevalence and socioeconomic impact of brucellosis. This is due to inadequate human capacity for research, poor surveillance systems and lack of standardized diagnostics which has led to underreporting, misdiagnosis and poor monitoring of control programs for brucellosis. There is need for operational One Health research that aims to estimate the burden, socioeconomic impacts and intervention costs of brucellosis in humans and livestock, this will also provide evidence to government agencies involved in prioritization and implementation of the integrated control strategy.

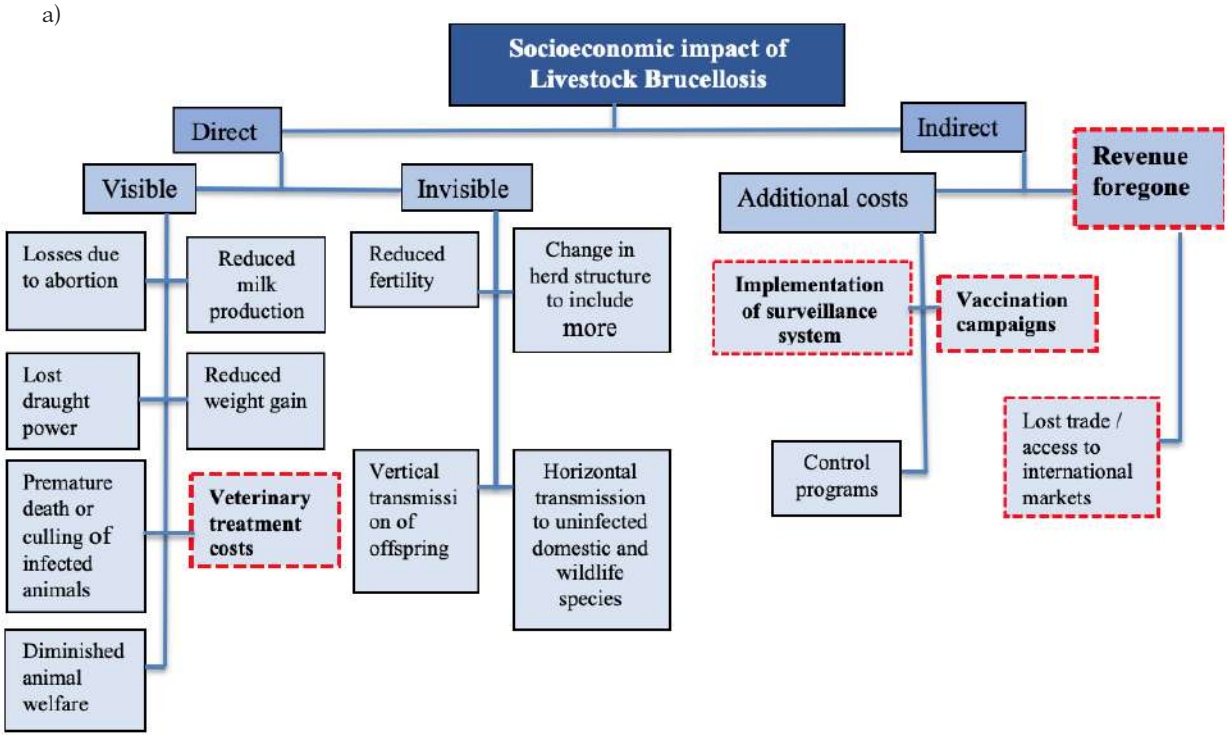
Brucellosis in livestock affects cattle, sheep, goats, camels and equines, which form the backbone of livelihoods for pastoral communities and livestock-based economies in Sub-Saharan Africa. Adverse effects of the disease in livestock include production losses due to abortions, stillbirths, infertility and reduced milk yields, and trade restrictions that lead to significant economic and household income losses. Livestock-associated economic losses equivalent to 4,219,617 EUR (Ksh 421, 961,700) are documented in Swaziland (Akappo *et al*., 2009) and per capita household income losses of up to 436.63 USD (Ksh 43, 663) due to brucellosis are documented in Zambia (Mwinyi *et al.*, 2002). In wildlife, brucellosis raises concerns of potential reservoir status and spillback of the disease from infected wildlife to livestock (Godfroid, 2017). Control measures of the disease at the wildlife-livestock-human interface and particularly spatial segregation and culling of wildlife raise ethical dilemmas.

This strategy proposes approaches that can be used to estimate both the socioeconomic losses, additional costs, intervention costs and public health impacts due to occurrence of brucellosis. There is need to establish collaborations that are aimed at conducting operational research that will have long-term benefits:

- Estimating the socioeconomic impact of Brucellosis has significant potential relevance to animal and health decision- making and policy making and as greater resources allocation to the overall quantification of health impacts.
- The management of Brucellosis will benefit from an approach involving interventions across animal and human health sectors.
- Estimating the costs of Brucellosis interventions is important to policy-makers as a component in assessing and improving of the overall national health system performance.
- Cost-of-illness(COI) or Burden of Disease(BOD) analysis or economic impact analysis of Brucellosis informs the medical, additional/non-medical resources to treat the disease and overall loss of productivity in humans and Livestock(Jo 2014).
- Brucellosis costing studies can be input into cost-effectiveness analyses (CEA) and provide important information for efficient resource allocation.
- Disease burden analysis using DALYs, willingness to pay (WTP) and other economic modelling methods are promising for resource allocation and intervention purposes.

This strategy proposes frameworks for estimating both livestock and socioeconomic impacts and human disease burden in (Figure 7a ,7b)

a)



b)

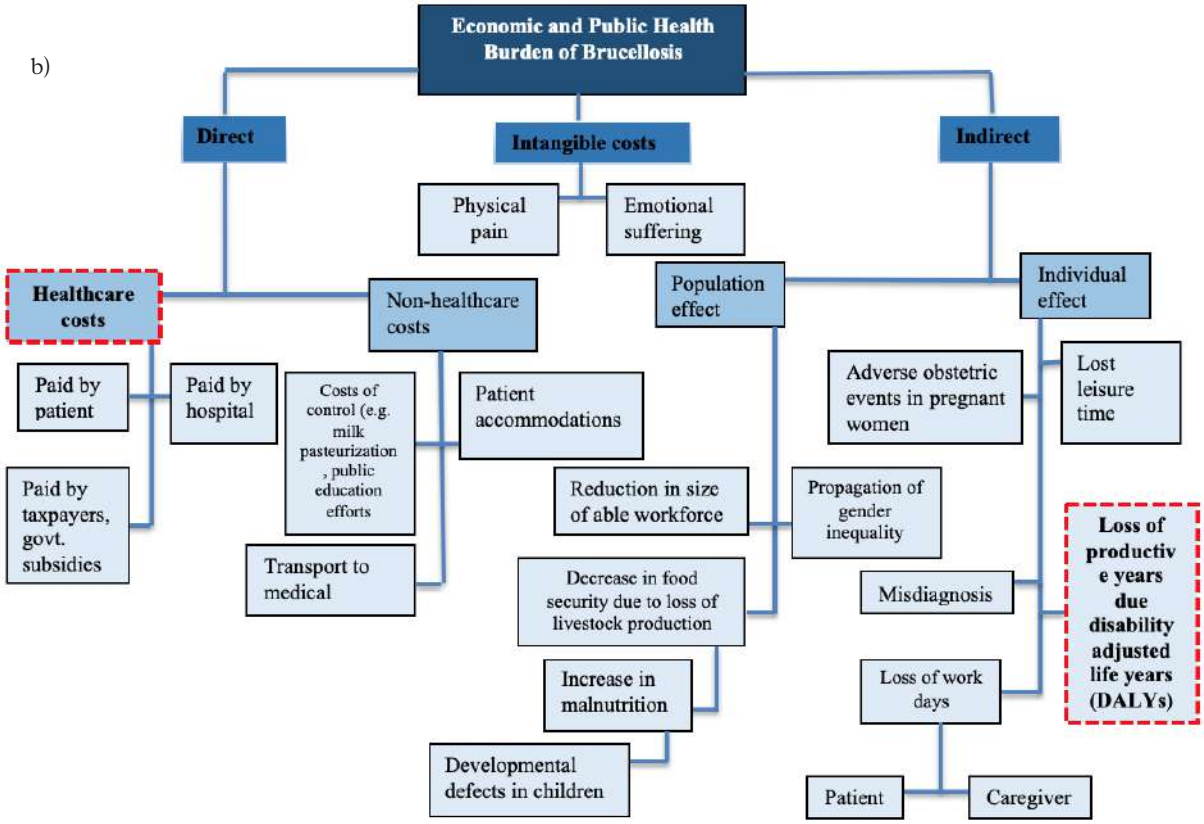


Figure 7: a) Socioeconomic Impact of Livestock Brucellosis and b)Public Health Impact of Human Brucellosis

2.6 Institutional Framework

The Brucellosis Prevention and Control Strategy will be implemented by the relevant line ministry departments within the framework of the Zoonotic Disease Unit (ZDU) and Zoonotic Technical Working Group (ZTWG) at the National level and the County One Health Units (COHUs) at the County level. The ZTWG will transition to a committee (Zoonotic Technical Committee (ZTC) that will link to County ZTC that will also be formed. A National Brucellosis Prevention and Control Committee (NBPCC), with representation from the various sectors will be established to coordinate the brucellosis prevention and control strategy. The COHUs will be responsible for implementation of the strategy at the county and sub-county levels. Representatives of COHU are designated officers (at CDVS and CDHS) who shall be coordinators responsible for overseeing day-to-day activities of the programme. (Figure 8)

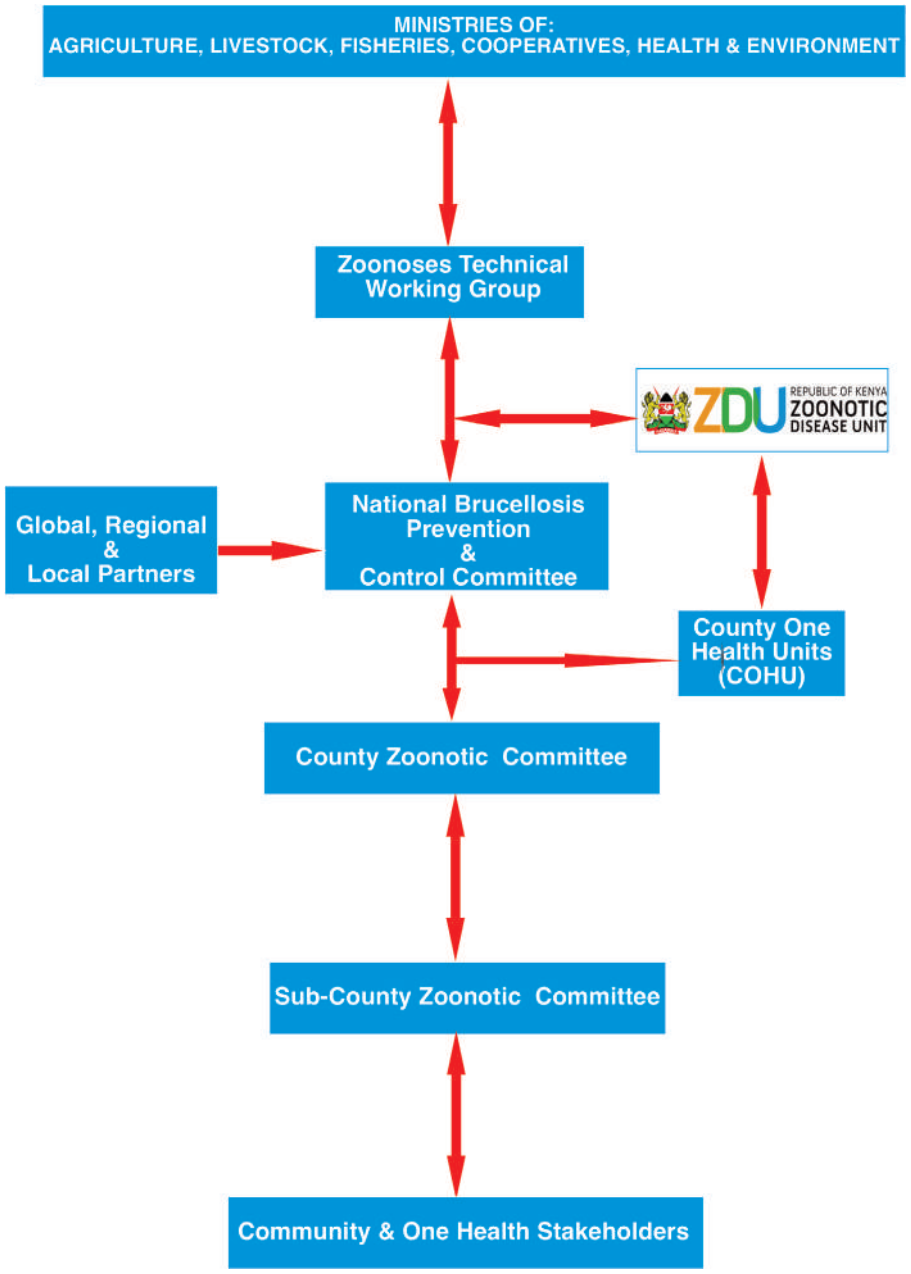


Figure 8: Institutional Framework Coordination of brucellosis prevention and control strategy

2.7 Policy Framework

The policies, laws and regulations guiding prevention and control of brucellosis at the national, regional and international level include the following:

- *International Health Regulations (IHR) (2005)* : Helps countries review and if necessary, strengthen their ability to detect, assess and respond to public health events.
- *National Action Plan for Health Security (NAPHS)* : Accelerates the implementation of IHR core capacities in a country and is based on a One Health approach. It captures national priorities for health security, brings sectors together, identifies partners and allocates resources for health security capacity development.
- *National Action Plan on Prevention and Containment of Antimicrobial Resistance* (NAPAMR, 2017-2022) : provides a common framework for action and management of AMR by multisectoral stakeholders in Kenya, human and animal health, agriculture, fisheries and environmental sectors
- *OIE/FAO/WHO* : provides broad guidance and protocols on disease surveillance, contingency planning, preparedness and response to zoonotic diseases.
- *World Organization for Animal Health (OIE)* terrestrial animal health code sets standards for the improvement of animal health and welfare and veterinary public health worldwide; OIE manual for diagnostic tests and vaccines for terrestrial animals and OIE Performance of veterinary services
- *World Health Organization (WHO)* - in partnership with OIE has developed manuals for brucellosis prevention and control.
- *FAO/OIE:* Progressive Control Pathways (PCPs) and the related roadmaps are staged, stepwise approaches increasingly used to structure the road to disease reduction and freedom for a range of human and animal diseases.
- *AU-IBAR* - Integrated regional coordination mechanism sets ways and multi-sectoral approaches for prevention and control of zoonoses.
- *Intergovernmental Authority on Development (IGAD)* : Provides an animal health framework that enhances domestic food security and increases access to livestock and livestock products to national, regional and international markets.
- *Vision 2030* - Big four agenda : Kenya Universal Health Care (UHC) provides access to quality primary health care to address over 80% of a person's health needs throughout the life cycle by focusing on preventive and promotive health interventions.
- *Kenya Veterinary Policy* - It provides guidance on control and prevention of zoonotic diseases particularly the use of multi-sectoral collaboration using one Health approach.
- *Kenya Health Policy (2014-2030)* - The overall objective is to attain universal coverage of critical services that positively contribute to realising the overall policy goal. Among the objectives are to eliminate communicable diseases and strengthen collaboration with other sectors that have an impact on health.
- *Biosafety and Biosecurity policy and guidelines* : define the scope and applicability of "laboratory biosecurity" recommendations, narrowing them strictly to human, veterinary and agricultural laboratory environments, generally focusing on dangerous pathogens and toxins, addressing the safekeeping of all valuable biological materials (VBM).
- *Animal Diseases Act, Cap 364* : Provides the legislative framework and power to carry out all necessary disease control actions needed to control notifiable diseases in Kenya.
- *Public Health Act - Cap 242* : Grants powers to local health authorities to protect the health of members of the public, including compulsory reporting of notifiable infectious diseases.
- *Meat Control Act, Cap 356* : Enables control to be exercised over meat and meat products intended for human consumption.
- *The County Governments Act No.17 of 2012* : gives the county governments powers to ensure efficiency in service delivery and partnership with organizations for work, service or function within the county
- *Veterinary Surgeons and veterinary para-professionals Act, Cap 366* : Gives Kenya Veterinary Board (KVB) powers to license, certify and discipline veterinary surgeons and veterinary para-professionals.
- *One Health (OH) Strategic Plan* : Its main objective is to strengthen surveillance, prevention and control of zoonoses, establish structures and partnerships to promote OH, and to conduct and promote applied research on zoonoses.

2.8 Stakeholder Mapping

In Kenya, there exists multisectoral and multidisciplinary teams of stakeholders who are drawn from human, animal and other sectors at the national and county levels and are coordinated from national Zoonotic Disease Unit (ZDU) and the County One Health Units (COHUs) respectively as outlined earlier in (Figure 7). The technical working groups, research institutions, universities and non-state actors are key in providing evidence for research, funding, capacity building and implementation. A summary of key stakeholders and their roles is outlined below in Table 1.The stakeholders include subject matter experts (SME) who harness public-private partnerships that immensely benefits from existing collaboration in research, resource mobilization and policy formulation.

Table 1: Stakeholder's roles involved in implementation of strategy

Thematic Area	Stakeholders
Policies, standards and regulations, development and implementation, and resource mobilization.	MALF, MoH, KWS, ZDU, CoG
Technical backstopping, capacity building and resource mobilization for disease prevention and control	WHO, FAO, CDC, OIE, NGOs (VSF), ACDC, OHCEA, HORN,IGAD, AU-IBAR,EAC
Reinforcement of policies laws and control interventions implementations	Ministry of Interior and Coordination KVB, KVA, KMPDB, KMA, CoG
Biosafety and Biosecurity	KEMRI,MALF, MOH, ILRI, CVL, NPHL, Public Health Regulatory Boards, Relevant NGO's, Universities
Research training and consultancy vaccine production	KEMRI, NPHL,KWS KALRO, ILRI, DVS, ZDU, Universities, HORN,OCHEA,CDC
Vaccine procurement and production	KEVEVAPI, Other Importers -Coopers K-Brands Limited and Highchem , CoG
Advocacy and ethical standards	KVB, KVA, KMPDB
Public awareness, prevention and control	MALF, MOH, FAO, WHO, ZDU, Other relevant NGO's, ACDC, EAC, CoG
Implementation of the strategy	MOH/MALF at National and County Governments, ZDU,KWS, CoG ,Other relevant NGO's, Communities

2.9 Strengths, Weaknesses, Opportunities and Threats (SWOT)

Brucellosis is a complex zoonotic disease with significant economic impact in endemic livestock keeping communities in Kenya. The successful prevention and control approaches face a myriad of myriad of challenges due to its complex epidemiology, surveillance and diagnostic challenges, vaccine shortages, control policies, husbandry practices and social cultural values of the communities. There exists strengths and opportunities that could be harnessed to eradicate Brucellosis in the country. However, there are several weaknesses and challenges that need to be addressed urgently for effective implementation of this strategy (Table 2).
The main issues to be considered during implementation include:

1. Policy and legal framework in support of brucellosis prevention and control
2. Human resource and skills to support brucellosis control
3. Institutional organization
4. Financial resources
5. Surveillance and Control tools
6. Research, training and development
7. Advocacy, Communication and Social Mobilization
8. Partnership and multi-sectoral collaboration
9. Monitoring and Evaluation

Table 2: Strengths, Weaknesses, Opportunities and Threats

Issue	Strengths	Weaknesses	Opportunities	Threats
1. Legal Framework and policies	Existence of national sectoral policies, strategies and legal framework e.g. • Kenya Veterinary Policy • Wildlife conservation and management act No 47 of 2015 • Kenya Health Policy, 2014–2030 • Animal Diseases Act, Cap 364 • Meat Control Act Cap 356 • Public Health Act, Cap 242 • Pharmacy and poisons board Act, Cap 244 • List of national priority zoonotic diseases • Biosafety Act , No.2 of 2009	• Inadequate implementation of animal diseases and public health acts. • Inadequate enforcement of disease control and livestock movement regulations. • Some outdated policy guidelines e.g. compensation policy • Delay in policy review and implementation to support reprogramming where necessary • Different levels of awareness among stakeholders • Lack of county specific guidelines and policies	• Availability of global guidelines and standards from international bodies like FAO, OIE, WHO, Global Health Security Agenda 2017 and International Health Regulations (IHR) • One Health Strategic Plan zoonotic diseases for 2019-2023 • National action plan on health security 2019-2023	• Change in global health regulations, policies and priorities
2. Skilled human resource	• Skilled human resource at various levels. (human, animal and environment) • Available/continuous professional development programmes	• Insufficient number of trained personnel (human, animal, environment) • Inadequate continuous professional development programmes in some cadres • Low numbers of vets in public sector • Demotivated staff	• Availability of training institutions/research facilities • Technical support from local, regional and international partners • Harnessing partnerships with veterinary professionals in private sector • Devolution of human and animal health sectors	• Inadequate funding to support human resource capacity
3. Financial resources for support of implementation of strategy	• Annual budgetary allocation for disease surveillance and control at national and county levels	• Inadequate funding for disease surveillance and control at national and county levels • Absence of budgetary utilization for disease surveillance at county level due to misdirection of funds. • Inadequate funding for preventive health services	• Partnerships with local, regional and international partners, • Presence of several consortia addressing brucellosis • Implementation of index based livestock insurance (IBLI) • Brucellosis prevention and control is a contributor to the big4 agenda (food security and nutrition, universal health care and manufacturing) • Increase of budgetary allocation for disease surveillance & control response.	• Change of priorities by partners • Weak collaboration and coordination • Natural and manmade disasters • Insecurity

Issue	Strengths	Weaknesses	Opportunities	Threats
4.Institutional organization	• Presence of one health coordination office at the national and county(some) levels	• Weak communication/ sharing of information/ samples to ensure detection and response • Duplication of implementation of activities • Absence of coordination units in some counties.	• One Health coordination framework/Networks- OHCEA, HORN • Presence of local, regional and International organizations • Research and academic Institutions • Formation of OH Technical working group for brucellosis • Increase of resources to ZDU	• lack of a legal framework establishing the one health coordination
5. Research, training development and diagnostics	• Presence of Research and Training Institutions • Presence of a laboratory network in human and animal health • Research regulation – NACOSTI • Political good will • Government commitment • Presence of pool of local experts on brucellosis • Ongoing research on brucellosis	• Weak coordination of research initiatives • Weak communication of scientific findings in a language that can be understood by policy makers and the general public • Inadequate publication of brucellosis research findings • Inadequate diagnostic laboratories and equipment.	• Building capacity for accreditation of CVL, NPHLS and KEMRI to be reference laboratories for brucellosis diagnosis, research and training • Collaboration with international reference laboratories • Conducting of more research on circulating strains. • Establishment of County laboratories • Upgrading and equipping regional veterinary laboratories.	• Inadequate funding • Distrust among team members • Poor communication and lack of common understanding among collaborators
6. Brucellosis surveillance and control (diagnostics, treatment, vaccines) reporting system and dissemination	• Availability of vaccines for animals • Availability of laboratory diagnostic capacity • Presence of a working surveillance system in both human and animal health • Availability of epidemiological data on humans and animals • Available treatment for human brucellosis • Use of mobile phone tools to promote reporting	• Low vaccination coverage • Absence of national standardized and validated diagnostic tests especially for humans • Poor quality surveillance data especially the syndromic surveillance • Poor linkage between surveillance data from human and animal health sectors • Misdiagnosis leading to unnecessary antibiotic prescription	• Presence of reference laboratories for diagnosis, research and training • Availability of technical support from local, regional and international partners • Established vaccination programmes • Presence of surveillance guidelines for priority zoonotic diseases	• Inadequate financial resources to support active and passive surveillance • Inadequate engagement between researchers • Lack of human vaccines and inadequate animal strain typing • Usage of same antibiotics for treatment of both brucellosis and TB leading to possible antimicrobial resistance
7. Knowledge on Brucellosis among public	• Existence of elaborate administrative structures down from the national level to the counties that can support public health and extension services • Availability of Brucellosis fact sheets and protocols by global bodies • Some knowledge on brucellosis • Existence of strong community health strategy (CHVs/ CDR) in some counties	• Poor practices on brucellosis prevention among public members • Insufficient advocacy materials, (posters, flyers, and protocols) at all levels in animal and human health sectors • Information, Education and communication (IEC) materials in language/ format not easily understood by public • Uncoordinated communication during and after suspected diseases in animals (abortions) • Inadequate social behavior change activities	• Presence of various media outlets • Good coverage of mobile phone networks and social media groups	• Socio-cultural barriers and beliefs • High poverty levels in some areas

Issue	Strengths	Weaknesses	Opportunities	Threats
8.Biosecurity and Biosafety	• Presence of relevant regulations (refer critical issue no1 above) • Presence of bio-containment equipment and facilities at various levels (national and regional labs, research labs and on some referral and private hospitals • National, regional and research labs are all secured • Personnel trained and IATA accredited personnel on sample packaging and shipping • Personnel trained on bio risk management	• Inadequate knowledge of the public and professionals on bio risk management • inadequate advocacy materials, • Few Personnel trained and IATA accredited on sample packaging and shipping • Few personnel trained on bio risk management	• Academic curriculum e.g. Masters programme on biorisk management available • National in-service curriculum-one health programme • Availability of brucellosis fact sheets and protocols by global bodies	• Socio-cultural barriers and beliefs • Lack of a BSL3 facility for brucellosis

Chapter Three: Strategic Framework

This section describes the scope, the vision, mission, goal and strategic objectives of the strategic plan as well as the process through which it was developed.

3.1 Approach and Scope

This strategy proposes a zonal approach for control and prevention of brucellosis at national and subnational levels in Kenya, where the implementation will be prioritized in high-risk areas and sequentially move to mid-risk before full-scale national implementation

3.2 Process of Development

An initial desktop review of the situation of Brucellosis in the country was undertaken in May 2019 and scoping missions were made to various ministries. The draft report developed formed the basis for two stakeholder consultative workshops during which a draft Brucellosis prevention and control strategy was developed. The draft was subsequently reviewed by subject matter experts and validated during a stakeholder workshop in September 2019.

3.3 Guiding Principles

- The successful control of brucellosis requires a multi-sectoral collaborative approach and partnerships.
- Prevention and control of brucellosis in animals by vaccination effectively reduces the negative impact on public health and national economy.
- The effective control of brucellosis involves interrupting the transmission and breaking the cycle of infection which can adequately achieved through early detection and notification of the disease and instituting proper intervention measures.
- Community engagement is integral in the prevention and control of brucellosis.

3.4 Vision

To have a nation that is free from brucellosis by 2040.

3.5 Mission

To eliminate brucellosis in humans and animals by improving safety of products of animal origin and to enhance livestock productivity through a One Health approach by 2040.

3.5 Goal

To reduce the burden and socio-economic impact of brucellosis by 80% in human and animal populations in Kenya by 2040.

3.6 Strategic Objectives

1. To streamline and harmonize appropriate legal/policy framework and institutional arrangement in the implementation of the plan
2. To enhance awareness and knowledge on brucellosis for professionals, policy makers, the community and the public
3. To initiate a national vaccination programme for livestock using public private partnership
4. Institutionalize brucellosis testing among febrile human cases in public and private health facilities
5. To support implementation of functional and quality integrated surveillance and diagnostic activities using One Health Approach
6. Promote and coordinate research and innovation on brucellosis interventions
7. Facilitate and support application of bio-security and bio-safety targeting risk groups
8. Advocate and mobilize resources for supporting implementation of the plan

A detailed description of the strategic objectives is provided in Appendix 1

Chapter Four : Implementation Plan

4.1 The Stepwise Elimination Pathway

The National Brucellosis Prevention and Control Strategy (2021-2040) for Kenya is guided by the stepwise approach to control and elimination of the disease that is suggested by OIE (Robinson, 2003) (Appendix 4). The approach aims to eliminate brucellosis by reducing the burden in humans and animals to less than 5% using a zonal approach that will involve four phases spanning 20 years.

The pathway will entail zonal risk mapping and a pre-implementation phase for establishment of standard operating procedures and brucellosis prevention and control committees. This implementation phase will have four phases as outlined below.

Phase 1: Establishment of disease burden and building of capacity for surveillance, diagnosis, prevention and control
Phase 2: Reduction of animal brucellosis prevalence and incidence of human brucellosis by 50%
Phase 3: Reduction of animal brucellosis prevalence and incidence of human brucellosis by 80%
Phase 4: Reduction of animal brucellosis prevalence and incidence of human brucellosis by more than 95% in bovine and more than 99% in humans.

The stepwise elimination pathway is described in detail in (Appendix 3).

4.2 Implementation of the Plan

This plan aims to achieve the stepwise elimination of brucellosis in the country, the objectives and activities explained in this section and further elaborated in the implementation matrix in Appendix 1

Strategic objective 1: To streamline and harmonize appropriate legal/policy framework and institutional arrangement in the implementation of the plan

Legal and policy framework is critical in that the proper prevention and control interventions for brucellosis are established and implemented. Although some legislations and policies exist they will be mapped, streamlined and harmonized to support brucellosis control and zoonoses in general. Law enforcers will be engaged to raise awareness to all stakeholders regarding legal aspects of animal and human disease control including brucellosis. The enforcement will facilitate compliance with the application of control measures. This objective will be realized through the following activities:

1.1. legal and policy framework analysis
1.2. advocacy and operationalization legal frameworks
1.3. stakeholder's engagement meetings especially for the law enforcers to involve them in disease control
1.4. development of appropriate regulations for the control of brucellosis and other diseases of importance

Strategic objective 2. To enhance awareness and knowledge on Brucellosis among health and veterinary professionals, policy makers and community at large.

Risk communication on brucellosis is critical as it raises public awareness on the risk of brucellosis among communities, empowers the community through behavioral change communication (BCC), facilitates mobilization of resources for prevention and control, and enhances knowledge of the disease among

health and veterinary professionals. Awareness raising and sensitizing various stakeholders (Livestock keepers, consumers, policy makers, CBO leaders) using different means including but not limited to schools, churches, Mosques, mass media (Radio, TV, Brochures, social media), drama and baraza meetings at different levels will be enhanced. Livestock keepers will be made aware of risks related to improper disposal of aborted fetuses, placenta and carcasses and good promotion of good animal husbandry practices including bio-security measures. Raising awareness on brucellosis prevention and control is essential in preventing human exposure due to consumption and contact. Enhanced awareness also improves brucellosis control efforts in animals by increasing reporting of potential animal cases and improving sanitary measures. A risk communication plan will be developed to implement this strategy. This objective will be achieved through the following activities:

2.1. Conducting of knowledge, Attitude, Practice (KAP) studies in communities and professional groups
2.2. Development of a communication and advocacy strategy
2.3. Conducting advocacy, communication and social mobilization
2.4. Conducting of epidemiological investigations and risk mapping

Strategic objective 3. To initiate a national vaccination programme for Livestock using public-private partnership

Vaccination of animals is one of the main methods of preventing the spread and maintenance of brucellosis in livestock particularly *B. abortus* and *B.melitensis* infections in cattle, goats and sheep. Effective vaccination will help to reduce economic losses and safeguard the general public from the disease while aiding in management and final elimination of the disease. This strategy will be achieved through the following activities:

3.1. Development and implementation of national vaccination plan
3.2. Production/procurement of vaccines
3.3. Conducting vaccinations in piloted areas at the subnational level(counties)
3.4. Conducting monitoring of vaccination programme

Strategic objective 4. Institutionalize Brucellosis testing among febrile human cases in public and private health facilities

Laboratory diagnosis for brucellosis is critical for routine screening and surveillance of the disease in animals and humans. Although laboratory screening is routinely conducted for animals, it has not been institutionalized in public and private health facilities. There would therefore be need to institutionalize brucellosis testing among febrile cases in public and private health. This objective will achieve this through the following activities:

4.1. Development of an SOP for testing of human febrile cases guided by evidence and research
4.2. Training personnel (Epi-Laboratory on biosafety and biosecurity)

Strategic objective 5. To support implementation of functional and quality integrated surveillance and diagnostic activities using One Health Approach

Effective brucellosis surveillance will require early detection in animals before spreading to humans. To achieve this syndromic and community-based surveillance would need to be enhanced through capacity building of human and animal health workers at various levels. This objective will achieve this through the following activities:

5.1. Procurement of diagnostic kits and reagents
5.2. Development of joint outbreak investigation protocols in humans and animals
5.3. Training personnel and equipping of national brucellosis surveillance units
5.4. Training and equipping field veterinary and health workers on data collection and reporting at the county level
5.5. Review of existing tools on brucellosis surveillance

Strategic objective 6. Promote and coordinate research and innovation on brucellosis interventions

Research on brucellosis using a multidisciplinary One Health approach will be critical in the prevention, control and elimination of the disease in the country. It will also provide evidence to inform the design of interventions during the implementation of the strategy, document best practices and guide optimal solutions to implementation challenges. The following activities will be conducted to achieve this objective:

6.1. Conducting research in innovative diagnostic technology on rapid detection, identification and differentiation of species.
6.2. Conducting research on epidemiology (spatial risk analysis, socioeconomics, disease burden analysis, predictive modelling)
6.3. Conducting research on vaccines development

Strategic Objective 7. Facilitate and Support Application of Bio-security and Bio-safety Targeting Risk Groups

There is a need to observe recommended biosafety, laboratory biosecurity and biocontainment procedures for bio-risk reduction and protect clinical and laboratory staff and the public from brucellosis infection. The personnel handling *Brucella* samples should act with extreme care to minimize breach of biosafety and biosecurity protocols (in-field, laboratory and clinic/hospital). Brucellosis is classified as an Emerging and Extremely Dangerous Pathogen (EDP) by the CDC for its ability to proliferate and hence as a potential biological weapons threat (bioterrorism).Effective biosecurity should be implemented to prevent or limit access to equipment, technologies, and information that could be used for malicious purposes involving biological weapons. This objective will be realized through the following activities:

7.1. Advocacy and awareness creation to first responders – farmers, extension officers
7.2. Development and dissemination of SOP's on biosafety and biosecurity on suspected cases of Brucellosis
7.3. Supporting regional veterinary investigative labs, central veterinary lab and establishment of county zoonosis labs for handling and identification of brucellosis
7.4. Training and equipping biosafety officers including veterinary and health workers, meat inspectors and market staff

Strategic Objective 8. Advocate and Mobilize Resources for Supporting Implementation of the Plan

Successful implementation of brucellosis prevention and control strategy requires support in terms of human resource, enabling infrastructure and financial strength. Using the needs assessment reports, priority areas of investment will be identified as procurement of vaccine stockpiles and logistics for delivery, diagnostics and human treatment supplies, joint surveillance, diagnostic capacity building, operational research, monitoring and evaluation. This objective will be achieved through the following activities:

8.1 Sensitization of policy makers and partners on the strategy
8.2 Conducting development partners mapping for resource mobilization within and outside Kenya

Chapter Five: Resource Mobilization, Monitoring And Evaluation

5.1 Resources of the Strategic Plan

An item based funding plan will be developed to ensure that support is available for implementation of each of the four phases. Budgetary justifications will be proposed for funding by the relevant government ministries. They include: Ministry of Agriculture, Livestock and Fisheries (MALF), Ministry of Health (MOH), county governments, research institutions as well as local and international partners. Technical support will also be sought in kind from local and international collaborating universities and research institutions.

5.2 Monitoring and Evaluation

Monitoring and Evaluation (M&E) of the brucellosis prevention and control strategic plan will be critical to measure the effectiveness of investments, innovations and interventions. A national brucellosis prevention and control committee will be established to report to the respective ministries. The taskforce will be mandated;

(i) To provide accurate and timely information to the brucellosis control program and all stakeholders for evidence based decision-making at all levels,
(ii) To ensure collection, collation, processing, analysis and use of appropriate brucellosis data at all levels of the control programme
(iii) To facilitate harmonization of brucellosis data collection based on standardized definitions, tools and indicators
(iv) To conduct midterm and end term monitoring and evaluation of the strategy.

Bi-annual stakeholder performance monitoring and review meetings at county and national levels will be held to assess the performance against targets, address any constraints to implementation and revise the activities if necessary.

Data audit: The NBPCC will conduct annual data quality audits and make official routine brucellosis surveillance data available to the government ministries and other stakeholders.

Annual review meeting: There will be need for all stakeholders to meet annually to review achievements against targets and milestones in the strategic plan and annual work plans. These meetings will also define and finalize priorities for the following year. A proposed monitoring and evaluation matrix is provided in (Appendix 2)

Appendix 1: Objectives of the Strategy

OBJECTIVES	ACTVITIES	TARGET PHASE				Budget Ksh(Million)	Responsible Body
		Phase 1	Phase 2	Phase 3	Phase 4		
Strategic objective 1. To streamline and harmonize appropriate legal/policy framework and institutional arrangement in the implementation of the plan	1.1 To carry out leg;al and policy framework analysis	■				20	MOALF MOH CoG
	1.2 To carry out advocacy and operationalize legal frameworks	■					
	1.3 To carry out stakeholder's engagement meetings especially for the law enforcers to involve them in disease control	■					
	1.4 To develop appropriate regulations for the control of brucellosis and other disease of importance	■					
Strategic objective 2. To enhance awareness and knowledge on brucellosis for professionals, policy makers, community and the public	2.1 Conduct knowledge, Attitude, Practice(KAP) studies in communities and professional groups	■				20	ZDU NBPCC Research Institutions
	2.2 Develop a communication and advocacy strategy	■					
	2.3 Conduct advocacy, communication and social mobilization	■					
	2.4 Conduct epidemiological investigations and risk mapping	■	■				
Strategic objective 3. To initiate a national vaccination programme for livestock using public-private partnership	3.1 Develop and implement national vaccination plan		■			50	DVS ZDU NBPCC CDVS
	3.2 Production/ procurement of vaccines		■				
	3.3 Conduct vaccinations in piloted areas at the subnational level(counties)		■	■	■		
	3.4 Conduct monitoring of vaccination programme		■	■	■		
Strategic objective 4. Institutionalize brucellosis testing among febrile human cases in public and private health facilities	4.1 Develop SOP for testing of human febrile cases guided by evidence and research	■				50	MOH
	4.2 Train personnel (Epi-Laboratory on biosafety and biosecurity)	■	■				

STRATEGIC OBJECTIVES	ACTVITIES	TARGET PHASE				Budget Ksh(Million)	Responsible Body
		Phase 1	Phase 2	Phase 3	Phase 4		
Strategic objective 5. To support implementation of functional and quality integrated surveillance and diagnostic activities using One Health Approach	5.1 Procure diagnostic kits and reagents	■	■	■	■	20	Stakeholders, line ministries
	5.2 Develop joint outbreak investigation protocol in humans and animals	■					
	5.3 Train personnel and equip national brucellosis surveillance units		■	■			
	5.4 Train and equip field veterinary and health workers on data collection and reporting at county level		■	■			
	5.5 Review of existing tools on brucellosis surveillance		■	■			
Strategic objective 6. Promote and coordinate research and innovation on brucellosis interventions	6.1 Conduct research in innovative diagnsostic technology on rapid detection, identification and differentiation of species.	■	■	■		100	ILRI,KEMRI, KALRO, NPHL, CVL. KEVEVAPI.
	6.2 Conduct research on epidemiology (spatial risk analysis, socioeconomics, disease burden analysis, predictive modelling)		■	■			
	6.3 Conduct research on Vaccines development		■	■			
Strategic objective 7. Facilitate and support application of bio-security and bio-safety targeting risk groups	7.1 Review, update and disseminate the biosafety and biosecurity policy		■	■		50	KEMRI, ILRI, CoG, NGOs, CDC, KALRO, CVL, NPHL, Hospital labs, Regional Vetlabs
	7.2 Advocacy and awareness to first responders – farmers, extension officers		■	■			
	7.3 Development and dissemination of SOP's on biosafety and biosecurity on suspected cases of Brucellosis			■			
	7.4 To support regional veterinary investigative labs, central veterinary lab and establishment of county zoonosis labs for handling and identification of brucellosis			■			
	7.5 Train and equip biosafety officers including veterinary and health workers, meat inspectors and market staff			■			
Strategic objective 8. Advocate and mobilize resources for supporting implementation of the plan	8.1 Development of brucellosis budget proposals for support of implementation of the plan	■	■	■	■	50	NBPCC Ministries MOH MOALF ILRI KEMRI Universities
	8.2 Sensitization of policy makers and partners on the strategy	■					
	8.3 Conduct development partners mapping for resource mobilization within and outside Kenya	■	■				

Appendix 2: Monitoring and Evaluation Matrix

OUTCOME	OBJECTIVES	ACTIVITY	INDICATOR	DATA SOURCE/ MEANS OF VERIFICATION	BASELINE
Better understanding of the disease situation	To enhance awareness and knowledge on brucellosis for professionals, policy makers, community and the public	• Conduct knowledge, Attitude, Practice (KAP) studies in different social, policy and professional group • Develop/review communication and advocacy strategy for the brucellosis diseases (cross cutting) • Develop, produce and disseminate IEC materials. • Conduct advocacy, communication and social mobilization on brucellosis • Carry out baseline survey and epidemiological investigation and undertake risk mapping	• Number of, KAP studies conducted and shared • Communication and advocacy strategy in place • IEC materials put in place and disseminated to the target groups at different levels. • Number of meeting for advocacy conducted • Surveys and investigations and risk mapping undertaken	Baseline survey report, post intervention survey reports	Derived from pre-existing and Published data
Increased vaccination coverage of livestock and enhanced public private partnerships	To enhance the national vaccination programme for livestock using public private partnership	• Develop national vaccination plan • Production/procurement of vaccines • Conduct monitoring of vaccination programme • To conduct vaccination campaigns at National and subnational levels • Advocacy for partners support	• National vaccination plan document • Number of Vaccine produced/ procured and consumed • Number of vaccination campaign/ monitoring visits • Number of partners involved in implementing the plan	• Availability of Reports and document on the activities conducted • Contribution of the partners	No Existing data
Supported and implemented functional and quality integrated surveillance and diagnostic activities using One Health Approach	To support implementation of functional and quality integrated surveillance and diagnostic activities using One Health Approach	• Train personnel and equip Epidemiology Unit for brucellosis surveillance. • Train personnel and equip Lab Unit for brucellosis detection. • Train clinicians for proper case management • Train and equip field staff/ health officers for data collection and reporting. • Develop joint outbreak investigation protocol in humans and animals • Undertake active surveillance in humans and animals	• Reports of the number of supplies and, equipment. • Number of trainings and surveillance. • Number of counties/ sub-counties equipped with data collection and reporting tools. • Joint investigation protocol developed	Reports and documents	No pre-existing data

OUTCOME	OBJECTIVES	ACTIVITY	INDICATOR	DATA SOURCE/ MEANS OF VERIFICATION	BASELINE
Institutionalized brucellosis testing among febrile human cases in public and private health facilities	institutionalize brucellosis testing among febrile human cases in public and private health facilities	• Procure diagnostic reagents, • Train personnel (Epi-Laboratory on biosafety and biosecurity) • Develop SOP for testing of human febrile cases guided by research evidence • Orient professionals on SOP, biosafety and biosecurity	• Availability of materials and health centers/facilities involved. • Number of training and trained individuals by counties/sub counties	• Availability of SOP document • Training and orientation reports	No pre-existing data
Coordinated research and innovation on Brucellosis intervention	Promote and coordinate research and innovation on brucellosis interventions	• Conduct innovative Brucellosis research to inform legislation and intervention planning • Research on Policy and coordination structure which support implementation and interventions • Research on disease epidemiology in wildlife, livestock and humans • Research on interactions which lead to outbreaks between the compartments • Research in new technology on rapid detection, identification and differentiation of species. • Validation of existing vaccines • Conduct research on making new vaccine candidates • Research on other options for Brucellosis control • Research on sociocultural drivers on Brucellosis transmission, prevention and control	• Number of research gaps identified • Number of proposals developed and sent for funding • Reports/publications and documents	Reports Proposal documents	Existing publications and reports on brucellosis
Mobilized resources for supporting the implementation of Brucellosis prevention and control strategy	Advocate and mobilize resources for supporting implementation of the plan	• Development of brucellosis proposals to support implementation of the plan • Conduct development partners mapping • for resource mobilization within and outside Kenya	• Number of brucellosis proposals developed. • An inventory of funding agencies available	• Reports of implementation. • Funding proposals.	Not existing

OUTCOME	OBJECTIVES	ACTIVITY	INDICATOR	DATA SOURCE/ MEANS OF VERIFICATION	BASELINE
Streamlined and harmonized appropriate legal/ policy framework and institutional arrangement for implementation of the plan	To streamline and harmonize appropriate legal / policy framework and institutional arrangement in the implementation of the plan	• To carry out legal and policy analysis, spot some weakness and amend accordingly • To carry out advocacy and operationalize legal frameworks • To carry out stakeholder's engagement meeting especially for the low enforcers to involve them in disease control • To establish linkage mechanism for research between line ministries and research institutions to support the control of brucellosis • To develop community based policy institutional and legal frameworks to support community engagement in the control of brucellosis	• Report of Revised document • Number of advocacy meetings • Number of stakeholders meeting conducted • Number of established linkage between line ministries and research institution to support control of brucellosis • Number of established policies and regulations	Reports and documents from activities	Existing policies/ legal frameworks
Improved application of biosecurity and biosafety targeting risk groups	Facilitate and support application of bio-security and bio-safety targeting risk groups	• Review, update and disseminate the biosafety and biosecurity policy and curricula • Creation of awareness to the first responders-farmers, extension officers • Train and equip biosafety officers including meat inspectors and market staff • Inventory of lab research and detection • To designate laboratories for handling and identification of Brucellosis • Development and dissemination of SOP's on biosafety and biosecurity on suspected cases of Brucellosis to avoid contamination	• Brucellosis outbreak response plan. • Number of staff trained. • Number of equipment procured. • Availability of lab research and detection • Availability of designed lab for handling and identification of Brucellosis • Availability of SoPs	• Presence of PPE, • Presence of safety cabinet in the laboratory	Not existing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Appendix 3: Step-wise Brucellosis Elimination Pathway (2021-2040)

A step-wise approach for the control and elimination of Brucellosis in Kenya will be adopted as previously suggested by OIE (Robinson, 2003). This approach shall involve four phases spanning over a 20 yr. period (2021-2040), whose aim will be to reduce the burden of Brucellosis to less than 5% in animals and humans. The activities will be synchronized in each phase to ensure cost-effectiveness, synergy and leverage. Each step will entail objectives, expected outcomes and summarized key activities as indicated in (Figure 9).

Zonal Risk Mapping (ZRM)

This strategy aims to eliminate Brucellosis by reducing the incidence and prevalence in humans and animals to acceptable thresholds using a zonal approach that will in the first phase select pilot areas of high prevalence based on evidence from sero-surveillance studies in humans and animals (Osoro *et al.*, 2015). The second phase of five years will gradually move to mid-risk zones as documented in other human and animal linked risk surveys (Muturi *et al.,* 2018; Obonyo 2018; Ogola *et al.,* 2014).This sequential approach assumes that contiguous or buffer zones are at a higher risk than distant zones, and thus this will be adopted for the last two phases to scale up a full national implementation as outlined in Figure 8

The prevalence status of Brucellosis in livestock in different production systems will be considered in spatial risk assessment to avoid selective bias of the targeted zones. There will be continuous interventions by livestock vaccination, restriction of animal movement and management of human cases in each of the selected zones. The ZRM will form the basis for both risk mapping and disease modelling where all models will be parameterized with clinical, epidemiological and cost data due to Brucellosis occurrence

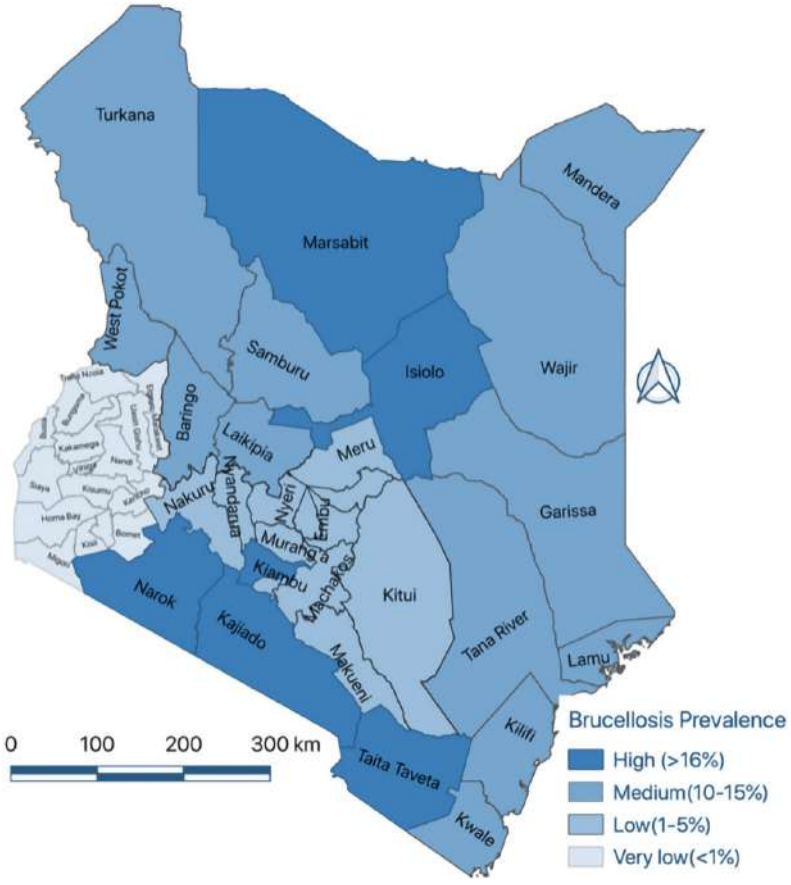

Figure 9: Risk based pilot zones for implementation of Brucellosis Control

Pre-implementation phase

The pre-implementation phase will include a consultative stakeholder process which will develop and adopt the elimination strategy. For successful implementation of the strategy, guidelines will be developed for operationalization.

5.2.1 Guidelines and Standard Operation Procedures (SOPs)

The following guidelines shall be developed to operationalize the strategy:

a. Human case diagnosis and management.
b. Animal case diagnosis and management (cull & slaughter).
c. Outbreak investigation using one health approach.
d. Surveillance in humans, animals and wildlife.
e. Vaccination in animals integrated with identification.
f. Infection, prevention and Control; bio-containment, decontamination, disinfection and waste disposal.
g. Sample collection, transportation, processing and storage.
h. Laboratory diagnosis.
i. Compensation and Indemnity for test and slaughter cases.
j. Risk mapping and communication.
k. Livestock movement control.

Establishment of Brucellosis Prevention and Control Committees

An inter-sectoral taskforce will be established for the coordination of the implementation of this strategy. Using the existing surveillance mechanisms in a national committee, will work with the subnational committees anchoring on the COHU model. The following government ministries and departments and subnational sectors will be supported by development partners, research institutions and universities:

i. Ministry of Agriculture, Livestock and Fisheries
ii. Ministry of Health
iii. Ministry of Interior and coordination of National government
iv. Ministry of Communication, Information and Telecommunication
v. Ministry of Devolution and Planning
vi. Kenya Wildlife Service
vii. Research /Training Institutions/ Non-governmental organization involved in Brucellosis prevention and control- Universities, ILRI, KEMRI,KALRO,KEVEVAPI
viii. County One Health units (Health, Livestock, Environment, Security)
ix. International and Regional research organization e.g. FAO, WHO, OIE, CDC, ACDC, AU-IBAR

The National Brucellosis prevention and control committee (NBPCC) will be a technical sub-committee of the Zoonotic Technical Working Group (ZTWG) and ZDU will be the secretariat. Roles of the NBPCC are;

- Overall responsibility for implementing the Brucellosis prevention and control strategy
- Provide technical guidance to County and Sub-county coordination structures
- Resource mobilization
- Provide periodic updates to government ministries
- Periodic updates to the stakeholders and public if need be
- Monitoring and Evaluation
- Provide technical advice to ZTWG
- Propose changes and amendments of regulation and laws on Brucellosis
- Develop memorandum for inter-county and transboundary engagements

The subnational coordinating committees will be established as the County Zoonotic Committee (CZC) and Sub-County Zoonotic Committee (SCZC). The SCZC will implement Brucellosis prevention and control activities at the sub-county level by replicating roles of CZC and providing regular updates to the CZC which will be charged with overall implementation at the county level while:

- Promoting public awareness
- Resource mobilization and advocacy
- Regularly updating the NBPCC on Brucellosis control activities.

The composition of the SCZC and CZC will be determined by County Executive Committee members in-charge of health, agriculture and livestock and environment respectively; the directors in-charge of Health and Veterinary services will be technical leads in coordination with security organs (commissioner and police) and other relevant departments. The community should be involved as primary sources of information and NGOs can play a vital role in publicity, resource mobilization and advocacy. The overall coordination structure has been previously described in Figure 7

Implementation phase

The implementation of the strategy will be guided by SWOT analysis in Table 2 where existing strengths and opportunities will be harnessed while focusing on enforcing or improving the following thematic issues:

- Research, training and development.
- Partnerships and multi-sectoral collaboration.
- Development of tools for surveillance and control (diagnostics, vaccines, reporting system, feedback response system)
- Legal frameworks in support of Brucellosis prevention and control.
- Human and institutional capacity building -Laboratory skills and infrastructure.
- Financial and social mobilization.
- Monitoring and Evaluation.

The Kenya national prevention and control strategy for Brucellosis will involve four phases as outlined in (Figure 9), they will be:

Phase 1: Establishment of disease burden and building of capacity for surveillance, diagnosis, prevention and control
Phase 2: Reduction of animal Brucellosis prevalence and incidence of human Brucellosis by 50%
Phase 3: Reduction of animal Brucellosis prevalence and incidence of human Brucellosis by 80%
Phase 4: Reduction of animal Brucellosis prevalence and incidence of human Brucellosis by more than 95% in bovine and more than 99% in humans.

Phase 1:

Objective: Establishment of disease burden and build capacity for surveillance, diagnosis, prevention and control (2021-2023)

Activities

- Establishment of Brucellosis task force at the national level and zoonotic disease committees at the county level
- Development of guidelines, modules for training and SOPs for operationalization
- Conducting baseline epidemiological surveys and epidemiological investigations
- Development of risk maps for Brucellosis in humans and animals by spatial risk analysis and predictive modeling.
- Strengthening surveillance systems at humans, livestock and wildlife interface and creation of a national database for human and animal Brucellosis
- Development of a Brucellosis risk communication plan.
- Conducting an economic impact assessment and cost-benefit analysis for Brucellosis prevention strategy.

- Conducting knowledge, attitude and practice assessment among stakeholders.
- Resource mapping and mobilization.
- Development of vaccination plans and continuous vaccinations for all eligible animals.
- Review and updating of policy and legal framework to support implementation of the strategy.

Indicators

- Spatial risk and predictive maps for both humans and animals
- Burden of Disease(BOD) analysis (DALYs) or socioeconomic impact analysis
- Cost-benefit /cost-effectiveness analysis of interventions (Vaccination coverage)
- Data driven computational simulation models for long term public health impacts.
- Strengthened laboratory and diagnostic capacity for Brucellosis and validation of test kits
- Evidence of a national Brucellosis surveillance database for human and animals
- Legal documents to support Brucellosis prevention and control in place
- guidelines in place
- Available capacity for local vaccine production, validation and quality assurance
- Availability of data on Brucellosis epidemiology, diagnostics, vaccine coverage and treatment
- Available communication and vaccination plans
- Established task force at the national level and zoonotic disease committees at county level
- Designate reference labs for Brucellosis confirmation

Phase 2

Objective: Reduction of animal Brucellosis prevalence and incidence of human Brucellosis by 50% (2024-2032). This will focus on identified high-risk areas for piloting initial vaccinations and sustaining of activities from the previous phase.

Activities:

a) Zonal approach /Piloting will bemade in high-risk zones, mixed production systems and border regions.
b) Stocking up of lab commodities, PPEs.
c) Conducting pre-vaccination testing and culling/slaughter of infected livestock in selected areas.
d) Conducting annual targeted vaccination, aimed at achieving 80% coverage in eligible(3 8months) livestock in selected areas
e) Development of MOUs with neighboring countries on surveillance and interventions (intercounty MOUs)
f) Sero-monitoring of livestock during pre and post interventions to determine coverage and seroconversion.
g) Restricting animal movement in line with the Animal Disease Control Act.
h) Drafting compensation guidelines to inform test and slaughter policy.
i) Conducting antimicrobial sensitivity testing on aborting animals secondary to Brucellosis to guide treatment in humans.
j) Disseminating of information, education and communication (IEC) materials
k) Continuous active and passive surveillance for animals and humans.
l) Diagnosis and treatment of human cases.
m) Promotion of artificial insemination and screening of genetic materials.
n) Continuous operational research.
o) Continuous capacity building of clinicians and laboratory personnel
p) Monitoring and evaluation

Indicators:

- Percentage of vaccination coverage achieved.
- Percentage of sero-prevalence in eligible livestock species vaccinated.
- Public awareness and advocacy plan in place.
- Percentage of increased uptake of Artificial insemination.

Phase 3:

Objective: To reduce animal Brucellosis prevalence and incidence of human Brucellosis by 80% (2033-2037).

Activities

a) Conducting continuous vaccination of eligible livestock species and identification of vaccinated livestock
b) Undertaking of risk map and cluster counties revision in order to prioritize vaccination programs and enable proceeding to mid risk counties
c) Sero-monitoring of vaccinated livestock
d) Enhancing passive surveillance for human and animals
e) Sentinel site surveillance for animals
f) Carrying out behavioral change surveys to asses change in practices
g) Laboratory quality assurance
h) Clinical quality assurance
i) Cost-effectiveness study for vaccination programs
j) Sustaining/continuous advocacy and awareness
k) Stocking up of lab commodities, PPEs etc.
l) Conducting antimicrobial sensitivity testing
m) Undertaking surveillance at markets and abattoirs in tissues and blood
n) Conducting regular stakeholder's meetings
o) Conducting regular technical working group meetings
p) Undertaking laboratory investigations of all abortion cases in pilot counties
q) Promoting artificial insemination and screening of genetic materials
r) Undertaking continuous operational research
s) Monitoring and evaluation

Indicators

- Percentage vaccination coverage achieved
- Percentage seroprevalence in eligible livestock species vaccinated.
- Public awareness and advocacy plan in place
- Percentage increase in artificial insemination uptake
- Number of genetic materials (semen and embryos) screened for Brucellosis
- Number of repository of research and survey findings done
- Number of lab and clinical quality assurance audits reports on improved scores.

Phase 4:

Objective: To reduce animal Brucellosis prevalence and incidence of human Brucellosis by more than 95% in animal and more than 99% in humans (2038-2040)

Activities

a) Zonal self-declaration based on article 8.45 of the OIE Terrestrial Code as free of Brucellosis
b) Targeted vaccinations of livestock in selected areas
c) Sero-monitoring of vaccinated herds
d) Gradually initiating test and slaughter and compensation for areas with <5% prevalence
e) Control of wildlife movement at Human-Livestock-Wildlife interface
f) Enhancing passive and active surveillance
g) Continuing operational research
h) Continuing dissemination of information, education and communication (IEC) materials
i) Promoting artificial insemination and mandatory screening of genetic materials
j) Monitoring and evaluation

Indicators:

- Reduced incidence of Brucellosis in livestock and humans by at least 95% in livestock and 99% in humans.
- Proportion of livestock tested to livestock slaughtered
- Number of abortions (animal losses due to Brucellosis) reported.

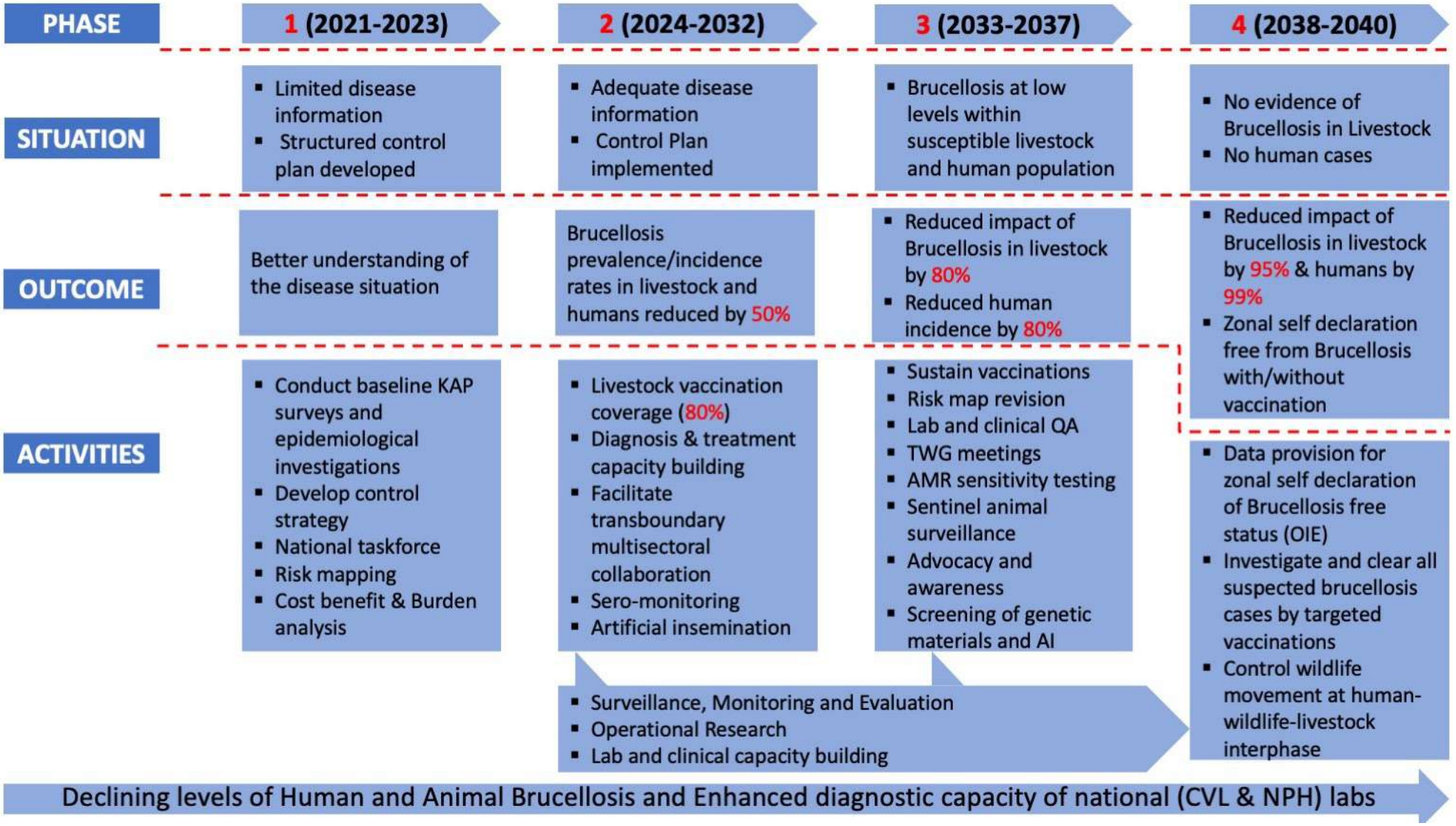

Figure 9: Road map for the stepwise prevention and control of brucellosis in Kenya

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