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# Process evaluation of Community-Based continuous mass dog vaccination delivery Strategies in the Mara region of Tanzania

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# PROCESS EVALUATION OF COMMUNITY-BASED CONTINUOUS MASS DOG VACCINATION DELIVERY STRATEGIES IN THE MARA REGION OF TANZANIA

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**A Thesis Submitted in Fulfilment of the Requirements for the Degree of Doctor of Philosophy in Life Sciences of the Nelson Mandela African Institution of Science and Technology**

**Arusha, Tanzania**

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## ABSTRACT

Rabies can be eliminated if coverage of domestic dog vaccination is sustained above 40% all year-round for five-seven consecutive years. Current approaches usually fail to achieve this required vaccination coverage and an alternative, a community-based continuous mass dog vaccination (CBC-MDV) approach, was designed and piloted in the Mara region of Tanzania. This thesis used mixed, qualitative, quantitative and participatory methods to evaluate the development and delivery of the CBC-MDV approach over two years to generate evidence to inform the optimization of the design prior to its evaluation in a full-scale randomized control trial. Specifically, it investigated the feasibility and fidelity of delivery and potential effectiveness of the CBC-MDV strategies, drivers of innovations in the implementation process, whether and how community engagement can be used to address barriers to participation in mass dog vaccination (MDV) campaigns and what factors will determine the normalization of CBC-MDV as the standard approach for delivering MDV in Tanzania. Qualitative data were analyzed using thematic analysis, both inductive and deductive. Quantitative data on delivery of CBC-MDV were analyzed descriptively. Regression analysis was used to identify population-related factors that have implications for participation in MDV. Two-proportion Z-tests and Mann-Whitney U test were used to assess whether the community engagement strategies were effective and can address barriers to participation in MDV campaigns. The findings showed that the development process of CBC-MDV was iterative and involved cross-sectoral participation but without the direct involvement of communities. In relation to feasibility, fidelity and potential effectiveness, CBC-MDV was delivered with 69% fidelity and performed better in terms of sustaining high vaccination coverage compared to the centralized approach. Design-, implementer- and context-related factors influenced delivery and effectiveness of the CBC-MDV strategies. We found that the community engagement activities positively influenced factors that underpin participation in MDV campaigns. In relation to integrating and sustaining the new approach in practice, CBC-MDV was well understood, accepted, operationalized with relative ease and positively appraised compared to the centralized approach. We conclude that it was feasible to deliver CBC-MDV in the context of Tanzania, it can be sustained in practice, and barriers to participation in mass dog vaccination can be addressed through community engagement processes. However, community participation in the design, delivery and evaluation of CBC-MDV is needed to foster ownership and sustainability of the intervention.

## DECLARATION

I, Christian Tetteh Duamor, do hereby declare to the Senate of the Nelson Mandela African Institution of Science and Technology that this thesis is my original work and that it has neither been submitted nor being concurrently submitted for a degree award in any other institution.

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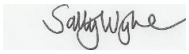
| Prof. Sally Wyke |  | 18.08.2023 |
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## CERTIFICATION

The undersigned certify that, they have read and hereby recommend for acceptance by the Nelson Mandela African Institution of Science and Technology a thesis titled ***"Process Evaluation of Community-Based Continuous Mass Dog Vaccination Delivery Strategies in the Mara Region of Tanzania"*** in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Life Sciences of the Nelson Mandela African Institution of Science and Technology.

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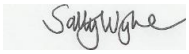
| Prof. Sally Wyke |  | 18.08.2023 |
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## DEDICATION

To my wife, Miss Patience Hozameh and our two boys, Tesa and Joomi, for bearing with me in my long and frequent stays abroad for five years in a roll. The joy is ours!

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| CAHWs | Community-Based Animal Health Workers |
| CBC-MDV | Community-Based Continuous Mass Dog Vaccination |
| CVR | Capture-Vaccinate-Release |
| DALYs | Disability-Adjusted Life Years |
| DLFO | District Livestock Field Officer |
| FAO | Food and Agriculture Organization |
| FGD | Focus Group Discussion |
| HTH | House-To-House |
| IDI | In-Depth Interview |
| LFOs | Livestock Field Officers |
| LMICs | Low- and Middle-Income Countries |
| MDV | Mass Dog Vaccination |
| MRC | Medical Research Council |
| ND | Newcastle Disease |
| NPO | Non-Participant Observation |
| NPT | Normalization Process Theory |
| NTD | Neglected Tropical Disease |
| ODK | Open Data Kit |
| OHC | One Health Champion |
| PEP | Post-Exposure Prophylaxis |
| RC | Rabies Coordinator |
| RCT | Randomized Controlled Trial |
| TSP | Temporal Static Point |
| WOAH | World Organization for Animal Health |
| WHO | World Health Organization |

# CHAPTER ONE

# INTRODUCTION

## 1.1 Background of the Problem

Rabies is a viral zoonotic disease that affects the central nervous system of mammals and causes about 59 000 human deaths each year globally (Hampson *et al.,* 2015). The majority (99%) of the global incidence and burden of rabies is in Africa and Asia (Hampson *et al.,* 2015; Knobel *et al.,* 2005). It is estimated that 552 (377 – 723) persons die of rabies each year in Tanzania (Hampson *et al.,* 2019). The main source of infection to humans are domestic dogs (*Canis lupus familiaris*). Upon a bite or scratch, the wound must be washed immediately under running water and with soap for about 15 minutes, then rabies immunoglobulin and post-exposure prophylaxis vaccination given within 24 hours to prevent progression of the infection to disease state should the bite be infective. Once clinical signs appear, rabies disease always results in death. Due to limited access to and pricing of these life-saving vaccines, tens of thousands of victims die each year across the globe because they could get the treatment (Hampson *et al.,* 2009; Knobel *et al.,* 2005).

Rabies constitutes a huge burden on the Tanzanian society in terms of trauma and economic losses. Between the years 1990 and 1996, the country recorded an average of 3387 dog bite cases per year and 42 669 dog bite cases were recorded in the year 2000 alone (Cleaveland *et al.,* 2002), which might be an indication of increasing bite incidences or increasing capacity of the surveillance system to detect these cases. Currently, it costs 120 000 TZS to complete the four course of post-exposure prophylaxis (PEP) vaccinations. This means that the 42 669 bite victims would have spent 5 120 280 000 TZS on direct PEP seeking alone. In addition to this cost, the health system also incurs indirect costs relating to medical consumables involved in the treatment of the wound and administering the vaccines such as: syringes, bandages, alcohol swaps, needles; the man-hours of doctors and nurses attending to the patients; transport and accommodation expenses by victims; as well as the opportunity cost for bites victims leaving their livelihood activities to seek treatment (Hampson *et al.,* 2015).

The incidence rate of dog bite in Tanzania may be increasing. According to a modeling study, 1% of the about 2.5 million dogs in Tanzania become infected with rabies each year, and an infected dog has a probability of 0.38 of biting someone before the dog dies or is killed (Hampson *et al.,* 2019). This implies rabies infection in dogs alone contributes 9500 bites cases

each year and the majority of dog bites are as a result of provoking of dogs or incorrect human-dog interactions. This also, implies that by preventing rabies infection in dogs via mass dog vaccination we can reduce the number of dog bites and hence the economic costs and psychological trauma that comes with dog bites, making mass dog vaccination (MDV) a profitable health investment. The challenge though has been sustaining adequate vaccination coverage.

The epidemiological dynamics of rabies transmission demonstrate that sustaining vaccination coverage of the domestic dog population above 40% all-year-round for five-seven consecutive years can eliminate transmission (Cleaveland *et al.*, 2003; Hampson *et al.*, 2009; Lembo *et al.*, 2010). The most cost-effective approach established for rabies prevention is MDV and different modes of delivery of MDV campaigns have been deployed in different settings. These includes temporal static point vaccination clinics, house-to-house vaccination clinics, capture-vaccinate-release (usually used to target stray or unowned dogs), use of oral rabies vaccination baits and dog population control measures (Undurraga *et al.*, 2020). On this premise, the WHO, the World Organization for Animal Health (WOAH) and the Food and Agriculture Organization (FAO), have pledged to eliminate human deaths from rabies by the year 2030.

### 1.2 Statement of the Problem

The planning and implementation of current mass dog vaccination strategies are usually centralized at district or organizational levels and excluded communities, and as a result can fail to mobilize adequate owner participation (Castillo-Neyra *et al.*, 2017; Sambo *et al.*, 2022; Savadogo *et al.*, 2021). Also, the campaigns are mainly delivered once a year to affected communities, with several communities being missed due to inclement weather or poor roads. As they are often delivered by teams traveling from distant central locations, they are associated with high operational costs (Ferguson *et al.*, 2020; Minyoo *et al.*, 2015a; Taylor & Nel, 2015) and hence not sustained. Again, because the planning of the MDV campaigns has tended to be top-down and centralized, they normally get limited buy-in from the targeted communities, who also usually have limited agency to participate in and to tailor the delivery processes to their local contexts (Bardosh, 2018; World Health Organization & African Program for Onchocerciasis Control, 2012). It follows that the planning and delivery of the campaigns are usually not properly situated around local prevailing environmental circumstances and socioeconomic activities so that people could participate with relative ease (Bardosh, 2018; Bardosh *et al.*, 2014; Mtuy *et al.*, 2020). Consequently, there is a lack of consistent and delivery

of mass dog vaccination and inadequate participation from affected communities. Hence, annual campaign vaccination coverage is usually below the levels required to maintain coverage above the critical threshold of 40% throughout the year.

The discovery of thermotolerance of the Nobivac® Canine Rabies Vaccine (Lankester *et al.,* 2016) and the feasibility of storing it in locally made, passive cooling devices (Lugelo *et al.,* 2020), has created opportunities for new approaches to rabies vaccine distribution and delivery. These include options for the storage of vaccines in remote communities, which would allow year-round routine vaccination of dogs by community-based personnel. A community-based continuous mass dog vaccination (CBC-MDV) approach, empowering communities, has the potential to sustain vaccination coverage above the critical threshold, as new puppies and other susceptible dogs (for example, newly acquired dogs or those that missed previous vaccination campaigns) can be vaccinated without having to wait for a year (Lugelo *et al.,* 2022).

However, since this community-based continuous approach has never been used to deliver mass dog vaccination, there is no evidence on how it should be delivered, if its delivery is feasible and how the design should be adapted during replication it in different settings.

### 1.3 Rationale of the Study

We evaluated the development and pilot implementation processes of CBC-MDV to generate formative insights for optimizing the design before dissemination in a full-scale randomized control trial against the centralized, pulse (once-annual) strategy across the Mara region of Tanzania, which was informed by the UK MRC guide (Skivington *et al.,* 2021). Process evaluation of the delivery of an intervention enables an understanding of the impact mechanisms of the key intervention strategies and how these strategies interact with contextual factors to produce outcomes. That is: a) how the key intervention strategies mediate to produce change in the outcome of interest, for example, dog vaccination coverage and b) how contextual factors moderate the potency of the key intervention strategies to shape observed outcomes (Glanzs, 2008; Glasgow, 2006; Moore *et al.,* 2014). Process evaluation considers the delivery of an intervention as well as its effects and interrogates if and how the key intervention strategies work to mediate the outcome of interest, and if and how contextual factors work to moderate the potency of the intervention strategies. Figure 1 illustrates how the theory of change of an intervention is followed during a process evaluation to understand the impact mechanisms of the strategies.

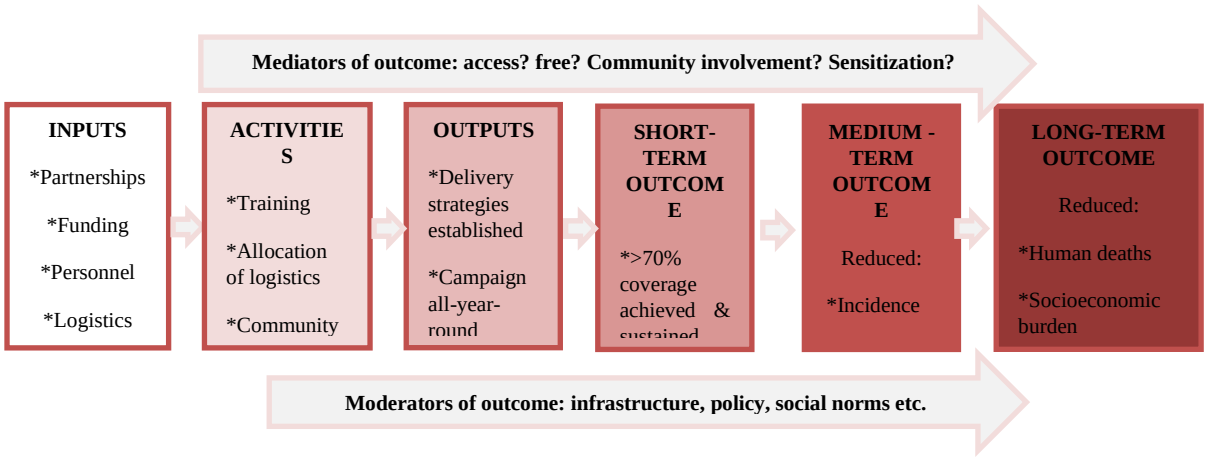


**Figure 1: Diagram of input-outcome chain logic model showing the rationale of a process evaluation**

## 1.4 Research Objectives

### 1.4.1 General Objective

To evaluate the development and implementation processes of the community-based continuous mass dog vaccination approach and inform optimization of its design prior to dissemination in a full-scale, randomized controlled trial.

### 1.4.2 Specific Objectives

The study aimed to achieve the following specific objectives:

(i) To document the development, feasibility and potential effectiveness of the community-based continuous approach to mass dog vaccination

(ii) To develop and evaluate approaches through community and public engagement to address barriers to participation in mass dog vaccination campaigns

(iii) To identify factors that will influence normalization of a community-based continuous approach in the context of Tanzania using the normalization process theory

(iv) To assess ownership and sustainability of implementation processes of the CBC-MDV approach

## 1.5 Research Questions

The study intended to answer the following questions:

(i) What were the development processes of CBC-MDV, the feasibility and potential effectiveness of its strategies?

(ii) What approaches can be developed through community and public engagement to address barriers to participation in mass dog vaccination campaigns?

(iii) What factors will determine normalization of the CBC-MDV approach as the standard way of delivering mass dog vaccination in Tanzania?

(iv) What design-, context- and implementation related factors influenced ownership and sustainability of implementation processes of the CBC-MDV approach?

## 1.6 Significance of the Study

The results of this study provide formative insight into optimization of the design of the community-based continuous approach to mass dog vaccination and how it can be replicated in different settings. The results provide understanding of what influences dog-owner participation in mass dog vaccination clinics and how communities can be mobilized and included in planning, implementing and evaluating mass dog vaccination campaigns. The findings are also useful in understanding the determinants of the likelihood of integrating and sustaining CBC-MDV in practice within the context of Tanzania. This study can be a useful guide to the development of national mass dog vaccination delivery strategies by LMICs, towards achieving the zero by 2030 goal.

## 1.7 Delineation of the Study

This is a formative process evaluation, embedded within a feasibility study of a community-based approach to delivering mass dog vaccination campaigns. The primary aim was to generate an understanding of how the CBC-MDV should be optimized prior to evaluating it in a large-scale RCT across the Mara region of Tanzania: whether its strategy components can be delivered in the context and whether it can sustain vaccination coverage above the 40% minimum threshold all-year-round. The study was carried out in 35 villages from 14 wards,

selected from three districts. Data was collected with mixed methods cross-sectionally in a prospective study design, which followed the implementation processes for two years.

Process evaluation has been carried out for a wide range of complex interventions, but to our knowledge, this study represents first application of process evaluation to mass dog vaccination campaigns anywhere across the globe. The study revealed implementation bottlenecks in the delivery, the understanding of the mechanism pathways underpinning these bottlenecks and also opportunities for addressing them. These insights could be of value when designing national rabies elimination strategies. The study was likely slightly affected by recall bias since sometimes data collection processes depended to a large extent on implementer reports. However, the use of mixed methods approach, including non-participant observations and following the intervention prospectively through the design and implementation phases provided first hand data for triangulation.

The use of before-after approach and same sets of questions to compare participants who received the full range of engagement activities, in order to measure the impact of the engagement activities provided a valid basis to associate any change in the variables measured to the engagement interventions. However, the field data collectors who evaluated responses after engagement were not blinded and may have introduced bias into their rating of responses.

Again, the NPT theory provided a strong theoretical basis to evaluate the likelihood of CBC-MDV becoming integrated and sustained in practice within the context of Tanzania. However, the positive views of implementers, community leaders and community members may be due to their enthusiasm for new programmes and could potentially abate unless efforts were put in place for continued engagement. Again, the positions of community leaders and community members expressed in this paper, to support delivery of CBC-MDV have to be tested in actual implementation to learn how that works.

Overall, following the intervention prospectively afforded us the opportunity to obtain firsthand information on the development, initialization and implementation phases, thereby reducing potential recall bias. The findings are largely transferable given the similarities in many respects of dog ownership practices, socioeconomic and environmental factors between the study area and other settings in low- and middle-income countries especially in Tanzania (although be less applicable to more urban areas and nomadic communities).

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Rabies

Rabies is a zoonotic infection of the central nervous system of mammals, caused by viruses within the *Lyssavirus* genus. The main source of infection in humans are domestic dogs (*Canis lupus familiaris*), which account for about 99% of human infections and act as the maintenance reservoir of the infection in Africa and Asia. In the Americas, human rabies is mainly contracted from wildlife such as Bats, Skunks, Mongooses, Jackals, Foxes and Racoons (Hampson *et al.,* 2015; Knobel *et al.,* 2005). The virus is harbored in the central nervous system and gets to the salivary glands via the cranial nerves and is excreted in saliva and body fluids of infected animals. The virus is transmitted through a bite or contact of the saliva with broken skin or mucus membranes such as the eyes or nostrils (Fisher *et al.,* 2019; Singh *et al.,* 2017; Tian *et al.,* 2018; Yousaf *et al.,* 2012).

Upon inoculation during bite or entry via broken skin, the virus binds to cell receptors and may replicate within striated muscle cells or directly infect nerve cells. The virus then travels via retrograde axoplasmic transport mechanisms to the central nervous system. Both motor and sensory fibers may be involved depending on the animal infected. Once it has reached the central nervous system, rapid virus replication takes place, causing pathologic effects on nerve cell physiology. The virus then moves from the central nervous system via anterograde axoplasmic flow within peripheral nerves, leading to infection of some of the adjacent non-nervous tissues, for example, secretory tissues of salivary glands. The virus is widely disseminated throughout the body during onset of symptoms. At this point, there is shedding of the virus in saliva and a bite victim can be infected, thus completing the infection cycle of rabies (Yousaf *et al.,* 2012). In humans, the incubation period for rabies is usually from 14 days to six weeks, although rarely it can take several years for the disease to develop following exposure (Fisher *et al.,* 2019; Singh *et al.,* 2017). In dogs, the incubation period ranges from two weeks to four months. The incubation period is shortened when an infective bite occurs on the head, neck, face or hands and with higher inoculating titers (Fisher *et al.,* 2019).

## 2.2 Burden of Rabies

Globally, there are about 3.9 billion people at risk of rabies infection. The global case-specific death rate for rabies is estimated at 59 000 deaths per annum, with 40% of cases being children under 15 years of age (Hampson *et al.*, 2015). Approximately 99% of human deaths from rabies occur in Africa and Asia where dog vaccines and life-saving post-exposure prophylaxis (PEP) are not consistently and timely accessible to the affected population due to social, geographical and economic factors (Hampson *et al.*, 2015; Sambo *et al.*, 2022). In Tanzania, the rabies-specific human death rate is estimated at 552 (394-731) per annum (Hampson *et al.*, 2019).

Rabies exact huge economic costs on the affected populations. The global economic cost was estimated to be more than 3.7 million disability-adjusted life years (DALYs) due to bite injuries and 8.6 billion USD in direct financial losses. The financial losses due to rabies are the results of premature death (55%), direct costs of post-exposure prophylaxis (PEP, 20%) and lost income whilst seeking PEP (15.5%), costs to the veterinary sector due to dog vaccination (1.5%) and costs to communities from livestock losses (6%) (Hampson *et al.*, 2015). Based on reported dog bite cases and the cost of seeking treatment for bites, the direct economic costs of rabies on the Tanzanian society could range from 1.5 – 5.1 billion Tanzanian shillings each year, in addition to the health system and victims costs (Cleaveland *et al.*, 2002; Hampson *et al.*, 2015).

Rabies also constitutes a huge source of psychological trauma for populations leaving with dogs in endemic regions due to the life-threatening injuries from dog bites and fear of being infected with rabies, and the real possibilities of death that come with that (Hampson *et al.*, 2015). Tanzania is well represented in this category of societal experience with respect to rabies; between the year 1990 and 1996, the country recorded an average of 3387 dog bite cases per year. However, the figure went up to 42 669 dog bite cases in the year 2000 alone (Cleaveland *et al.*, 2002), indicating an increasing incidence of dog bite cases or an increasing capacity of the veterinary and health sectors' surveillance systems at detecting these cases. This calls for strong and effective actions to prevent rabies infection even in the cases of bites from rabid dogs.

## 2.3 Prevention of Rabies Infection and Disease

It has been demonstrated that the vast majority of transmission of rabies virus to humans and other domestic animals can be interrupted through mass vaccination of domestic dogs; and

ensuring that at any point in time, at least 40% of the dog population are vaccinated consistently for five-seven consecutive years (Cleaveland *et al.,* 2003; Hampson *et al.,* 2009). On this premise, the Tripartite, comprising the World Health Organization (WHO), the World Organization for Animal Health (WOAH) and the Food and Agriculture Organization (FAO), have developed a global target to eliminate human deaths from rabies by the year 2030. However, rabies infection to humans and livestock is still high in many regions of the world due to inadequate and inconsistent mass vaccination of dogs. To achieve rabies elimination by this date, endemic countries must prioritize mass dog vaccination, build the capacity of the animal health services departments to vaccinate, increase rabies education and mobilize their societies for action, and back the control effects with enforcement of regulations (Global Alliance for Rabies Control, 2016; Wallace *et al.,* 2017).

As demonstrated by findings from a modeling study, rabies infections can result in 9500 dog bites each year in Tanzania (Hampson *et al.,* 2019), and that means one of the immediate outcomes of mass dog vaccination is a reduction in bites cases and hence a reduction in rabies infection. Dog bite cases can also be reduced through good dog population management and good ownership practices, which will reduce human-dog encounters (Global Alliance for Rabies Control, 2016; Hiby *et al.,* 2023). Some of the dog population management practices currently recommended include birth control, rehoming of stray dogs and euthanasia of severely sick dogs or dogs that have become extremely dangerous to people around them (Hiby *et al.,* 2023).

However, when dog bites occur, there are recommended steps to ensure that even if the bite is infectious, it does not lead to a rabies disease. Upon a bite or scratch, the wound must be washed immediately under running water and with soap for about 15 minutes, then rabies immunoglobulin is injected into the wound and post-exposure prophylaxis vaccination is given within 24 hours to prevent the progression of the infection to disease state. However, due to limited access to and pricing of these life-saving vaccines, tens of thousands of victims die each year across the globe (Hampson *et al.,* 2009; Knobel *et al.,* 2005). Hence alternative approaches for eliminating the transmission of rabies are needed to prevent these deaths.

### 2.4 Proof of Concept for Rabies Elimination

Domestic dog mediated rabies transmission is amenable to elimination via a strategy focusing on mass dog vaccination (MDV) for several reasons: a) domestic dogs are the main reservoirs

and responsible for about 99% of human infections (Hampson *et al.,* 2015); b) the number of secondary cases that result from a primary case (basic reproductive number- $R_0$) has been found to be consistently low, approximately 1.2 across a wide range of settings and regardless of dog population density (Hampson *et al.,* 2009); c) the low $R_0$ means that the critical vaccination threshold required to achieve herd immunity to eliminate on-going transmission from the dog populations, and from all other secondary hosts, including wildlife, livestock and humans is relatively low (approximately 40%) (Cleaveland *et al.,* 2003; Hampson *et al.,* 2009); and studies have demonstrated that contrary to popular belief, the majority of domestic dogs in endemic regions of Asia and Sub-Saharan Africa have some form of ownership, even in rural settings, making it possible to reach them by mass parenteral vaccinations campaigns (Davlin & Vonville, 2012; Lembo *et al.,* 2010).

Examples are Latin America and the Caribbean where human rabies cases have been reduced from 300 cases in 1983 to 3 in 2019 through mass dog vaccination; with Mexico, officially certified by the WHO in 2019 as the first country to have eliminated human rabies (Pan-American Health Organization & World Health Organizaion, 2020). However, rabies transmission remains high in Africa and Asia where mass dog vaccination campaigns have not been consistently organized.

### 2.5 Current Approaches to Mass Dog Vaccination Campaigns

Current strategies for delivering MDV include: a) temporal static point (TSP) vaccination clinics which allow high numbers of dogs to be reached in one location, with its success depending largely on the cooperation of owners, b) the labour-intensive house-to-house (HTH) vaccination, which aims to ensure all dogs are reached by visiting individual households and c) capture-vaccinate-release (CVR) programmes, which are effective at reaching stray, aggressive or very shy dogs, but are labor-intensive and require specialized dog catching and handling training (Arief *et al.,* 2017). In recent years, oral rabies vaccination, coupled with dog population management are gaining traction to augment traditional mass parenteral campaigns, they hold the potential in reaching more dogs and overcoming the difficulties related to physically handling dogs (Freuling *et al.,* 2023).

One or a combination of these MDV strategies is usually employed for the delivery of campaigns in endemic countries. Currently, in most endemic countries including Tanzania, where mass dog vaccination has been initiated, they used temporal static point strategy to

conduct annual vaccination clinics in targeted villages. The campaigns are planned and delivered by government vaccination teams, usually from district veterinary offices with reliance on cold-chain stored vaccines. However, these annual team-led approach, (referred to in this study as the pulse approach) is affected by several factors that limit its ability to achieve and sustain vaccination coverages above the critical threshold needed to interrupt the transmission of rabies. The main challenges are discussed as follows:

## 2.6 Challenges to Current Mass Dog Vaccination Campaign Approaches

### 2.6.1 Difficulties in Achieving Adequate Vaccination Coverage

Where mass dog vaccination campaigns are delivered once annually, the campaigns must achieve 70% coverage to sustain vaccination coverage above the minimum threshold over the course of the year (Cleaveland *et al.,* 2003; Hampson *et al.,* 2009). Otherwise, due to high dog population turn-over rates from deaths and emigration of vaccinated dogs, immigration of unvaccinated dog and the birth of new puppies, the proportion of vaccinated dogs in communities falls below the minimum threshold between campaigns (Beran, 1982; Kitala *et al.,* 2001). This causes herd immunity to be lost and transmission resumes (Cleaveland *et al.,* 2018). However, achieving 70% vaccination coverage consistently across the vast remote landscape of countries like Tanzania is hindered by a number of factors including: geophysical and socioeconomic challenges, as well as implementation bottlenecks such as limited veterinary human resources and high fixed costs (Ferguson *et al.,* 2020; Minyoo *et al.,* 2015b; Taylor & Nel, 2015). Studies of mass dog vaccination campaigns in Tanzania show campaign coverage is usually below 50% (Kaare *et al.,* 2009; Bardosh *et al.,* 2014; Minyoo *et al.,* 2015; Sambo *et al.,* 2022). Also, because the campaigns are mainly delivered once a year to affected communities, several communities are missed due to inclement weather or poor roads.

### 2.6.2 Geophysical and Socioeconomic Limitations

The annual, team-led campaigns target of reaching a village in a day is significantly impacted by local environmental and socioeconomic events. These challenges arise because the planning and implementation of the campaigns are usually centralized at district or organizational levels and excluded communities, and as a result fail to mobilize adequate owner participation (Castillo-Neyra *et al.,* 2017; Sambo *et al.,* 2022; Savadogo *et al.,* 2021). Because the planning of the MDV campaigns has tended to be top-down and centralized, they normally get limited buy-in from the targeted communities, who also usually have limited agency to participate in

and to tailor the delivery processes to their local contexts (Bardosh, 2018; World Health Organization & African Program for Onchocerciasis Control, 2012). It follows that the planning and delivery of the campaigns usually are not properly situated around local prevailing environmental circumstances and socioeconomic activities so that people could participate with relative ease (Bardosh, 2018; Bardosh *et al.,* 2014; Mtuy *et al.,* 2020).

Participation of dog owners has been noted to be poorer where campaigns coincide with farming or rainy seasons, cultural festivities, or school days (as children mostly are those who bring a household's dogs to the centers) (Sikana *et al.,* 2021). Thus, the participation of dog owners in mass dog vaccination campaigns has been characterized to be low across many endemic countries (Castillo-Neyra *et al.,* 2017; Sambo *et al.,* 2022; Savadogo *et al.,* 2021). Other contributory factors to low levels of dog owner participation are fear of dogs (Robinson *et al.,* 1996), poor knowledge of dog behavior (Wera *et al.,* 2015), poor dog handling techniques (Beyene *et al.,* 2018; Castillo-Neyra *et al.,* 2017; Robinson *et al.,* 1996; Thomas *et al.,* 2013; Wera *et al.,* 2015); lack of appreciation of dogs' welfare (Enlund *et al.,* 2020), negative perceptions of the impact of vaccination on dogs (Beyene *et al.,* 2018) and vaccination fees (Durr *et al.,* 2009). Owner-charged vaccination campaigns have been shown to perform poorly, forcing local governments or implementing organizations to bear all the costs (Durr *et al.,* 2009; Savadogo *et al.,* 2021).

### 2.6.3 High Operational Costs

In addition to procuring vaccines, programmes also have to maintain cold-chain systems to store the vaccines and pay the per diems of vaccinators and assistants. Also, due to the centralized nature of the campaign organization, the programmes have to make arrangements, even at the village level, including payment for advertising of the campaigns. Centralizing of activities and dependence on cold-chain stored vaccines also meant that vaccinating teams have to, in many instances, travel long distances on dirt roads to reach targeted communities. This results in high fixed costs, with cost-per-dog vaccinated for team-led campaigns which could reach as high as $7.44 (Ferguson *et al.,* 2020; Taylor & Nel, 2015). For a Neglected Tropical Disease (NTD), this expenditure for vaccinating dogs against rabies could hardly be made or sustained. In spite of this high operational cost associated with the centralized approach, similar approach was deployed by Mexico in eliminating human deaths from rabies (Pan American Health Organisation, 2020; United Against Rabies, 2022).

### 2.6.4 Veterinary Service Human Resource Gap

As demonstrated by Wallace *et al.* (2017), capacity of endemic countries to vaccinate their huge dog populations will determine if mass dog vaccination campaigns will be widely and consistently conducted. In Tanzania, dog vaccination can be administered by paravets, named livestock field officers stationed at ward (cluster of 3-4 villages) levels. Data on registered paravets in Tanzania as of 2018 stood at 1072 in 3082 wards, leaving 2010 wards without service. Also, the use of vaccination teams entirely dependent on district veterinary staff, meant that there are not enough teams to conduct vaccination campaigns for the thousands of villages due to limited availability of veterinary professionals (George *et al.*, 2022).

## 2.7 Surmounting the Challenges to Mass Dog Vaccination Campaigns: Current Developments

### 2.7.1 The Discovery of Thermotolerance of Nobivac®

A recent study conducted in Tanzania demonstrated that the Nobivac rabies vaccine is thermotolerant and it maintains its immunogenicity activating properties when stored at 30°C for three months or at 25°C for six months, and elicits a similar immune response to those stored under cold-chain (4°C) conditions (Lankester *et al.*, 2016). This implies, that as in the cases of smallpox (Henderson & Petra, 2013) and rinderpest (Mariner *et al.*, 2012), the eradication of rabies could be possible through storage of the vaccines in remote communities independent of cold-chain facilities to support consistent and community-wide vaccination of dogs.

### 2.7.2 Storage of Vaccines in Low-Tech Passive Cooling Clay Pots

Following the discovery of thermotolerance of the Nobivac rabies vaccine, feasibility of keeping the vaccines in low-tech passive cooling devices that do not require electricity was investigated in rural Tanzania. The results showed that the devices kept the vaccines at temperatures between 18-20°C despite ambient temperatures reaching 37°C, and thermotolerance remained (Lugelo *et al.*, 2020). These advancements created opportunities for new approaches to rabies vaccine distribution and delivery, including options for the storage of vaccines in remote communities which could allow all year-round routine vaccination of dogs by community-based personnel (Kaare *et al.*, 2009).

### 2.7.3 Delivery of Mass Dog Vaccination by Lay Animal Vaccinators as Stop-Gap Measure

#### (i) Use of lay animal vaccinators in animal vaccination programmes

The World Health Organization defines nonprofessional or lay health workers, also known as village or community health workers, as health workers who are given limited, non-formal professional training to perform health care delivery functions in the context of an intervention (Nkonki *et al.,* 2011; World Health Organisation, 2013). In animal health care, lay workers, also known as community (based) animal health workers (CAHWs), have a different status from that of veterinary paraprofessionals, livestock field officers or animal health technicians who have undergone an officially recognized training and are formally integrated within veterinary systems (Castroldale, 2007). During interventions, CAHWs have been temporarily recruited from other professions, such as the army, police or environmental health officers, nurses, teachers, or even be retirees, farmers or community-based volunteers (Belotto, 1988; Castroldale, 2007). The eradication of smallpox was made possible through the participation of nonmedical personnel in the community-wide vaccination campaigns needed to achieve herd immunity (Henderson & Petra, 2013). In the same vein, lay animal health workers have also been deployed in the animal health sector, and were key to the success of mass cattle vaccination campaigns leading to the eradication of rinderpest (Mariner *et al.,* 2012).

#### (ii) Reach of lay animal vaccinator programmes

Studies on use of lay animal vaccinators date back to 1982 to 2018; lay vaccinators have been used in both developed and developing countries. These included: Afghanistan (Schreuder & Ward, 2004); Brazil (Belotto, 1988); Canada (Brook *et al.,* 2010); Ethiopia (Admassu *et al.,* 2005; Faris *et al.,* 2012; Mola *et al.,* 2019); Ghana (Mockshell *et al.,* 2014); India and Nepal (Bessell *et al.,* 2017); Kenya (Mugunieri *et al.,* 2004a, 2004b); Malawi (Hüttner *et al.,* 2001; Mgomezulu *et al.,* 2005); Mozambique (Bagnol, 2012; Harrison & Alders, 2010); Uganda (Bugeza *et al.,* 2017; Jost *et al.,* 1998), UK (Cresswell *et al.,* 2014); USA (Middaugh & Ritter, 1982); South Africa (McCrindle *et al.,* 2007); South Sudan (Jones *et al.,* 1998) and Tanzania (Bagnol, 2012; Bessell *et al.,* 2017; DeBruyn *et al.,* 2017; Komba *et al.,* 2012; Makundi *et al.,* 2012). The lay vaccinators were mainly deployed in rural or remote pastoral and agropastoral settings where professional veterinarians were in short supply or completely unavailable.

### (iii) Who deployed the lay animal vaccinators?

Lay vaccinators have been mainly deployed by research projects (Bagnol, 2012; Bessell *et al.*, 2017; Bugeza *et al.*, 2017; De Bruyn *et al.*, 2017; Harrison & Alders, 2010) or non-governmental organizational projects (Cresswell *et al.*, 2014; Faris *et al.*, 2012; Makundi *et al.*, 2012; Mockshell *et al.*, 2014; Mola *et al.*, 2019), with few by governments (Msoffe *et al.*, 2010; Mwakapuja *et al.*, 2012). Community participation was cited in the selection of the lay vaccinators (Bagnol, 2012; Bugeza *et al.*, 2017; Mbyuzi *et al.*, 2012; Mola *et al.*, 2019; Msoffe *et al.*, 2010). The lay animal vaccinators were deployed for reasons including: limited professional veterinary services in under-resourced settings (Faris *et al.*, 2012; Makundi *et al.*, 2012; Mbyuzi *et al.*, 2012; Mockshell *et al.*, 2014; Mola *et al.*, 2019); remoteness which made accessibility to professional services difficult (Bugeza *et al.*, 2017; Faris *et al.*, 2012; Swai *et al.*, 2012); lack of infrastructure to support services of professional veterinarians (Bessell *et al.*, 2017; Brook *et al.*, 2010; Mariner *et al.*, 2012) and the inability of very small-scale farmers to afford the services of professional vets (Bessell *et al.*, 2017; Bugeza *et al.*, 2017).

The literature showed that the deployed lay vaccinators were given training that included knowledge of disease transmission, vaccine administration and storage, farm management practices and practical lessons that were undertaken to supplement the theory (Bessell *et al.*, 2017; De-Bruyn *et al.*, 2017; Kaare *et al.*, 2009; Mgomezulu *et al.*, 2005).

### (iv) The extent of responsibilities assigned to the lay animal vaccinators

The lay vaccinators performed several roles including: administering vaccines to hooved livestock (cattle, camel, goat and sheep) against a range of diseases, such as anthrax, blackleg, contagious bovine pleuropneumonia, contagious caprine pleuropneumonia, peste des petits ruminants, hemorrhagic septicemia, lumpy skin disease, pasteurellosis and rinderpest (Bugeza *et al.*, 2017; Cresswell *et al.*, 2014; Makundi *et al.*, 2012; Mockshell *et al.*, 2014; Mola *et al.*, 2019); poultry against Newcastle Disease (ND) (Bagnol, 2012; Bessell *et al.*, 2017; De Bruyn *et al.*, 2017; Mbyuzi *et al.*, 2012; Mwakapuja *et al.*, 2012) and dogs against canine distemper virus, canine parvovirus and rabies (Belotto, 1988; Brook *et al.*, 2010; Kaare *et al.*, 2009; Middaugh & Ritter, 1982).

The vaccines administered by the lay vaccinators included: thermotolerant ND vaccine strains (Bagnol, 2012; Bessell *et al.*, 2017; De-Bruyn *et al.*, 2017; Mbyuzi *et al.*, 2012; Mwakapuja *et al.*, 2012); Thermovax rinderpest vaccine (Jones *et al.*, 1998; Jost *et al.*, 1998; Mariner *et al.*,

2012); attenuated homologous PPR virus (Nigeria 75/1) strain vaccine (Faris *et al.,* 2012); β-propiolactone activated suckling mouse brain vaccine for rabies (Belotto, 1988) and Nobivac Rabies and Puppy Distemper vaccines (against rabies, canine distemper virus and canine parvovirus) (Kaare *et al.,* 2009). Apart from vaccinating, lay animal vaccinators were also reported to have played other roles, including encouragement of responsible dog ownership and management as part of dog population control measures (Brook *et al.,* 2010), sensitization and awareness raising of animal health programmes (Bessell *et al.,* 2017; Brook *et al.,* 2010), and as general advisors to farmers regarding animal health (Hüttner *et al.,* 2001).

**(v) Effectiveness and other benefits of lay animal vaccinator programmes**

Positive outcomes were generally reported for the lay animal vaccinator programmes in the contexts where they were used. These included: increased flock and herd sizes and improved farmer knowledge of best farm management practice, with contributions to improved livelihoods and farmer assurance in animal assets (De-Bruyn *et al.,* 2017; Harrison & Alders, 2010; Jones *et al.,* 1998; Mariner *et al.,* 2012; Mugunieri *et al.,* 2004b). Some studies also reported decreased disease transmission and outbreaks, reduced mortality among vaccinated animal populations and prevention of zoonotic diseases among herds (Admassu *et al.,* 2005; Hüttner *et al.,* 2001; Jones *et al.,* 1998; Mbyuzi *et al.,* 2012; Mola *et al.,* 2019). Vaccination coverage achieved the lay vaccinator programmes was comparable to those achieved by professional-led programmes (Belotto, 1988; Bessell *et al.,* 2017; Kaare *et al.,* 2009; Komba *et al.,* 2012). Studies that compared sero-conversion and birth rates among herds vaccinated by lay vaccinators versus those vaccinated by professional veterinarians reported no significant differences (Faris *et al.,* 2012; Jones *et al.,* 1998; Mugunieri *et al.,* 2004b).

**(vi) Facilitating factors of lay animal vaccinator programmes**

Several contributory factors were cited for the success of lay animal vaccinator programmes. These included the opportunity for communities to participate in the selection of vaccinators, and in the delivery and monitoring of the interventions (Belotto, 1988; McCrindle *et al.,* 2007; Mola *et al.,* 2019; Nalitolela & Allport, 2002; Schreuder & Ward, 2004); public support (Brook *et al.,* 2010; Cresswell *et al.,* 2014; Middaugh & Ritter, 1982; Mugunieri *et al.,* 2004a; Swai *et al.,* 2012); comprehensive training of livestock keepers, community leaders and vaccinators (Faris *et al.,* 2012; Jost *et al.,* 1998; Kaare *et al.,* 2009; Msoffe *et al.,* 2010; Nalitolela & Allport, 2002); ethno-veterinary knowledge of the lay vaccinators (Admassu *et al.,* 2005; Jost *et al.,*

1998; Makundi *et al.,* 2012; Mariner *et al.,* 2012); satisfactory compensation for the vaccinators (Bagnol, 2012; Jones *et al.*, 1998; Kaare *et al.,* 2009; Schreuder & Ward, 2004), heightened awareness of the programmes amongst beneficiary livestock keepers (Belotto, 1988; De Bruyn *et al.,* 2017) and relative affordability of the services provided (Jost *et al.,* 1998; McCrindle *et al.,* 2007; Nalitolela & Allport, 2002).

The lay vaccinators were also cited to be relatively more accessible, more trusted, more flexible, and more familiar with local terrains compared to professional veterinarians, which enabled them to deliver the interventions in varying socioeconomic contexts (Mariner *et al.,* 2012; McCrindle *et al.,* 2007). The development of thermostable or thermotolerant vaccines was also cited to have made it possible for the lay vaccinators to use these vaccines outside of cold-chain systems (Cresswell *et al.,* 2014; Mbyuzi *et al.,* 2012; Mockshell *et al.,* 2014; Mugunieri *et al.,* 2004b; Nalitolela & Allport, 2002).

**(vii) Challenges of lay animal vaccinator programmes**

The most frequently cited challenge faced by lay vaccinator programmes was lack of legalized institutional support for the programmes (Belotto, 1988; Bugeza *et al.,* 2017; Jones *et al.,* 1998; Nalitolela & Allport, 2002). Competing financial interests of vaccinators and community leaders was also cited to have derailed success of the programmes. For instance, in some programmes, community leaders criticized financial arrangements where vaccinators autonomously collected fees from farmers for their services, and some village leaders also complained that only the vaccinators went to training and received per diems, T-shirts and caps. On the other hand, some vaccinators and farmers were also unhappy where village authorities placed tax on birds vaccinated in the programme. It was reported that vaccinators who received remuneration per bird vaccinated tended to focus on households with larger flock sizes (Bagnol, 2012; De-Bruyn *et al.,* 2017; Martin Curran & MacLehose, 2002; McCrindle *et al.,* 2007; Mugunieri *et al.,* 2004b).

Another challenge faced by lay vaccinators was opposition from professional veterinarians. This was on the grounds of poor performance, and low levels of professionalism, technical capabilities and effectiveness (Admassu *et al.,* 2005; Cresswell *et al.,* 2014; Faris *et al.,* 2012; Mockshell *et al.,* 2014). In some cases, there was inadequate engagement between implementing organizations and local professional veterinarians, eliciting opposition to the programmes (Bagnol, 2012; Bugeza *et al.,* 2017; Jones *et al.,* 1998). Sometimes farmers

mistrusted and did not readily accept the services of lay vaccinators, for example fearing they were providing information about their herds to governments for the purposes of taxation (Brook *et al.,* 2010; Bugeza *et al.,* 2017; Jones *et al.,* 1998).

### (viii) Integration of lay animal vaccinator programmes into veterinary systems

Our review of the literature did not find any legally integrated lay vaccinator programme in a LMIC. The review found records of legalized and integrated policy instruments for lay vaccinator programmes that prescribe the selection processes, minimum training, certification and monitoring for the northern territories for Canada, the UK and the USA (Brook *et al.,* 2010; Cresswell *et al.,* 2014; Middaugh & Ritter, 1982; Mockshell *et al.,* 2014).

### (ix) Decentralization of (planning & implementation) mass dog vaccination

The feasibility of storing the Nobivac® rabies vaccine in low-tech passive cooling devices (Lankester *et al.,* 2016; Lugelo *et al.,* 2020) and delivery by lay vaccinators (Kaare *et al.,* 2009) supports the possibility of decentralizing the delivery of mass dog vaccination campaigns to ward and villages levels. Lessons from the participation of community-based personnel in the eradication of smallpox (Henderson & Petra, 2013), rinderpest (Mariner *et al.,* 2012), the global initiative for polio eradication (United Nations International Children's Emergency Fund - Afghanistan, 2015) and community-wide participation in the delivery of mass drug administrations against diseases amenable to chemotherapy (Amazigo *et al.,* 2021; Lemoine *et al.,* 2016; Richards *et al.,* 2011; The Cummuty-Directed Interventions Study Group, 2010; World Health Organisation & African Program for Onchocercisis Control, 2010; World Health Organization & African Program for Onchocerciasis Control, 2012), demonstrate the feasibility of decentralizing mass dog vaccination campaigns to community levels. Decentralized health campaigns were successful where there were institutional support (Anyiam *et al.,* 2017). Government and the veterinary system's support for decentralized mass dog vaccination strategies will be important for their successful implementation.

## 2.8 Process Evaluation of Interventions

Process evaluation focuses on details of activities performed during implementation of an intervention in order to answer questions relating to the feasibility of delivering the intervention strategies, what initiated variation in the way the intervention was supposed to be implanted and how the design can be improved (Skivington *et al.,* 2021). New and complex interventions

usually undergo substantial modifications when rolled out in the field or implemented in different settings (George *et al.,* 2022; Moore *et al.,* 2014). So process evaluation is important in capturing what is delivered in practice, with close reference to the theory of change of the intervention, to enable the distinction between adaptations to make the intervention fit different contexts and changes that undermine fidelity, and reasons for varying the implementation protocol (Moore *et al.,* 2014). Process evaluation also explores contextual factors that shape implementation or are shaped by the intervention, leading to an understanding of which components of the intervention work and for whom and under what context situations (Moore *et al.,* 2014; Steckler & Linnan, 2002).

The CBC-MDV is a complex intervention, with several interacting components such as the involvement of local veterinary authorities and communities, local storage of dog rabies vaccines outside of the cold chain system, and a continuous approach to dog vaccine delivery. Consequently, the implementation of the intervention may not be feasible as planned or may work differently depending on it is delivery or how it was impacted contextual factors. Process evaluation would therefore be useful in generating evidence regarding the feasibility of implementation, scale-up, replication and normalization CBC-MDV in different settings (Glanzs, 2008; Glasgow, 2006; Moore *et al.,* 2014; Skivington *et al.,* 2021).

## 2.9 Disseminating/Replicating, Normalizing and Sustaining New Interventions in Practice

Though an intervention can perform well when rolled out in one setting, it might not work well or attain similar level of success when disseminated in other settings that differ in terms of socioeconomic and geophysical environments (Funnell & Rogers, 2011; Glasgow, 2006; Skivington *et al.,* 2021). This calls for a need to study the implantation process in order to generate insights to guide replicating the implementation of the intervention under varying contextual situations. Also, the normalization of new interventions into routine practice has been shown to be influenced by many factors including: level of involvement of intervention managers and key people in design and delivery, whether implementers have good knowledge of the intervention and skills sets, organizational support and resources needed to deliver it (Drew *et al.,* 2015; Fredriksen *et al.,* 2021; Holtrop *et al.,* 2016); interpersonal relationships among key stakeholders and clear communication of intervention values and benefits (Asiedu *et al.,* 2019). At the design and feasibility testing stages, it was not clear what could influence normalizing and sustaining CBC-MDV in practice as the new approach for delivering MDV

campaigns within the context of communities and the veterinary system of Tanzania. The normalization process theory provides a robust methodological framework for measuring the likelihood that a new intervention would be adopted into routine practice (Gillespie *et al.*, 2018), which we applied to explore if CBC-MDV will be normalized in Tanzania and what would determine that.

# CHAPTER THREE

# MATERIALS AND METHODS

To address the four research questions, a process evaluation embedded in a pilot trial and community engagement activities evaluated with a mixed method before and after design, was conducted. Overall, the study took two years.

## 3.1 Study Settings

### 3.1.1 The Pilot Trials

The CBC-MDV was developed to be delivered in rural Tanzania and was piloted in three districts Rorya, Tarime and Butiama, of the Mara region, in north-west Tanzania between Lake Victoria and Kenya. The Mara regions was chosen for this study because it is one of the regions with high dog populations in the country. Also, because it shares borders with the Serengeti National Park, studying how mass dog vaccination delivery strategies should be implemented here presents an opportunity for understanding the impact of controlling rabies in domestic dogs on rabies in wildlife. This area is home to several ethnic groups who are primarily engaged in agro-pastoral and fishing activities. Dog ownership is common with larger households and those having livestock tending to own more dogs (Knobel *et al.,* 2008; Sambo *et al.,* 2014; Sikana *et al.,* 2021). The pilot phase included 12 wards, four from each district (three delivered the CBC-MDV strategies and one delivered the pulse). Wards are clusters of 3-4 villages; villages are divided into sub-villages; the number of subvillages per village ranged from 2 to 13 in our study area. Subvillages comprise approximately 70 – 100 households, which are grouped into units of 10 households and headed by leaders called “mabalozi”. The study wards were appreciably separated geographically and culturally.

### 3.1.2 The Community Engagement

The community engagement activities were conducted in two wards, Kyangasaga (comprising Gabimori and Kyangasanga villages) and Kwihancha (comprising Gibaso, Karakatonga, and Nyabilongo villages) of Rorya and Tarime districts respectively. At the time of this study, there was no regular mass dog vaccination in Kyangasaga ward, whereas dog vaccination had been conducted annually since 2003 in Kwihancha ward by the Serengeti Health Initiative (Minyoo *et al.,* 2015a). Figure 2 shows the map of the study area.

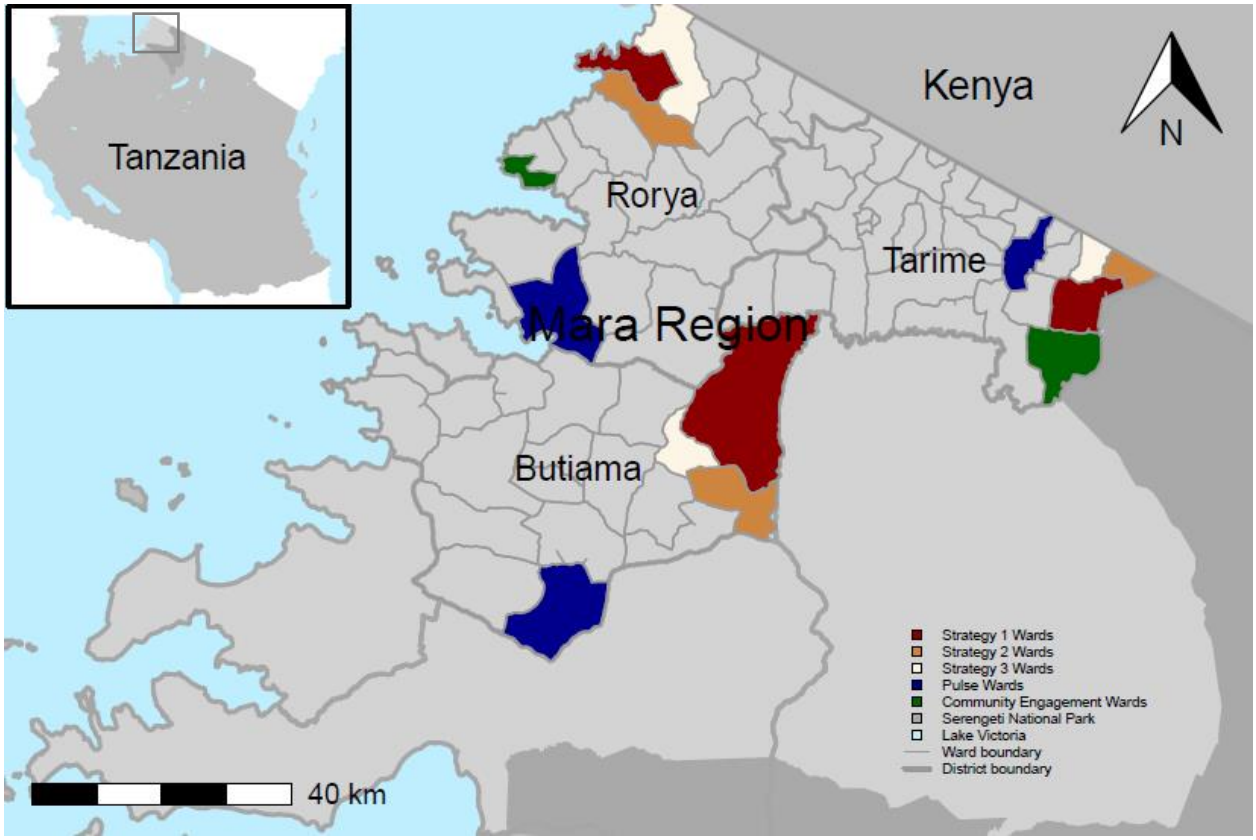


**Figure 2: Map of study area, showing Mara region, study districts and wards**

## 3.2 Methods and Study Designs

### 3.2.1 Methodology

To answer objectives 1, 3 and 4, a cross-sectional study nested in a prospective design was employed in a process evaluation which followed the implementation of CBC-MDV through its development, implementation and pilot-evaluation phases and data were collected at month 1, 6 and 12 using mixed methods, including: a) non-participant observations, b) Conversational interviews (focus group discussions – FGDs and in-depth interviews – IDIs), c) meeting/ workshop reports, d) implementation audits and e) household surveys. Community engagement activities were conducted and evaluated using a mixed method before and after design to answer specific objective two.

## 3.3 Design of the Pilot Trial – Specific Objective One

The community-based continuous approach is new in the area of mass dog vaccination. It was planned to test the feasibility of delivering three versions (strategies) of its design. Nine (9) wards, three from each district, were assigned to receive dog vaccination by one of the

strategies of the community-based approach. Then, three wards, one from each of the districts were assigned to receive dog vaccination by the pulse (government team-delivered) strategy. Vaccination coverage was measured at month 1 and month 11 to evaluate which of the four strategies maintain coverage above the minimum threshold of 40%. Figure 3 illustrates the design of the pilot trial.

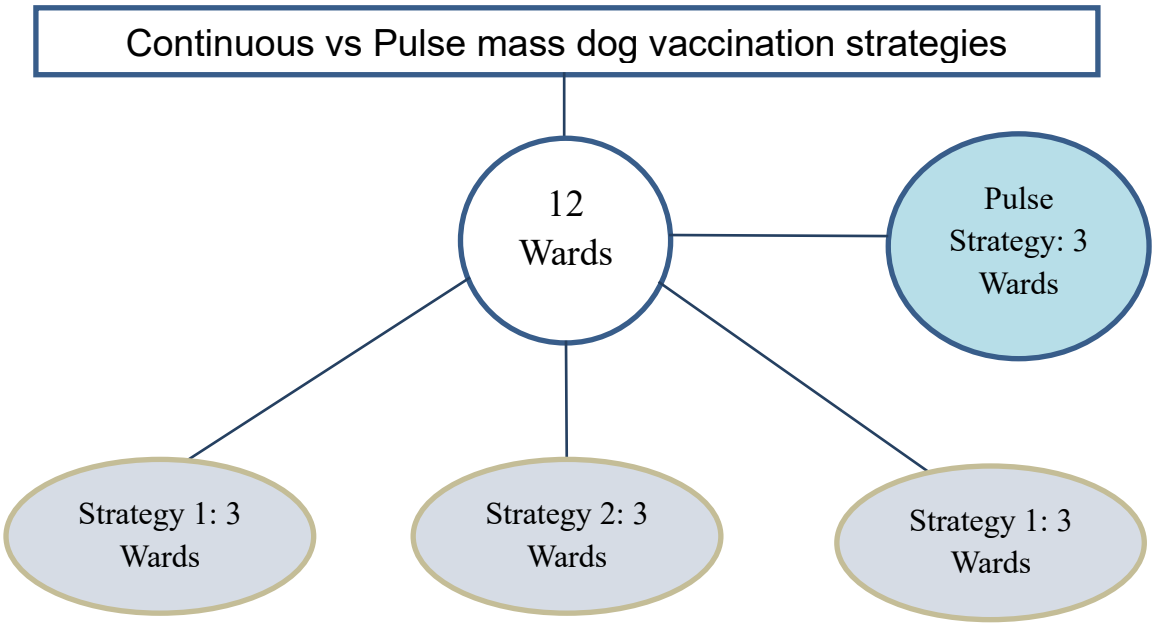


**Figure 3: Design pilot trial of continuous vs pulse dog vaccination strategies**

### 3.4 Design of the Process Evaluation

The design of CBC-MDV was guided by the UK Medical Research Council Guidance on developing and evaluating complex interventions prior to a full-scale evaluation. The guide outlines a systematic, two-stage approach: a) evidence-based development of components of CBC-MDV and b) field testing of feasibility of delivering components, to intervention development (Skivington *et al.*, 2021). Figure 4 provides a schematic overview of the processes involved in developing and testing CBC-MDV.

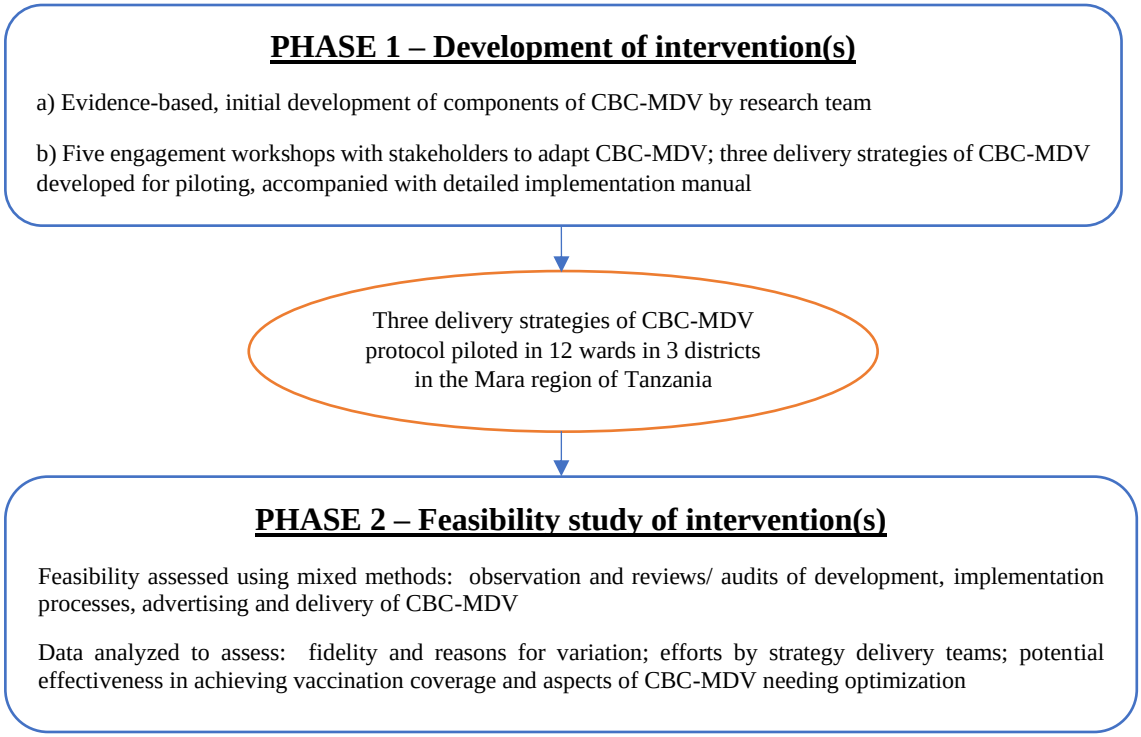


**Figure 4: Development and feasibility testing processes for community-based continuous mass dog vaccination prior to full-scale evaluation**

### 3.4.1 Development of Components of Community-Based Continuos Mass Dog Vaccination

Evidence on barriers to a centralized, team-delivered dog vaccination approach (as laid out in the introduction), the feasibility of storing the Nobivac Rabies Vaccine in locally made passive cooling devices (Lankester *et al.,* 2016; Lugelo *et al.,* 2020) and the ability of community-based persons to vaccinate dogs (Kaare *et al.,* 2009) provided the context for developing initial components of CBC-MDV.

The initial design was discussed with potential stakeholders in the Mara region (where a large-scale randomized controlled trial (RCT) is proposed to take place following on from this pilot study) and subsequently with national level veterinary officials and international experts, with workshops taking place between May 2018 and May 2019. Table 1 describes the stakeholder groups involved and aim of each workshop.

**Table 1: Stakeholder groups, purpose and date of engagement workshops**

| S/N | Stakeholder Group | Purpose of Workshop | Dates; Venue |
|---|---|---|---|
| 1. | National Level Veterinary Officials, Mara Regional Medical and Veterinary Officers, District Medical and Veterinary Officers, Nurses and Livestock Field Officers plus research staff | To introduce national veterinary officials and Mara region stakeholders to potential CBC-MDV strategies | 23-26 May, 2018;<br><br>Mugumu – Serengeti |
| 2. | Veterinary technical staff from Ministry of Livestock and Fisheries Development, community health specialist from World Health Organization – Tanzania country office, the Mara Regional Medical Officer, representatives from Ministry of Health and Tanzanian One Health Coordination Unit plus research staff. | To share evidence for the safety of use of locally made passive cooling devices to store vaccines & non-animal health professionals to vaccinate dogs and to demonstrate that the research evidence was strong enough for local use. | 17- 18 July, 2018;<br><br>The Prime Minister's Office – Dar es Salaam |
| 3. | Three Rabies Researchers from Global Animal Health – Tanzania, Director of Veterinary Services and Registrar of Tanzanian Veterinary Council | To provide the outcome of Workshop 2, and to share evidence of use of locally made passive cooling devices to store vaccines & non-animal health professionals to vaccinate dogs | 17th November, 2018;<br><br>Office of Director of Veterinary Services – Dodoma |
| 4. | Researchers from Washington State University (5), University of Glasgow (5), Global Animal Health – Tanzania (6), Director of Veterinary Services, Chairman and Registrar of Tanzania Veterinary Council, President of Tanzania Veterinary Association, representatives from Ministry of Health and One Health Coordination Unit | To finalize design of CBC-MDV for the pilot study, define roles of district, ward and village level implementers and to launch the research project | 22nd – 23rd Mar, 2019;<br><br>Arusha. |
| 5. | Mara Regional Commissioner and Administrative Secretary, Researchers from Global Animal Health – Tanzania (6), Director of Veterinary Services, Chairman and Registrar of Tanzania Veterinary Council, President of Tanzania Veterinary Association, Mara Regional Medical and Veterinary Officers, District Medical and Veterinary Officers, Nurses and Livestock Field Officers | To bring the research team and human and animal health staff of the Mara region together, to outline logistical needs for implementing CBC-MDV and to declare the research a learning project to inform national mass dog vaccination strategies for Tanzania | 7th – 8th May, 2019;<br><br>Office of the Mara Regional Commissioner |

The PhD student participated in and made notes (11 observation days) of all the workshops, and documented stakeholders' opinions and concerns of CBC-MDV, specifically: how vaccines will be stored outside of the cold chain system in wards using locally made passive cooling devices, the level of training required to vaccinate dogs, local involvement in implementation and roles of district-, ward- and village-level implementers. The research team met after each workshop to revise the components of CBC-MDV.

Following the final workshop, the research team developed a theory of change model and a manual to guide implementers (district livestock field officers - DLFOs, ward-based rabies coordinators – RCs and village-based one-health champions – OHCs) in delivering the CBC-MDV components. To identify the most efficient approach to delivering the components, three delivery strategies of CBC-MDV were designed to be piloted. The DLFOs and RCs were those in charge of the targeted districts and wards respectively, were automatically included in the study, whilst the OHC positions were advertised at the villages and they were selected based on qualification.

### 3.4.2 Feasibility of Delivering the Components of Community-Based Contiuous Mass Dog Vaccination

The three delivery strategies of CBC-MDV were piloted over a 12-month period and evaluated using mixed methods and the outcomes compared to that of the pulse (annual team-delivered) approach. Table 2 summarizes which methods were used to assess the feasibility and potential effectiveness of the delivery strategies as well as to formulate lessons learned.

**Table 2: Summary of research methods used to assess the feasibility of delivering community-based continuous mass dog vaccination, potential effectiveness and formulate lessons learnt**

| The aspect of CBC-MDV delivery assessed | Method | Data |
|---|---|---|
| Feasibility of delivery<br>(i) Fidelity to protocol | Observation of advertising of vaccination clinics and delivery of CBC-MDV components to assess which were delivered as intended or varied | 36 days of observation (6/55 advertising days, 30/235 delivery days) |
| (ii) Reasons for resultant variation in the delivery of CBC-MDV<br>(iii) Efforts required to deliver each strategy | Interviews with those responsible for aspects of the delivery of CBC-MDV to audit the implementation process and to capture what was delivered and the reasons for variation | All 47 implementers at month 1 and repeated at month 6 |
| Potential effectiveness<br>Vaccination coverage of the CBC-MDV delivery strategies compared with pulsed delivery | Household surveys | 1,386 and 1,445 households from 47 villages surveyed at month 1 and 11 respectively |
| Lessons for optimization and replication | Feedback and appraisal meetings of the research team examining the delivery processes and exploring feasible and effective alternative approaches | 24 fortnightly meetings; from July 2019 to June 2020 |

### 3.4.3 Assessing Fidelity, Variation and Efforts

To assess the fidelity of the implementation process during phase 2 of the development process and the reasons for variation in delivering CBC-MDV, we conducted observations on advertising (6/55 days) and delivery of vaccination campaigns (30/235 days) noting whether implementers delivered components of CBC-MDV as planned and factors responsible for the variation.

We audited delivery of CBC-MDV using semi-structured interviews with implementers (one with each of the 47 implementers) about aspects of delivery of campaigns and how vaccines were managed at district veterinary offices and wards, and installation and maintenance of locally made passive cooling devices and their temperature loggers within wards. Notes were taken on which components of CBC-MDV were delivered as planned and on potential reasons for variation. The audits were carried out early in the delivery of CBC-MDV at month 1 and repeated at month 6 and 12.

We used observation and audit data to assess and compare efforts required for each of the CBC-MDV strategies and the fidelity of their delivery.

### 3.4.4 Assessing Potential Effectiveness

When dogs were vaccinated owners were given a vaccination certificate and dogs were microchipped. To assess how the strategies performed with respect to vaccination coverage, random samples of households (Table 2) were surveyed in each village, scanning dogs for a microchip and inspecting vaccination certificates. If neither the dog nor the certificate could be found, we asked household members whether their dog(s) had been vaccinated. The surveys were conducted at month 1 and 11 after roll out of CBC-MDV.

### 3.4.5 Barriers to and Drivers of Innovation During Mass Dog Vaccination Campaigns

During the vaccination clinics, we looked for situations that were barriers or drivers of innovation in the implementation process: the amount of time spent by dog owners, number of animals brought by the dog owner, number of dogs vaccinated on the day and vaccination approaches used were documented quantitatively. To measure the amount of time spent by each dog owner at the vaccination center, one of the data collectors was assigned to hand numbered cards to dog owners as soon as they arrived and recorded the time at which they arrive; the cards were collected as soon as the dog owner is done and the time recorded. The time spent was obtained by subtracting the arrival time from the departure time. We also documented if a dog struggled during inoculation process and if that varies with age of the dog owner, number of dogs vaccinated on the day and how the dog was restrained.

### 3.4.6 Lessons for Optimization and Replication

To optimize CBC-MDV, the research team reviewed the observation and audit data on the delivery process through fortnightly feedback and appraisal meetings to identify components of CBC-MDV that were not working and designed alternative approaches. The team also identified best practices by implementers and components of CBC-MDV that were context sensitive.

## 3.5 Design of the Community Engagement – Specific Objective Two

Community engagements were conducted in two wards of the Mara region to learn about the population’s perceptions of impact of vaccination on dogs, to engage the population on dog

handling at home and during vaccination and involved the leadership of one of the wards in planning a demonstration vaccination. A participatory approach was employed in the design and delivery of engagement activities, and a mixed method, before-and-after approach was embedded to evaluate the impact of engagement activities on perception of impact of dog vaccines, dog handling and feasibility of involving village leadership in planning and implementing mass dog vaccination campaigns.

### 3.5.1 Community Engagement Activities

#### (i) Training and community engagement content development workshops

The engagement activities were conducted from January to June 2020. A team of eight members delivered the engagement activities. This team included: a research officer from Nelson Mandela African Institution of Science and Technology (the PhD student) specializing in process evaluation of complex interventions, five field researchers including one livestock field officer, one police dog trainer, three community development experts with experience in field data collection, and two community informants. The team was trained on the concepts of community engagement by CTD and on how to use Open Data Kit (ODK) to collect data by a data scientist from Ifakara Health Institute during a 5-days workshop. The concepts of community engagement on which the team was trained were: community engagement as a process co-authored with communities, effective community entry, facilitation of group-based participatory processes, community ownership of solutions to local problems (rabies), community empowerment through partnerships and ownerships, and the difference between community engagement and sensitization/ education. The team then worked together and developed the content of the engagement activities including posters, leaflets, flipcharts, videos and data collection tools in ODK. The engagement materials were developed with reference to the expert literature, online videos, text, images and international guides on recommended dog handling practices (Appendix 5a-e).

#### (ii) Implementation of the community engagement

Four introduction meetings were held, two each with leaders of the two targeted wards. At the first meetings the purpose and activities of the community engagement events were discussed and support was sought for the engagement activities. This was followed by another meeting between the research team and leaders of the two wards to schedule the activities for their villages.

The activities carried out included: a) sub-village level/ school-based forums on dog behavior, dog handling and dog vaccination, where the research team solicited the views of the community members and school children, and shared information using flip charts and short videos; b) dog handling demonstrations by owners and vaccinators; and c) distribution of posters and leaflets (on dog behavior, dog handling, rabies and dog vaccination) to households included in the baseline survey across the two wards. The engagement with the materials and attendance at a community forum were expected to increase knowledge about dog behavior/ body language interpretation, how to restrain dogs and safe ways to interact with dogs, with an eventual increase in participation in vaccination campaigns.

**(iii) Involvement of village leadership in vaccination campaigns**

The research team, three members from Rorya district veterinary office, and 13 leaders of Kyangasaga wards (where dog vaccination campaigns had not been happening at the time of engagement) had a community-based meeting, lasting three and a half hours to plan a community-led mass dog vaccination campaign. The meeting had three agenda items: first, participants discussed the effects of rabies in their communities; second, participants identified and discussed key activities/ steps in organizing mass dog vaccination campaigns and third, participants identified key stakeholders in organizing mass dog vaccination and assigned roles to these stakeholders for the planned mass dog vaccination campaigns. This meeting was followed up with a community-led mass dog vaccination exercise after three months to demonstrate the actual performance of assigned roles. An observation was carried out on the vaccination exercise to identify factors that facilitated or impeded involvement of community leadership in the vaccination activities. All activities were conducted in Kiswahili, the local language, and data were later translated into English.

**(iv) Engagement activities and participants involved**

Seven sub-village-level, plus three school-based (2 secondary and 1 primary) meetings, two dog handling demonstration sessions and four meetings with village leadership were held. Altogether, 2903 people participated in the engagement activities, including: 24 community leaders, 16 teachers and 729 students/ pupils. Eight hundred and twenty-six (826) people were reached with 2000 posters and 1000 leaflets in 375 households. Four hundred and seventy-eight (478) and 805 community members were reached through sub-village level forums and video screenings respectively. Nine (9) people who were dog handlers during vaccination

campaigns and 16 dog owners participated in the dog handling demonstrations. Further details on participation in the various engagement activities are provided in Appendix 4.

### 3.5.2 Evaluation of the Impact of Engagement Activities

#### (i) Household survey

Sampling: The effect of engagement activities was evaluated using before and after design, with households (randomly selected) surveys. The survey was piloted with 50 respondents in a nearby ward with a similar demographic profile.

***Measurements***

Baseline: data was collected on the demographic profile of participants, dog ownership, participants' knowledge of dog behavior, of dog handling and of safe ways of interacting with dogs, using a structured questionnaire with participant-self-rated and interviewer-rated responses.

Knowledge was measured in three areas:

(a) Dog behavior – assessed through the ability to correctly interpret dog body language with 21 questions (accompanied with pictures showing dogs behaving in different ways). The interviewers then compared their answers to recommended interpretations.

(b) Dog handling -assessed through ability to restrain at home, how to calm down a dog and recommended ways of holding big and small dogs during vaccination. participants were asked to describe these activities, the interviewers then compared their answers to recommended practice and rated their answers as 'not correct', 'partially correct' or 'correct'.

(c) Safe ways of interacting with dogs – assessed through knowledge of how to avoid dog attacks (11 questions) and how to limit injury in case of attack (five questions). Participants were asked to enumerate and explain ways to avoid dog attacks or limit injury when attacked, the interviewers then compared their responses to recommended steps.

To score answers in measuring knowledge of dog behavior and safe ways of interacting with dogs, a binary scale of 0 (for not the correct answer) and 1 (for a correct answer) was applied (Duamor *et al.,* 2017; Mburu *et al.,* 2021). Correct answers were defined as one that conforms

with what is generally recommended by expert literature (Appendix 5a-e). The interviewers were trained on these and had the information to hand for reference where necessary.

Follow up survey: Households were revisited three months after the baseline survey and engagement activities and the questionnaire repeated with respondents from the same households (n=728 respondents). Additionally, respondents were asked through which medium of information (poster, leaflet, engagement activity) they received information on dog behavior and handling, and through which of them they were most informed on the topic.

**(ii) Coverage estimation of the demonstration vaccination**

Sub-village chairpersons went house-to-house to count the number of dogs in each household before the start of the vaccination exercise. The number of dogs vaccinated in each sub-village was recorded in a register. Vaccination coverage was expressed as percentage of dogs in the sub-village that were vaccinated.

**(iii) Focus group discussions**

Perceptions of the impact of dog vaccination, knowledge of dog behavior, knowledge of dog handling and knowledge of safe ways of interacting with dogs were further explored through focus group discussions (FGD). Four FGD (two per ward) were held after engagement activities, with participants purposively selected to ensure there was equal gender and community representation. Each FGD included 9 people, and was conducted separately for young people (below 20 years of age) and adults of both genders, this was to ensure the young people were able to express themselves without fear. Discussions were conducted in Kiswahili by members of the research team who were experienced interviewers, using topic guides. Discussions lasted about 40 minutes each and were recorded with an Olympus VN-541PC voice recorder. The PhD student took summary notes during the discussions. Informed consent was obtained from all respondents or their guardians.

**(iv) Observations and meeting reports**

We conducted participant observation of all engagement sessions, recorded using field notes written by PhD student to consider further insights into societal underpinnings of perception of and participation in dog vaccination, and dog handling.

***Involvement of village leadership in vaccination campaigns***

Participant observation of all meetings and activities together with formal reports on meetings were used to assess the feasibility of involving community leadership in mass dog vaccination. The performance of roles assigned to the key stakeholder groups and factors that influenced the involvement of community leadership were observed and documented during the vaccination exercise. These observations were recorded using a structured (qualitative) proforma (Appendix 8).

## 3.6 Design of the Normalization Evaluation – Specific Objective Three

To understand factors that will influence normalization of a community-based continuous approach data from the process evaluation were collected and analysed using normalization process theory (NPT) to qualitatively explored feasibility of its integration and routinization as the new standard approach for delivering mass dog vaccination in Tanzania. The NPT framework employs four constructs to describe determinants of routinization of new complex interventions into practice. These are: a) implementers' understanding of the new intervention, b) their willingness to engage with it, c) their ability to deliver it collectively including having sufficient resources for delivery and d) their ability to appraise and amend the intervention in the course of implementation (Finch, 2013). The data were analyzed within the framework of the NPT, with themes derived from the constructs (Table 3).

**Table 3: The definitions of constructs of the normalization process theory**

| COHERENCE<br>**(Understanding of the new intervention)** | COGNITIVE PARTICIPATION<br>**(Willingness to engage with it)** | COLLECTIVE ACTION<br>**(Ability and resources to deliver it)** | REFLEXIVE MONITORING<br>**(Ability to appraise and amend)** |
|---|---|---|---|
| Differentiation | **Enrollment** | **Skill set workability** | **Reconfiguration** |
| **Do stakeholders see a difference between new vs current approach?** | Are stakeholders willing to invest time and energy into it? | Are implementers able to deliver the new approach? | Can stakeholders amend the new approach, based on experience? |
| Communal Specification | **Activation** | **Contextual integration** | **Communal appraisal** |
| **Is there shared understanding of aims, objectives and benefits of the new approach?** | Are stakeholders able to define activities and work needed to sustain the new approach? | Is the new approach supported by local policy and resources? | Can stakeholders collectively assess effectiveness and benefits of the new approach? |
| Individual Specification | **Initiation** | **Interactional workability**<br>Does the new approach make completion of routine tasks easy? | **Individual appraisal** |
| **Are individual tasks and responsibilities understood?** | Are stakeholders willing and able to get others involved? | | Can implementers assess impact of the new approach on them and their roles? |
| Internalization | **Legitimation** | **Relational integration** | **Systematization** |
| **Are the values, benefits and importance of the new approach appreciated?** | Do stakeholders believe that they should be involved in delivery of the new approach? | Do stakeholders trust the new approach and implementers? | Can stakeholders judge effectiveness and/or success of the new approach? |

## 3.7 Assessing Ownership and Sustainability of Community-Based Continuous Mass Dog Vaccination – Specific Objective Four

Community ownership refers to the act or degree of responsibility taken by the community towards programs activities (Sarriot & Shaar, 2020). To assess likelihood of ownership and sustainability of CBC-MDV, the delivery process in terms of community involvement, continuity in delivering components of CBC-MDV, number of days spent on vaccination campaigns and outputs of campaigns; were evaluated over the first two-year period.

## 3.8 Sample Size Determinations

### 3.8.1 Observations, Conversational Interviews and Meeting/ Workshop Reports

Qualitative data were collected based on the principle of saturation. The number of qualitative data points needed to achieve saturation, that is to observe any existing pattern, is estimated to be 4-8 and 9-17 for FGDs and IDIs respectively (Hennink & Kaiser, 2022).

### 3.8.2 Implementation audits

All 47 implementers were interviewed using semi-structured questionnaires to review components and activities of the intervention were delivered at district-, ward- and village-levels.

### 3.8.3 Household Survey for Community Engagement

The number of household individuals to interview during the survey was determined using the one-sample proportion approach, obtainable using the formula:

$$N = \frac{\mathbf{Z^2 * P * (1 - P)}}{\mathbf{d^2}}$$

Z = 1.96 at 95% confidence interval,

d = precision (0.05) i.e within 5% points (90%) confidence,

p = Anticipated level of vaccination coverage = 0.7 (70%).

$N = \frac{3.8416*0.21}{0.0025} = \frac{0.806736}{0.0025}$ 322.6944 + (10% of 322.6944) ≈ 355 individuals, taking into account non-responsiveness during the follow up survey * 2 wards = 710 individuals.

## 3.9 Study Population and Eligibility Criteria

### 3.9.1 Study Population

#### (i) Observations, Conversational Interviews and Meeting/Workshop Reports

Observations were conducted on the development workshops of CBC-MDV. Participants in the development workshops included: Mara regional Commissioner and Administrative Secretary, Mara regional and district Medical and Veterinary Officers, Nurses and Livestock Field Officers, Veterinary technical staff from the Ministry of Livestock and Fisheries Development of Tanzania, community health specialists from World Health Organization –

Tanzania country office, representatives from Ministry of Health and Tanzanian One Health Coordination Unit, Director of Veterinary Services and Registrar of Tanzanian Veterinary Council, Chairman of Tanzania Veterinary Council, President of Tanzania Veterinary Association, five rabies researchers from Washington State University, five rabies researchers from University of Glasgow, 2 research staff from Global Animal Health – Tanzania and 4 PhD students on the project.

Observations were also conducted on the training of implementers (three district livestock field officers – DLFOs, nine ward livestock field officers – LFOs and 35 village-based one health champions – OHCs) and implementation processes of the mass dog vaccination campaigns. In total, 157 hours of non-participant observations, spanning a period of two years during development and rollout of CBC-MDV, were conducted by the PhD student using a semi-structured proforma.

Twenty-four in-depth interviews were conducted with 3 district livestock field officers (DLFOs), 7 rabies coordinators (RCs), 8 one health champions (OHCs) and 6 community leaders. The OHCs and community leaders who participated in the in-depth interviews were purposively selected considering equal representation from each of the study wards across the three districts. Sixteen focus group discussions (FGD), 12 on implementation of CBC-MDV and 4 during the community engagement were conducted: three with the implementers (9 RCs and 35 OHCs), 3 with 35 community leaders across the three districts, and 10 with 90 community members composing of both genders, and young and old persons. Participants in the FGDs were purposively selected across the 35 villages, considering fair representation of leadership, age group and gender.

The interviews were conducted 12 months after rollout of CBC-MDV between December 2019 and July 2020. The interviews were conducted using topic guides (based on the NPT constructs), in Kiswahili, by experienced interviewer, in-person and after consent was obtained. The interviews lasted 18 - 65 minutes on average and were recorded with Olympus VN-541PC voice recorder.

**(ii) Implementation audits**

The implementation of CBC-MDV components, installation of low-tech passive cooling devices and their temperature loggers, management of vaccines and vaccination materials, reporting on campaigns were audited with all 47 implementers using semi-structured

questionnaire. The audits were conducted twice, at month 6 and month 12 during the two-year period.

**(iii) Household survey for community engagement**

Households in each of the two wards were sampled by starting from the house of the sub-village chairperson and selecting every other house while moving east to west or vice versa across the settlement. In total, 375 households were selected from the two wards (n=165 in Kyangasaga and n=210 in Kwihancha – the bigger ward). All villages in each ward were targeted, while sub-villages were conveniently selected on the basis of accessibility to people. Following the information and consenting process at household level with the 'head of household', one to three respondents aged 14 years and above (when they are likely able to understand and answer the questions) were interviewed per household, using a structured questionnaire designed in ODK. The number of people interviewed were 728 from 375 households in the before and after surveys.

### 3.9.2 Eligibility Criteria

(i) All participants in the development workshops, training of implementers, and selected advertising and vaccination clinics were observed.

(ii) Participants in the FGDs and IDIs were either implementers, leaders or members in one of the villages where CBC-MDV was implemented.

(iii) Participants in the household surveys during the community engagement were from households that received the full range of the engagement interventions and aged 14 to 99 years.

(iv) Participants in the FGDs, IDIs and household surveys read the participant information sheet and asked questions if any, then indicated whether they understood and they agreed to participate by signing an informed consent form.

(v) Consent was obtained from the household heads for participants who aged less than 18 years.

## 3.10 Data Management and Statistical and Qualitative Data Analysis

### 3.10.1 Data Management

#### (i) Qualitative data

Audio recordings of IDIs and FGDs were transcribed and translated verbatim by a hired translator. Nine meeting reports were extracted: five from the development workshops of CBC-MDV and 4 from the community engagements. The transcripts from IDIs and FGDs, and field notes from non-participant observations were then assigned unique identifiers and imported into NVivo 12 Plus version 20.5.1.940 (University of Western Australia, 2019) for coding and analysis.

#### (ii) Quantitative data

Quantitative responses from implementation reviews were extracted and organized in tables. Household survey data were transcribed from ODK into "Microsoft Excel" version 16.0.14827.20158 (www.microsoft.com). The data were cleaned and variables labeled as required.

### 3.10.2 Statistical and Qualitative Analyses

#### (i) Fidelity of delivery and reasons for variation

To assess the extent to which the components of CBC-MDV were delivered as intended, field notes from observations of advertising and from the audits of the implementation process were read and summarized as either 'delivered as planned', 'delivery modified', 'not delivered as planned' or 'delivered in excess of what was planned'. To assess the reasons for variation from what was planned, qualitative notes from observation of the advertising process and audits were thematically (Gale *et al.,* 2013) analyzed as follows. The main themes were: community engagement, estimation of dog population, advertising of campaigns, starting and closing time of vaccination clinics, delivery of continuous vaccination and choice of approaches for clinics. The coded texts were used in complementing, expanding and elaborating on understanding of the manner in which CBC-MDV was delivered and factors that influenced feasibility of delivering the different components (Objective 2).

### (ii) Assessing work inputs by each strategy

To assess the effort that was required to implement each of the three CBC-MDV strategies data were collected on the number of times and hours spent advertising, and number of campaigns delivered. Data on number of times and hours spent advertising were collected using a semi-structured interview with the village-based one health champions (OH) and triangulated with non-participant observation of the advertising activities. Data on number of campaigns conducted were obtained from the implementer's register of campaign activities. These data were examined to determine whether the efforts varied by strategy with frequency plots.

### (iii) Assessing potential effectiveness

Vaccination coverage achieved by each delivery strategy was calculated as the proportion of the dog population surveyed that had either a) a microchip, b) a vaccination certificate or c) owner recall that the dog had been vaccinated. The coverage estimates at month 1 and month 11 were summarized, annual averages achieved by each CBC-MDV strategy and the pulse strategy in a tabular form.

### (iv) Lessons for optimization and replication

To ensure successful replication of CBC-MDV in other settings, the research team, through the appraisal meetings, identified components of CBC-MDV that were appreciably influenced by contextual factors. Based on the conclusions reached by the research team, alternative approaches were designed for the CBC-MDV components that were not working as planned. Best practices among implementers were identified and incorporated into the CBC-MDV design for implementation in the full-scale trial planned for the Mara region.

### (v) Identifying barriers and drivers of innovation in vaccination campaigns

Linear models were employed to explore factors that are associated with smooth implementation of mass dog vaccination campaigns. From the non-participant observations of the vaccination clinics, it was observed that the time spent (sometimes more than half a day) by dog owners at vaccination centers constitutes large part of their investment into vaccinating their dogs, a linear model (family=poisson) was used to explore how: a) vaccination approached, b) number of animals brought by the dog owner and c) number of dogs vaccinated on the day influenced how much time the dog owner spent at the vaccination center. Wilcoxon

(Mann-Whitney U) test were used to compare time spent by dog owners when clinic was held at village-level versus when clinic was held at Subvillage-level.

Again, from the non-participant observations of the vaccination clinics, dogs struggling during the inoculation process was an impediment to smooth delivery of mass dog vaccination campaigns, a generalized linear model, family=binomial (link="logit") was used to explore how the odds of a dog struggling varies with age of the dog owner, number of dogs vaccinated on the day and how the dog was restrained. Crude Odds ratios were calculated by fitting each of the explanatory variables one after the other while adjusted Odds ratios were calculated by fitting all the explanatory variables in the model at a time.

### (vi) Developing and evaluating approaches to address barriers to participation in mass dog vaccination campaigns through community engagement

#### *Population-related factors that predicted 'knowledge' level of dog behavior, dog handling and safe interaction with dogs*

Predictors of 'knowledge' level of dog behavior, handling and safe ways to interact with dogs: To assess which population-related factors should be considered in tailoring sensitization interventions, a binomial, generalized linear mixed-effects model (fitted using the glmmTMB package) (Bolker *et al.,* 2009) was used to identify which of these factors are associated with the 'knowledge' level score at baseline, before being exposed to engagement activities. The variables 'ward', 'village' and 'household' (nested within village) were included as random effects. The variable 'knowledge' was the response variable and is an unweighted aggregation of the individuals' binary scores determined from three variables: a) their knowledge of dog behavior (ability to correctly interpret dog body language), b) knowledge of dog handling (ability to restrain a dog at home, how to calm a dog down and recommended ways of holding big and small dogs during vaccination) and c) knowledge of safe ways of interacting with dogs (how to avoid dog attacks and how to limit injury in case of attack). Out of 14 explanatory variables originally considered, two were dropped due to strong correlation (coefficient $\geq 0.5$) with other variables. The validity of the model assumptions of linearity and homoscedasticity was assessed visually by plotting residuals against fitted values. The best-fitting model was selected by backwards selection starting from the full model and sequentially eliminating the term with the highest likelihood ratio test p-value until all terms in the model gave $p < 0.05$.

### *Assessing impact of engagement activities*

The prevalence of negative perceptions of the impact of dog vaccination on dogs (such as dog will develop skin rashes, become infertile, docile or die when vaccinated), whether a participant had ever received training on dog behavior, dog handling and safe ways to interact with dogs, were quantified with proportions of 'yes/ no'. Participants also rated their abilities to communicate with dogs, restrain dogs, calm dogs down or hold dogs during vaccination: on a scale of 'very low', 'low', 'average', 'high' and 'very high'. Two-proportion Z-tests were used to compare responses before and after engagement to assess change in knowledge level and perceptions.

Mean scores on correct dog body language interpretation, dog handling, ways of avoiding dog attacks and ways of limiting injury when attacked for before and after engagement activities were compared with a Wilcoxon (Mann-Whitney U) test. Frequency charts were used to compare the reach of each medium delivered among follow up survey participants.

Participation in mass dog vaccination was also explored qualitatively under the themes: perception of dogs and dog vaccination, bonding with dogs, dog body language interpretation (communication with dogs), facilitators and barriers to participation in dog vaccination, and dog restraining and handling. The thematic framework was applied in NVivo and the content of themes was then extracted into separate word files for referencing in presenting the results.

### *Assessing reach of media of engagement*

Reach of engagement media were assessed to determine which the strategies/ tools of engagement reached more participants. Frequency chart was used to show the number of participants reached by each engagement media (posters, leaflets, video screening, village forum).

### *Feasibility of including communities in mass dog vaccination campaigns*

To demonstrate the feasibility of including communities in planning and implementing mass dog vaccination campaigns, meeting reports and the field observation notes on vaccination exercises were explored inductively using the thematic framework to confirm actual performance of assigned roles and to identify potential barriers and opportunities to community participation.

### (vii) Evaluating the likelihood of integrating and sustaining community-based continuous mass dog vaccination in the context of Tanzania, using the normalization process theory

The likelihood of integrating and sustaining CBC-MDV in the context of communities and the veterinary system of Tanzania were explored deductively with codes developed within the NPT constructs. The coded extracts were summarized within the 16 NPT constructs and used in elaborating on and supporting conclusions of findings for each of the constructs.

### (viii) Assessing ownership and sustainability of community-based continuous mass dog vaccination

Indicators of intention or likelihood of ownership of CBC-MDV at the veterinary system, implementer and community levels were explored qualitatively. The efforts made by each strategy team at delivering CBC-MDV components aimed at involving community in the process were compared during implementation at month 0, month 6 and month 12. The number of days spent by each strategy team on vaccination campaigns and number of dogs vaccinated were compared between year 1 and year 2 with time series graphs to show if and how campaign activities and outputs were being sustained.

Quantitative data analyses were performed in Excel version 16.0.14827.20158 (www.microsoft.com) and in R software version 4.2.1 (Harris, 2018).

Qualitative data analysis was done using QSR NVIVO version 12.5.0. The data was coded by the PhD student, guided by a coding manual developed by the PhD student and one of the supervisors following the 7-stage framework method proposed by Gale *et al.,* (Gale *et al.*, 2013). The student and the supervisor independently applied the coding frame to five transcripts, using a combination of deductive (themes developed based on 16 NPT constructs) and inductive approaches (Bryman *et al.*, 2002; Gale *et al.,* 2013), they then met repeatedly to clarify coding differences until consensus reached and the coding frame finalized.

## 3.11 Ethical Considerations

The protocol for this study was reviewed and approved by the Institutional Animal Care and Use Committee, Washington State University [Approval No. 04577 – 001], the Tanzania National Medical Research Institute [NIMR/HQ/R.8a/Vol.IX/2788], the Tanzania Regional

Administration and Local Government [AH.213/420/01] and the Ifakara Health Institute [IHI/IRB/No:024-2018]. Administrative permissions were sought from Rorya, Butiama and Tarime district veterinary offices and the leaderships of the wards and villages involved in the study.

## 3.12 Dissemination of Findings

### 3.12.1 Publications and Public Engagements

Four articles have been published from this research work in peer reviewed journals. Communities (leaders and members), ward-, district-, regional- and national-level human and animal officials, within country and international rabies researchers from University of Glasgow and Washington State University, officials of WHO and One Health (Tanzania country office), and local government were engaged through a series of five public meetings (Table 1) and seven community engagement meetings (Section 4.1.2.3 (iii)) on the design of the community-based continuous approach to delivering mass dog vaccination campaigns. Two wards in the Mara region were also engaged with information on dog behaviour and handling techniques to improve their ability to restrain their dogs during mass dog vaccination. findings from this work have been presented in eight scientific conferences.

### 3.12.2 Data Availability

The raw data supporting the conclusions of this thesis will be made available by the authors, without undue reservation.

# CHAPTER FOUR

# RESULTS AND DISCUSSION

## 4.1 Results

### 4.1.1 Development, Potential Effectiveness and Feasibility of Implementing Components of the Community-Based Continuous Approach to Mass Dog Vaccination – Specific Objective One

#### (i) Phase 1: Development of the community-based continuous mass dog vaccination intervention

Table 4 summarizes the essential components of CBC-MDV, the rationale for their inclusion, the views on each component expressed by stakeholders during meetings and adaptations made to the design of the components to address concerns. The detailed components of each ingredient are outlined in Appendix 1. The development process of CBC-MDV was iterative and participation in the workshops was multisectoral and included participants who both work in either the public health or animal health sector and are members of local communities, but did not specifically include community leaders/ decision-makers. The inclusion of stakeholders at higher levels fostered acceptance of CBC-MDV at policy levels, but there was little buy-in at community levels as they were not directly involved in the design.

**Table 4: Essential components of the community-based continuous mass dog vaccination and responses to stakeholder concerns**

| Essential ingredient | Rationale | Stakeholder views | Adaptation |
|---|---|---|---|
| Local delivery of CBC-MDV to be led by district level veterinary authorities | A new service is more likely to be adopted and sustained if it has buy-in and fits within existing systems | Stakeholders agreed district level veterinary authorities should lead implementation and suggested specific adaptations | Each district would have a district livestock field officer or a district veterinary officer who should oversee the delivery |
| Involvement of village level leadership in roll out of CBC-MDV | Support from village leadership is essential for high dog owner participation and local support for sustainability | Stakeholders expected village leaders to ensure members send their dogs for vaccination | Village leadership should enforce local laws to ensure community members vaccinate their dogs |
| Use of village-based people, trained prior to implementation and called One Health Champions (OHCs), to support ward-level livestock field officers to carry out vaccination activities | Local knowledge will facilitate organization and greater reach; employment of local people also provides key additional human resource | Because vaccination is professionally regulated within Tanzanian law, stakeholders would not allow people without an animal health certificate to vaccinate dogs | Each ward would have a ward-based livestock field officer<br>Trained village-based persons (OHCs) to be allowed to register dogs and issue certificates<br>A village-based assistant could be employed as well |
| Widespread communication at village level about CBC-MDV and advertising of campaigns using multiple forms of communication and venues | Widespread communication would be essential to achieve high coverage/reach | Use of village-based OHCs would facilitate local mobilization | Each village will have an OHC who will coordinate dog vaccination activities in the village |
| Use of locally made passive cooling devices to store rabies vaccine in wards | Local storage will improve operationalization of continuous dog vaccination by reducing time and travel costs thus improving access | Stakeholders agreed to storage of vaccines in locally made, locally made passive cooling devices | Livestock field officers should ensure conducive places are prepared for installation of cooling devices and their temperature monitors |
| A continuous approach to MDV activities which will be delivered on a quarterly basis and also available on demand by dog owners all year round | All year-round access to dog vaccination will support maintaining sufficient coverage necessary to interrupt transmission | Stakeholders agreed livestock field officers can devote time to organizing four rounds of vaccination campaigns in a year and to delivering vaccination on demand | Livestock field officers should collaborate with OHCs to identify dogs that missed previous rounds of quarterly vaccination |
| Delivery of dog vaccination must be free of charge to the dog owners | Fees have been documented to discourage owner participation | Stakeholders agreed vaccination of dogs and cats on this project will be free of charges to owners | To assist with the cost of implementation, local government authorities of Mara region agree to contribute US$2,000 annually to dog vaccination |
| Monitoring and feedback on vaccination coverage among research team, district veterinary authorities, vaccinators and communities. | Frequent feedback among implementers and district authorities will enable local actions to maximize CBC-MDV activities | Stakeholders agreed to monitor processes and outcomes through a joint steering committee and reporting via the district veterinary offices | Livestock field officers must submit weekly reports to district office and research team, and provide feedback to communities |

***The strategies of the community-based continuous mass dog vaccination approach tested***

Stakeholders determined that the essential components of CBC-MDV could be delivered slightly differently and used the pilot (phase 2) to assess the three forms of delivery (Table 5), each of which included the essential components. A ward from each district was allocated to each of the three CBC-MDV delivery strategies. An additional ward from each district was then allocated to the pulse (once annual) strategy.

**Table 5: Strategies for delivering components of the community-based continuous mass dog vaccination approach in the pilot study**

| Strategy | Frequency | Rationale |
|---|---|---|
| One: Village level temporal static point clinics in month 1 for all villages in the ward | Campaigns repeated at months 3, 6, and 9 using either the same approach or house-to-house, plus on-demand vaccination, i.e. responding to alerts from owners of dogs needing vaccination | Within three months enough puppies and new dogs would have arrived in villages in manageable numbers for efficient vaccination |
| Two: Sub village level temporal static point clinics in month 1 for all villages in the ward. | Campaigns repeated at months 3, 6, and 9 using same approach or house-to-house, plus on-demand. | Bringing clinic centers closer to more people should increase owner participation |
| Three: Implementers will deliver mass dog vaccinations using whichever of the above methods they consider to be best. | Continuous quarterly campaigns (at months 1, 3, 6, and 9) | Discretion to implementers and their knowledge of local terrain and context will influence their choices of vaccination approach and improve performance. |

Figure 5 presents the logic model agreed between research team members and the stakeholder groups as to how CBC-MDV in general is expected to work.

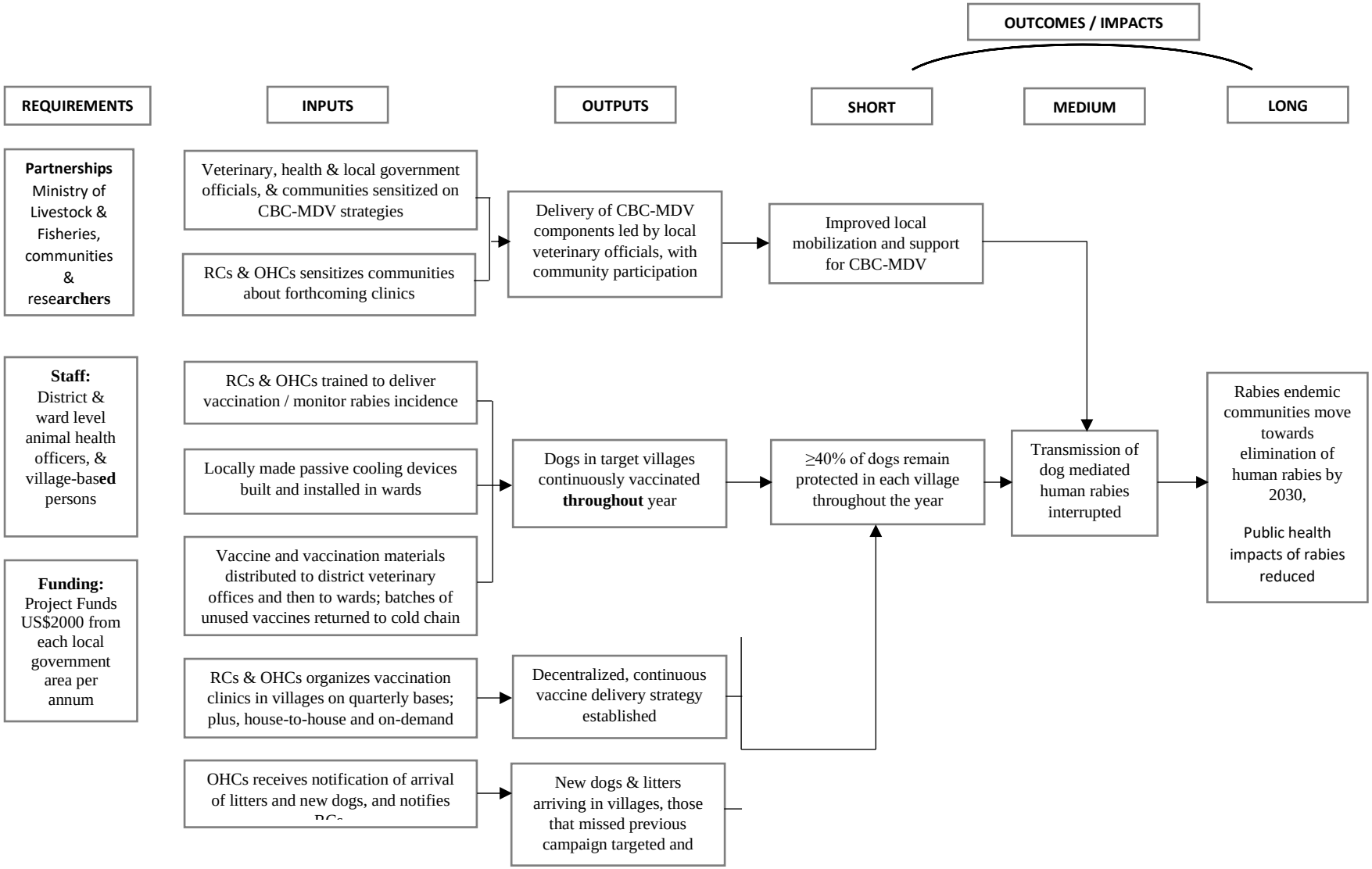


**Figure 5: Logic model of delivery and impact mechanisms of the community-based continuous mass dog vaccination approach**

### (ii) Phase 2: Assessment of feasibility, work inputs and potential effectiveness

***Fidelity and Reasons for Variation***

Table 1 (Appendix) presents an expanded form of the essential (45) components of CBC-MDV and summary analysis of fidelity of delivery: 20 components (44%) were delivered as planned, 14 (31%) were not delivered at all, nine (20%) were modified and two (5%) were delivered in excess of what was planned. The components were broadly categorized into eight groups (as detailed in Table 4) and their fidelity described as follows:

- **Local delivery of the community-based continuous mass dog vaccination approach to be led by district level veterinary authorities to foster buy-in**

Of the four components relating to district veterinary authority roles, two were modified in delivery. To foster community acceptance of the one health champions and rabies coordinators, the district livestock field officers were to write letters to introduce the vaccinators to their villages. All the district officers wrote letters after the training workshop. The district officers took stocks of vaccines received from the research project and distributed them to the ward-level implementers as planned. However, vaccines returned from two wards to district offices were not labeled and stored as planned. The district officials reported only supervising and monitoring campaigns as part of routine district veterinary functions. They cited lack of vehicle and fuel as key challenges to supervision. All the RCs reported they were not supervised by district officials as planned.

- **Involvement of village level leadership in roll out of the community-based continuous mass dog vaccination approach to foster owner participation and local support**

There were five components of CBC-MDV to be implemented to bring community leadership on-board with delivery of dog vaccination. Of these, four were modified or partly delivered as planned and one was not delivered. Of 35 OHCs, the majority received letters introducing them to their villages (31, 89%). However, most of them received the letters just a few days before or after the process had started and there were very few or no opportunities to introduce them at village meetings. Of the 19 (54%) introduced, 17 were introduced only in a leaders' meeting; while in the cases of those not introduced (16, 46%), the RCs or OHCs only informed ward or

village executive officers about the programme. Hence, most villagers did not have the opportunity to link the RCs and OHCs with the vaccination campaigns before they started.

The protocol also required RCs to discuss vaccination timetables with village leaders; only four out of nine RCs reported directly informing a community leader about their timetables. Again, OHCs were to work with 'mabalozi' (leaders of a cluster of ten houses) to estimate the village dog population. These were partly implemented; only a few (3, 9%) OHCs reported working with 'mabalozi'; the rest either went to houses directly (19, 54%) or instead worked with subvillage chairpersons (13, 37%). The frequently cited reasons for not working with 'mabalozi' included: 'mabalozi' perceived OHCs as not belonging to their political party or seen the project as not a community agenda and hence requested money (15, 43%); *"one 'balozi' said, you went to the workshop and received big allowances and you have come to tell us to go and work"* (OHC-21, Implementation Audit, District 2). Also, the concept of 'mabalozi' is not practiced uniformly across all jurisdictions (11, 31%). Other reasons were OHCs thought they were to work instead with subvillage chairpersons (6, 17%) or they did not trust 'mabalozi' to produce accurate figures on the dog population (4, 11%).

- **Use of trained village-based one health champions to support ward-level rabies coordinators with local knowledge to carry out vaccination activities**

There were six essential ingredients relating to village-based personnel supporting delivery of CBC-MDV at village levels. Out of these six, two were delivered as planned, one was partly delivered, two were not implemented and one was implemented in excess of what was planned. To ensure that only the required number of vaccines for a round were requested, all OHCs (35, 100%) provided estimates of the village dog population to RCs for request of vaccination materials. All OHCs also advertised vaccination clinics as planned. On the other hand, only two out of 35 OHCs conducted sensitization in village meetings. The opportunities for OHCs were likely limited as most of the villages did not hold meetings before the start of campaigns. Over the course of the year none of the OHCs documented dogs that missed the previous rounds as planned. All OHCs supported vaccination clinics in other villages of the ward in addition to theirs, as the workload at a center is ideally for three people. Not all of OHCs had cooperation from their village leadership, possibly because most of the OHCs were not persons with influential village positions.

- **Widespread communication at village level about the community-based continuous mass dog vaccination approach and advertising of campaigns using multiple forms of communication and venues to promote high reach**

Advertising of campaigns was largely carried out as planned. Of three components relating to advertising, one was delivered as planned, one modified and one delivered in excess of what was planned. All OHCs (35, 100%) delivered the complete contents of the adverts as designed, which included: date, time, location of clinic, specified animals to be vaccinated as dogs and cats, and vaccination being free-of-charge, using mega phones and posters at vantage points as prescribed. However, instead of the night before, announcements started two to three days before, likely occasioned by perceived workload (nature of settlement and size of villages – need to cover long distances). Out of a total of 55 announcements of the first round of campaigns, only 24 (44%) were carried out in the evenings; the rest were carried out in mornings (20, 36%) or afternoons (11, 20%) in variation with the protocol, and was probably when the vaccinators presumed most people were at home.

- **Use of locally made passive cooling devices to store rabies vaccine in wards to support provision of continuous vaccination**

To ensure vaccines do not remain outside of the cold chain for more than six months, eight CBC-MDV components were to help to deliver the vaccines to wards in batches. Six out of these were implemented as planned including: coordinated requests and transport systems; basing requests on ward dog population; returning unused vaccines after six months; installation of cooling pots away from sunlight; and monitoring daily temperature in pots. However, labeling of unused vaccines was not carried out as planned; only two out of nine RCs reported having ever returned unused vaccines to the district office and these were given to wards which were not part of the studies for use. Four out of nine pots were not in full use because they developed cracks and leaked when water is added to the cooling sand layer.

The prescribed waste management plans were partially implemented. The different kinds of waste were mostly separated during vaccination clinics (7/9), but instead of returning metallic and biohazard wastes to district offices or nearest health centers for incineration, most teams burnt everything at the location of clinics (6/9), indicating it was safe to do so.

- **A continuous approach to MDV activities; quarterly basis and available on demand by dog owners all year round thereby providing continuous access to dog vaccine**

Of the five components of CBC-MDV targeted at supporting provision of continuous dog vaccination, two were implemented as planned, one was modified and two were not implemented as planned. The CBC-MDV protocol prescribed that each strategy team conducts four rounds of campaigns in a year. However, only three out of the nine teams conducted four rounds of campaigns. The frequently cited reasons for variation in vaccination schedules included: farming/ rainy seasons, national activities such as elections, counting of poor households and mass animal vaccination campaigns (in which some RCs participated), social events such as cattle auction days, funerals, puberty rites celebrations and school cycles, with campaigns more patronized on weekends during school terms. For example, some dog owners indicated that during the farming season, either they or their dogs were required in the farms during the day time to guard against monkeys destroying their crops. It was also noted in one district that campaigns were halted during the month-long puberty rites celebrations.

The activity where OHCs were visit houses to find dogs that missed previous vaccination rounds was not implemented as planned. The implementers cited that this activity was labor-intensive and not feasible in the absence of an existing village register of dogs. To ensure dog owners have easy and continuous access to vaccinators, the protocol prescribed that OHCs give their mobile numbers out during first round of campaigns. None of OHCs reported giving their numbers out directly as planned (0, 100%) but most (32, 91%) wrote them on the 5-10 posters per village they pasted. The research team observed giving numbers out was practically difficult to do during advertising or vaccination given how busy they were at the centers. However, more than half of OHCs (20, 57%) reported having received calls from dog owners to visit their homes to vaccinate their dogs.

- **Delivery of free dog vaccination clinics using suitable approaches to encourage owner participation**

Out of the eight components related to organizing vaccination clinics, five were implemented as planned, one was modified and two were not implemented as planned. The CBC-MDV protocol prescribed that vaccination should take place between 08:00 – 14:00; in practice clinics started as early as 07:00 and as late as 12:00; and closed as early as 11:00 and as late as

18:00. The length of clinics was dependent on turnout at centers. House-to-house campaigns took longer where houses were further apart. The starting time for clinics depended on when farmers had returned home, whether RCs had to perform other duties on the same day (e.g., having to inspect meat) before clinics or whether RCs had to attend to personal business. Vaccinators also pointed out that microchipping of dogs (during which a number of dogs struggled) and entering data into the digital data collection device was time-consuming.

To ensure safe vaccination of dogs by reducing dog aggression, the implementation manual prescribes separation of registration and inoculation points with at least a 20-meter distance and muzzling of potentially aggressive dogs. However, none of the vaccination teams (0/9) implemented these. Dog aggression was associated with poor dog handling techniques by vaccinators. It was observed that vaccinators may not have had enough time to assimilate the benefits of separating dogs being registered and those being inoculated to reduce aggression. Dog aggression was observed to increase the time-per-dog vaccinated and on rare occasions resulted in injury, especially of dog owners.

Muzzles were not used out of fear of being bitten or the muzzles could tear in the process. One rabies coordinator said: "*is too difficult to use muzzles, dogs are too fierce to use it on them, it will get loose, we are afraid, we use the Y-stick*" (RC, Implementation Audit, Strategy 2-Tarime). Others recommended muzzles of three different sizes, whilst others perceived use of muzzles as time consuming. Consequently, implementers in Butiama and Rorya Districts restrained aggressive dogs by tying the rope or chain on the neck of dogs closely to a tree, and holding the hind legs firmly whilst inoculating the dog. While those in Tarime District used a 'Y-stick' to pin down the dog at the neck region with the help of the rope or chain.

The vaccination teams varied the delivery strategies that were prescribed for them, citing the following reasons: villagers saying it was difficult to bring dogs over long distance to centers, large dog populations in their villages, and their own perception of which strategy was likely to reach more dogs. Remarks by implementers indicated they thought subvillage level temporal static point clinics was the most effective approach, with the following quotes exemplifying this, "*subvillage level is very good at reaching more dogs*" (RC, Implementation Audit, Strategy 1, District 2); "*the Strategy [subvillage level temporal static point approach] is good because we had time to educate the dog owners*" (RCs, FGD, Strategy 2, District 3); "*I think Strategy 3 is good, it covers a lot of places because we use sub-village level [temporal static*

*point approach], house to house and on demand*" (RC, Implementation Audit, Strategy 3, District 1).

- **Monitoring and feedback on vaccination coverage among stakeholders to promote collaborative local action**

Of the six components relating to monitoring, reporting and providing feedback on CBC-MDV, only two (RCs reporting on dogs vaccinated, daily temperature recording of the low-tech cooling devices and rabies events) were delivered as planned. Supervision of campaigns by district veterinary officers was not carried out; the district veterinary officers cited lack of transportation to carry out this task and they expected per diem payment while supervising. OHCs also did not provide weekly reports on dogs needing vaccination and considered the weekly reporting was too frequent to allow for completion. Communities' self-monitoring of the campaigns and feedback to the research team and the district veterinary office were also not carried out, largely due to weak community involvement in the design of the CBC-MDV and sensitization on this role.

***Assessing work inputs by each strategy at delivering the components of the community-based continuous mass dog vaccination approach***

**Involvement of village level leadership in roll out of CBC-MDV:** The strategy teams delivered components relating to involving village leaders with varied degrees of fidelity. For example, not all of the strategy teams discussed their timetables with a village leader to get their approval and support (0/12 for Strategy 1, 2/13 for Strategy 2 and 2/10 for Strategy 3). OHCs largely did not work with ten-cell leaders (Mabalozi) to estimate the dog population in their ward: Strategy 1 (3/12), Strategy 2 (0/13) and Strategy 3 (0/10). Further information about how the delivery of the additional components were delivered is provided in Appendix 2.

All components relating to use of trained village-based OHCs to support vaccination were delivered as planned by all strategies, except sensitization of villagers about campaigns at village meetings which differed: Strategy 1 (2/12), Strategy 2 (8/13) and Strategy 3 (9/10) Table 2 (Appendix). All strategies delivered advertising components as required, but the effort put into the advertising differed: The number of times and hours per village advertised in the first round, and total number of days of vaccination per village were all lowest in Strategy 1 and highest in Strategy 3 respectively (Fig. 6). The vaccinators reported that having to walk for a long distance or personally pay for travel by motorbike created challenges to advertising.

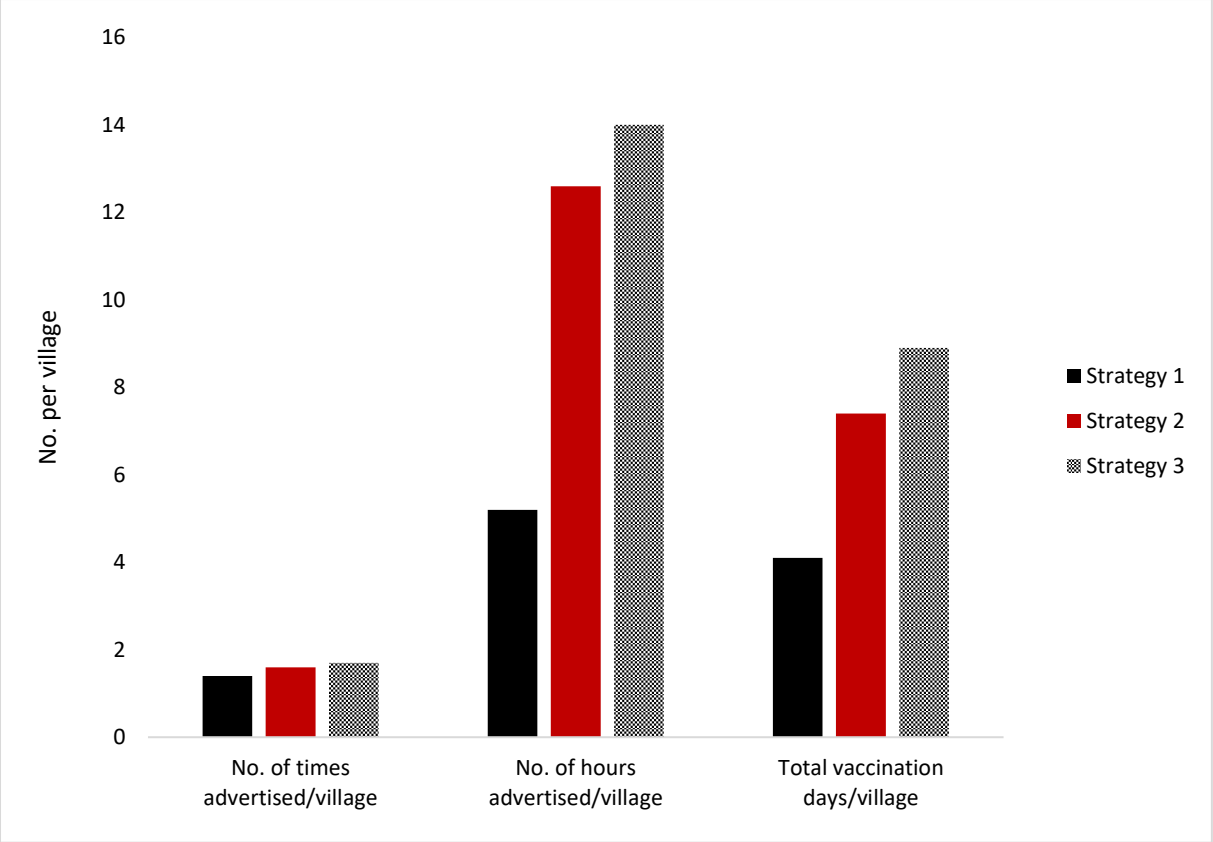


**Figure 6: Effort at advertising and delivering vaccination campaigns by strategy (totals for all three team per strategy)**

For all strategies, the number of days of campaign activities reduced substantially after the first round. Over the one-year period, the three strategies together used 237 days on campaigns: Strategy 1 (49, 21%), Strategy 2 (95, 40%) and Strategy 3 (91, 39%). The majority of days (189 days, 80%) were spent during the first two rounds (Fig. 7).

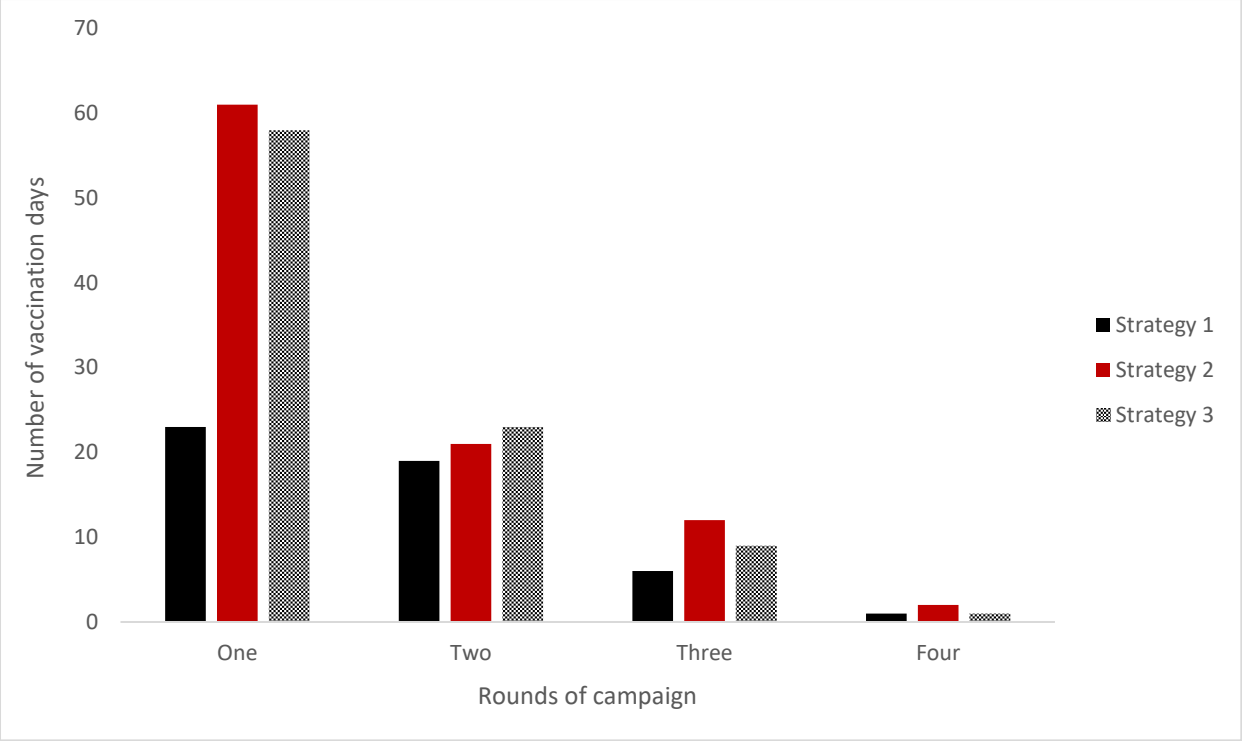


**Figure 7: Number of days implementers conducted vaccination activities during each round (totals for all three team per strategy)**

The strategy teams differed in terms of numbers of days spent finding dogs that missed central point clinics, responding to on-demand vaccination by dog owners and in organizing quarterly campaigns Table 2 (Appendix).

**Waste management after vaccination clinic:** All teams installed and managed vaccine batches as planned. However, there was discrepancy with regards to how used needles and microchip units were disposed. Some teams either incinerated or disposed of these items in pit toilets: Strategy 1 (2/3 teams), Strategy 2 (2/3 teams) and Strategy 3 (1/3 teams), whilst the rest of the teams burnt all waste at vaccination centers (Appendix 2).

**Delivery of free dog vaccination clinics using suitable approaches:** none of the Strategy teams implemented separating registration and inoculation centers with a distance of at least 20 meters and muzzling of potentially aggressive dogs as planned. The Strategy teams partly followed CBC-MDV manual in selecting approaches to deliver dog vaccination: All Strategy 3 wards opted for subvillage level temporal static point approach, the same approach as was prescribed for use in Strategy 2 wards in round 1 (6/6). In round 2, two of the Strategy 3 wards avoided the lengthy campaign days that come with subvillage level temporal static point approach by deciding to use village level temporal static point. A remark by an RC exemplifies

this: "*it [subvillage level temporal static point approach] took long*" (RC, Implementation Audit, Strategy 3, District 2). Conversely, two out of the three Strategy 1 teams switched from village level in round 1 to subvillage level temporal static point approach in round 2. The reason given for this switch was that many dogs remained unvaccinated after the round 1 village level temporal static point clinics and so they decided to instead employ a subvillage level temporal static point approach to reach more dogs. All teams employed some house-to-house and on-demand (9/9) approaches. Subvillages were combined for single clinics where implementers considered them to be smaller in size, had smaller dog populations or were closer to each other (Appendix 3).

Overall, subvillage level temporal static point and on-demand approaches were the most (173 occasions) and least-used (20 occasions) respectively (Fig. 8).

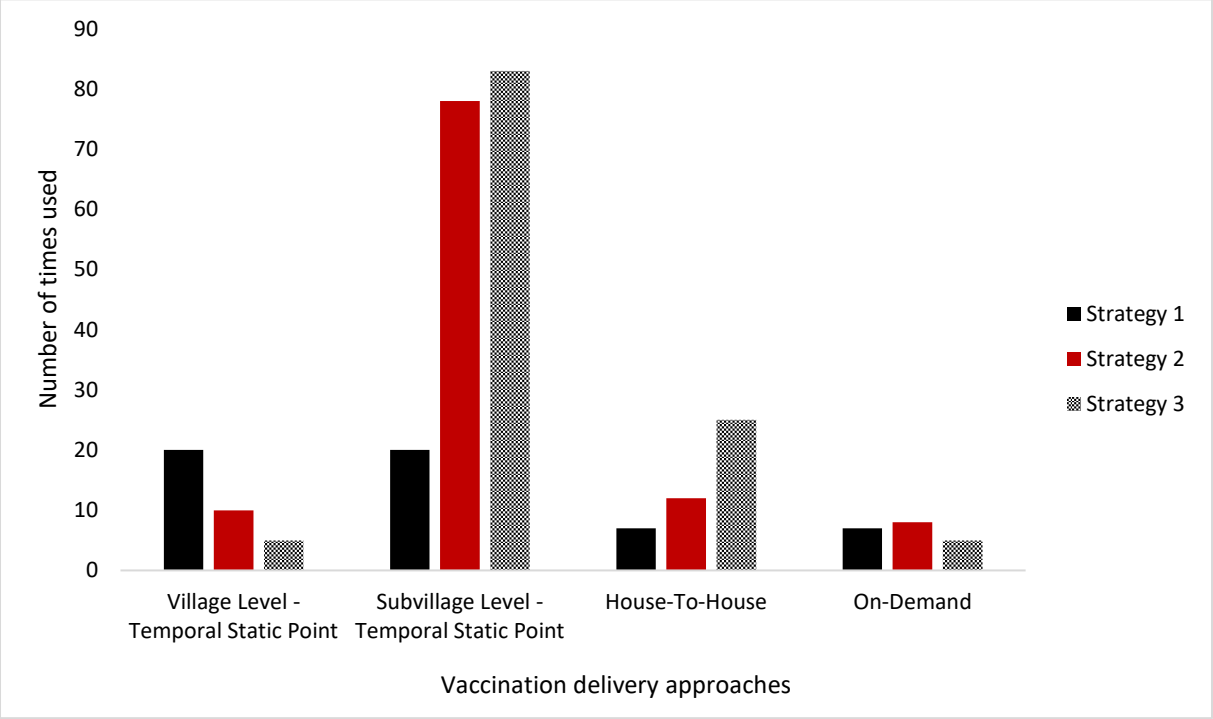


**Figure 8: Use of vaccination delivery approaches by strategy team (totals for all three team per strategy)**

***Potential effectiveness of the community-based continuous mass dog vaccination strategies***

To interrupt rabies transmission requires sustaining vaccination coverage above the critical vaccination threshold (approximately 40%). Coverage estimations at month 1 and 11 showed all continuous strategies did sustain coverage above this level, whilst the pulsed approach did not achieve the ≥70% target (Table 6). Coverage at month 11 was slightly lower in Strategy 1

and 3 and slightly increased in Strategy 2, but none were significantly different (Table 6). Strategy 3 which recorded the highest work inputs in terms of advertising and vaccination days, recorded slightly higher annual average vaccination coverage: Strategy 1, 2 & 3 (61.5%, 63.0% & 63.5%), respectively (Table 6).

**Table 6: Vaccination coverage achieved by the delivery strategies at month 1 and 11**

| Vaccination coverage achieved by delivery strategies | | | |
|---|---|---|---|
| **Strategies Arms** | **Month – 1 (%)** | **Month – 11 (%)** | **Annual Averages (%)** |
| Pulse | 35.9 | 32.1 | 34.0 |
| Strategy 1 | 65.1 | 57.8 | 61.5 |
| Strategy 2 | 61.0 | 64.9 | 63.0 |
| Strategy 3 | 68.0 | 58.9 | 63.5 |

***Identifying barriers and drivers of innovation in vaccination campaigns***

- **Determinants of owner-time-spent at vaccination center**

One of the key inputs dog owners make in sending their dogs for vaccination is the investment of their time. The time spent by 610 dog owners at 9 vaccination clinics was modeled. How much time a dog owner spent at the vaccination center was higher when the clinic was at village level compared to subvillage level and also dependent on the number of dogs vaccinated on the day (Table 7).

**Table 7: Determinants of owner-time-spent at vaccination center**

| **Variable** | **Coefficient** | **CI 2.5-97.5%** | **p-value** |
|---|---|---|---|
| Intercept | 1.7556 | 1.7051 – 1.8057 | 0.0001 |
| Village level clinic | 0.2629 | 0.2304 – 0.2956 | 0.0001 |
| Number of dogs the owner brought | 0.0002 | -0.0161 – 0.0164 | 0.9810 |
| Number of dogs vaccinated | 0.0130 | 0.0127 – 0.0134 | 0.0001 |

- **Comparison of time spent by dog owners by approach of vaccination clinic**

Further comparing the time spent by approach showed the mean time spent by dog owners attending village level clinic was significantly (three times) higher than those attending sub-village level clinics (Table 8).

**Table 8: Comparison of time spent by dog owners by approach of vaccination clinic**

| Approaches | Time spent at vaccination center by owner (minutes) | | | Mean time spent compared W (*p*-value) |
|---|---|---|---|---|
| | Range | Median | Mean ± SD | |
| Village Level | 3 - 150 | 58 | 61.5 ± 40.02 | 19 945 ($p<0.0001$) |
| Sub-village Level | 1 - 134 | 14 | 23.3± 24.45 | |

- **Determinants of dog aggression during vaccination**

A generalized linear model was used to explore determinants of a dog struggling during inoculation of dogs 696 at nine vaccination clinics. The adjusted odds ratios showed the likelihood of a dog struggling during vaccination when the owner was young was 0.16 less than when the owner was older (>21 years). The odds of a dog struggling increased by 5.2 when the number of dogs vaccinated on the day increased by 100. The odds of a dog struggling during vaccination was only 0.01 when owner was able to restrain the dog (Table 9).

**Table 9: The odds of dogs struggling during vaccination under different circumstances**

| | Crude Odds Ratios | | | Adjusted Odds Ratios | | |
|---|---|---|---|---|---|---|
| **Variable** | **OR** | **CI (2.5% – 97.5%)** | ***p*-value** | **OR** | **CI (2.5% – 97.5%)** | ***p*-value** |
| Intercept | 0.23 | -1.73 – -1.16 | <0.0001 | 9.58 | 1.41 – 3.28 | <0.0001 |
| Being Young | 0.81 | -0.60 – 0.18 | 0.288 | 0.84 | -0.73 – 0.37 | 0.5251 |
| Number of dogs Vaccinated >100 | 1.46 | -0.02 – 0.79 | 0.0669 | 6.20 | 1.12 – 2.60 | 0.0001 |
| Owner held dog | 0.01 | -5.80 – -4.01 | <0.0001 | 0.01 | -6.43 – -4.46 | <0.0001 |

***Lessons for optimization and replication***

Table 10 details optimization of some components of CBC-MDV for replication in the full-scale trial and lessons for dissemination in other contexts.

**Table 10: How the community-based continuous mass dog vaccination approach can be optimized for replication in the full-scale trial and dissemination in other contexts**

| Optimization of MDV-CBC design for the full RCT in response to delivery challenges | |
|---|---|
| Delivery challenge | **How the delivery has been modified** |
| Dog aggression | Feasibility of a facial recognition application is being tested in the RCT as a means of identifying vaccinated dogs instead of microchipping to avoid microchipping needles irritating dogs and making them aggressive |
| | Vaccinators will be trained on dog behavior and handling techniques |
| Microchipping was time-consuming | Facial recognition application is relatively faster |
| OHCs not receiving maximum cooperation from "mabalozi" | Village chairpersons were selected to be OHCs, to use their authoritative positions to enhance community engagement and sensitization, potentially leading to improved community acceptance, support and participation in vaccination campaigns |
| Further potential optimization of MDV-CBC design that can be made to overcome other delivery challenges | |
| Dog aggression | The sequence of procedures at clinic centers can be reordered; where painless procedures such as tying of collars are carried out before painful procedures such as inoculation. This potentially will avert dog aggression and bites of owners while tying collars |
| Delivery of CBC-MDV components being affected by community level environmental, economic and sociocultural factors such as elections, mass animal vaccination campaigns, cattle auction days, funerals, puberty rites celebrations and school cycles | Inclusion of community leaders in planning of CBC-MDV could lead to integration of CBC-MDV into village annual calendars (highly revered and largely adhered to), potentially improve tailoring of delivery to local events |
| | Village authorities will be more inclined to earmark resources towards CBC-MDV implementation: transport and launch allowances for vaccinators, volunteers to assist clinics, enforcing dog vaccination and community self-monitoring of campaigns |
| Identifying dogs that missed previous campaigns being labor-intensive | Campaigns can begin with a census of the entire village dog population linked to households, and will be ticked as dogs are vaccinated. Thus, dogs that missed a round of vaccination and where they live can easily be identified and targeted. |
| | This potentially will facilitate effective logistics planning, accurate coverage estimation and delivery of continuous vaccination |
| Implementers finding it challenging to give their telephone numbers out during vaccination clinics | Vaccination cards can be printed with the telephone number of the RC of the ward on them. This would allow villagers ready access to vaccinators and potentially will promote on-demand/ continuous vaccination |

| Optimization of MDV-CBC design for the full RCT in response to delivery challenges | |
|---|---|
| RCs' routine duties and personal businesses influenced timing and frequency of vaccination schedules | Schedules composed of 3-rounds of vaccination (at the village / sub-village level) per year will be more manageable for RCs given their other duties. The campaign must include robust arrangements for on-demand to target new dogs and puppies that arrive in the village and dogs that missed previous vaccination rounds |
| OHCs having to participate in campaigns for each village of the ward | The work load at a vaccination center ideally requires three people. Hence provisions should be made to support OHCs/ volunteers to assist campaigns in other villages. |
| Lack of supervision of vaccination campaigns by district veterinary officers | Frequent supervision and higher number of days spent vaccinating can be encouraged by a remuneration system that is based on performance: a portion of implementers' salaries can be paid as bonuses/ allowances upon delivery of certain indicators: e.g., for RCs - carrying out all rounds of campaigns of the year, complete & timely monthly reporting, achieving coverage above a minimum threshold at month 11, no animal rabies cases recorded in the ward; for district veterinary officers – number of verifiable supervision days, number of feedback provided to research team and or communities |

### 4.1.2 Developing and Evaluating Approaches to Address Barriers to Participation in Mass Dog Vaccination Campaigns Through Community Engagement – Specific Objective Two

#### (i) Demographic information of participants of household surveyed in the community engagement

Table 11 summarizes information on demography and livelihoods of 728 respondents who took part in the household surveys across the two wards. Of these, 55% were female, most (64%) were between 20-49 years of age, they were predominantly farmers (85%), and about one-third (32%) did not have formal education. Only 31 respondents (4%) were unemployed; the main religions were Christianity (59%) and Islam (28%) and the majority (83%) were married. The two communities are broadly similar, except that mass vaccination campaigns have been happening in Kwihancha ward since 2013, and fishing communities are only present in Kyangasaga ward.

**Table 11: Socio-demographic characteristics of household respondents**

| Variables | Categories | Ward | | Totals (%) |
|---|---|---|---|---|
| | | Kwihancha n (%) | Kyangasaga n (%) | |
| Sex | Female | 236 (32) | 164 (23) | 400 (55) |
| | Male | 197 (27) | 131 (18) | 328 (45) |
| Age (years) | 14-19 | 41 (6) | 47 (6) | 88 (12) |
| | 20-49 | 269 (37) | 195 (27) | 461 (64) |
| | 50> | 123 (17) | 53 (7) | 176 (24) |
| Level of education | None | 137 (19) | 94 (13) | 231 (32) |
| | Primary | 275 (38) | 186 (25) | 461 (63) |
| | Secondary | 21 (3) | 15 (2) | 36 (5) |
| Occupation | Unemployed | 15 (2) | 16 (2) | 31 (4) |
| | Student | 22 (3) | 19 (3) | 41 (6) |
| | Fishing | 20 (3) | 11 (2) | 31 (5) |
| | Farmer | 376 (51) | 249 (34) | 625 (85) |
| Religion | Traditional | 9 (1) | 12 (2) | 21 (3) |
| | No Religion | 41 (6) | 28 (4) | 69 (10) |
| | Islam | 133 (18) | 74 (10) | 207 (28) |
| | Christian | 250 (34) | 181 (25) | 431 (59) |
| Marital Status | Single | 54 (7) | 54 (7) | 108 (14) |
| | Married | 362 (50) | 236 (33) | 597 (83) |
| | Widowed | 17 (2) | 5 (1) | 23 (3) |

### (ii) Population-related factors that predicted 'knowledge' level of dog behavior, dog handling and safe interaction with dogs

Six out of 12 variables included in the model were significantly associated with knowledge level. The model predicted that: a 1-year increase in a participant's age, if a participant owned a dog, if a participant said he/she was taught how to hold a dog during vaccination and if a participant said he/she was threatened or bitten by dog were associated with 0.4%, 5%, 37% and 13% increased odds of scoring correct on knowledge level respectively. Whilst if a participant said he/she sent dog(s) for vaccination during the last vaccination campaign and if a participant said he/she was afraid of dog (compared to those who said they were somewhat afraid, a little or not afraid at all of dogs) corresponded with 10% and 4% decreased odds of scoring correct on knowledge level respectively (Table 12).

**Table 12: Participant-related factors that predicted 'knowledge level' of dog behavior and safe interaction with dogs**

| | | Likelihood Ratio Tests | |
|---|---|---|---|
| **Variable** | **OR (95% CI)** | **$\chi^2$** | **p-value** |
| Intercept | 7.5122 (5.8650 – 9.6222) | - | - |
| Age of participant | 1.0040 (1.0021 – 1.0058) | 17.512 | 0.0001 |
| Participant owned a dog (Yes) | 1.0453 (1.0070 – 1.0851) | 5.3892 | 0.0203 |
| Trained on how to hold a dog (Yes) | 1.3695 (1.1341 – 1.6537) | 10.755 | 0.0010 |
| Ever bitten by a dog (Yes) | 1.1258 (1.0589 – 1.1969) | 14.25 | 0.0002 |
| Fear of dog (Yes) | 0.9595 (0.9315 – 0.9882) | 7.5081 | 0.0061 |
| Participated in last vaccination campaign (Yes) | 0.9033 (0.8385 – 0.9733) | 7.1079 | 0.0077 |

### (iii) Assessing impact of engagement activities

Comparison of participants' scores on dog body language interpretation, dog handling, ways of avoiding dog attacks and ways of limiting injury when attacked, before and after engagement activities.

Mean scores on dog body language interpretation, dog handling, ways of avoiding dog attacks and ways of limiting injury when attacked were compared with a Wilcoxon M-W U test at

p<0.05. All scores significantly improved after engagement activities (Fig. 9). However, scores were low for both before and after. For example, 50% answered just 3 out of 21 questions correctly for interpretation of dog body language. The majority (86%) of participants responded that they were a little or very much afraid of dogs, but less than half (41%) reported they had been bitten and/ or threatened by a dog.

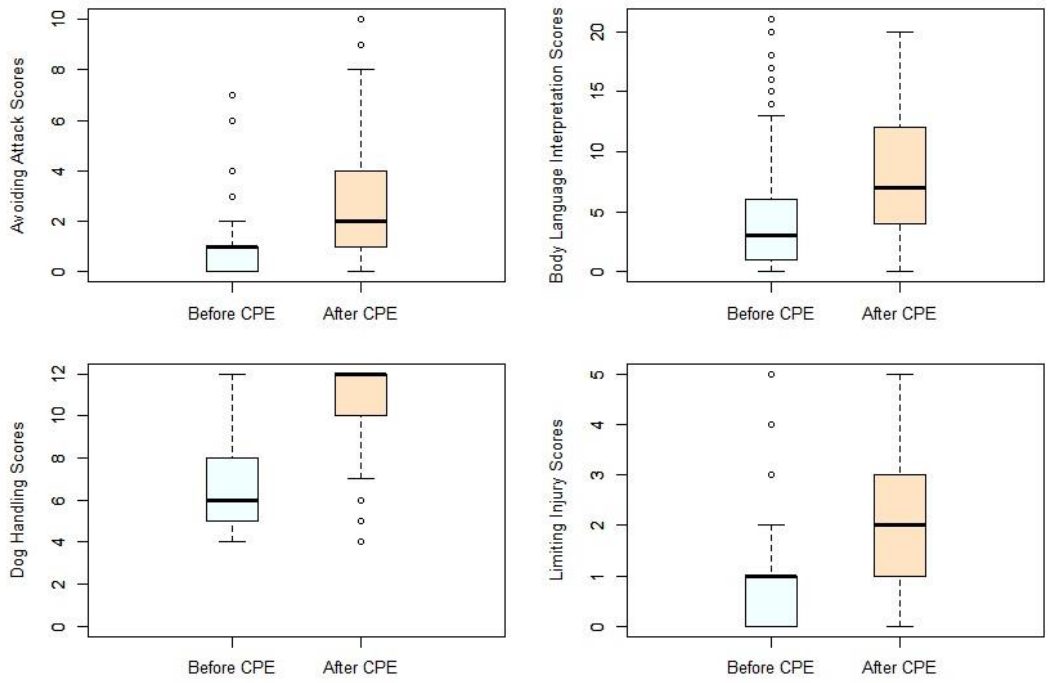


**Figure 9: Boxplots showing median scores on dog body language interpretation, ways of avoiding dog attacks, ways of limiting injury when attacked and dog handling, before and after engagement activities**

***Participants' views on dog behavior, dog handling and safe interaction with dogs***

The views of participants in FGDs suggested that dog behavior has implications for participation in dog vaccination as exemplified in the following quote:

> *Another thing is the behavior of the dog, like being very reactive or calm and friendly. If a dog is very reactive, it barks at strangers and even attempts to chase them away. Therefore, that will be a major problem [for taking it to be vaccinated] and even if you take it to the vaccination center it will take a lot of strength to hold it because when it sees people different from those it sees at home it will react* (A teenager, P3, FGD, District 1).

In discussing barriers to sending dogs for vaccination, two themes dominated: distance to the vaccination point and relationship with the dog:

> *[…] . If you are not used or close to your dog and just one day you want to tie it up with a rope or chain and take it for vaccination that will be a difficult case. […] because during the vaccination you have to hold your dog, if you can't hold it even the person who is giving the vaccination will be afraid because it is dangerous* (An adult, P3, FGD, District 2).

Though knowledge of dog handling techniques was very low among study participants (none of the 16 dog owners and 9 dog handlers demonstrated perfectly accurate knowledge as recommended), some had ideas of how to restrain a dog, making them confident in their ability to take their dogs for vaccination:

> *I think nothing will make it difficult for me to take my dog for vaccination. If you see the dog showing signs that it does not want to go, you have to use other mechanisms since that is your dog and you know it very well. You can set a trap like a rope ready to catch it then you lure it with food, when it comes then you catch it and then you can take it for vaccination* (An adult, P6, FGD, District 2).

***Perceptions of dog vaccination before and after engagement activities***

Overall, only a few respondents (8%) held all four negative perceptions about the impact of dog vaccines at baseline, believing that vaccines will cause dogs: to die (5%), to develop skin rashes (1%), not reproduce (4%) and not to bark or hunt well (4%). The majority (92%) did not have any negative perceptions. Although the prevalence of negative perceptions was not significantly improved after engagement activities (Table 13), respondents' views from the review of the demonstration vaccination exercise suggested that participation in vaccination campaigns could help change negative views as this quote illustrates: *"after the vaccination they saw that their dogs did not die, they were happy and now they are asking when the dogs will be vaccinated again"* (Vaccinator, Demonstration Vaccination Review, District 2). Many participants also expressed the view that vaccines provide protection: "*The vaccination is a kind of protection against diseases, that is to say, it is prior protection before a certain disease attacks the dog*" (A teenager, P3, FGD, District 1), or does not have negative effects:

> *Vaccination is a treatment for dogs, it eradicates the long-time diseases. So, if the dog gets vaccination, it will not affect it or make it unable to bark or to guard as usual, or not able to reproduce again. No, it will continue to do those things as usual and you have to train it* (An adult, P6, FGD, District 1).

**Table 13: Two-proportion Z-tests comparing change in perceptions of dog vaccination, interviewer- and participant-rated knowledge of dog handling and safe interaction with dogs: before and after the engagement activity**

| Variables | Categories | Frequencies (%), n=728 | | 95% CI (difference: before-after) | p-value |
|---|---|---|---|---|---|
| | | Before | After | | |
| Perceptions of dog vaccination | | | | | |
| Vaccine causes rashes | No | 687 (94) | 714 (98) | -0.0416 – 0.0306 | 0.8163 |
| Vaccine causes infertility | No | 706 (97) | 718 (99) | -0.0392 – 0.0337 | 0.9388 |
| Vaccine reduces barking | No | 708 (97) | 722 (99) | -0.0392 – 0.0337 | 0.9388 |
| Vaccine causes death | No | 700 (96) | 722 (99) | -0.0405 – 0.0322 | 0.8777 |
| Interviewer-rated knowledge of dog handling | | | | | |
| **Knowledge of ways of restraining dog** | I don't know | 124 (17) | 13 (2) | | |
| | Wrong | 94 (13) | 6 (1) | | |
| | Partially correct | 293 (40) | 155 (21) | | |
| | Correct | 217 (30) | 554 (76) | -0.0911 – -0.0353 | 0.0001 |
| **Knowledge of how to calm a dog** | I don't know | 222 (30) | 18 (3) | | |
| | Wrong | 187 (26) | 22 (3) | | |
| | Partially correct | 257 (35) | 127 (17) | | |
| | Correct | 62 (9) | 561 (77) | -0.1185 – -0.0683 | 0.0001 |
| **Knowledge of how to hold a small dog** | I don't know | 204 (28) | 13 (2) | | |
| | Wrong | 255 (35) | 27 (4) | | |
| | Partially correct | 205 (28) | 104 (14) | | |
| | Correct | 64 (9) | 584 (80) | -0.1230 – -0.0721 | 0.0001 |
| **Knowledge of how to hold a big dog** | I don't know | 203 (28) | 11 (2) | | |
| | Wrong | 251 (34) | 41 (6) | | |
| | Partially correct | 234 (32) | 112 (15) | | |
| | Correct | 40 (6) | 564 (77) | -0.1222 – -0.0729 | 0.0001 |
| Participants' self-rated knowledge of sate interaction with dog | | | | | |
| **Ability to communicate with a dog** | Very low | 252 (34) | 7 (2) | | |
| | Low | 160 (22) | 4 (1) | | |
| | Average | 224 (31) | 122 (17) | | |
| | High | 85 (12) | 515 (70) | | |
| | Very high | 7 (1) | 80 (10) | -0.0226 – -0.0021 | 0.0155 |

| Variables | Categories | Frequencies (%), n=728 | | 95% CI (difference: before-after) | p-value |
|---|---|---|---|---|---|
| | | Before | After | | |
| Participants' self-rated knowledge of sate interaction with dog | | | | | |
| Ability to restrain a dog | Very low | 219 (30) | 5 (1) | | |
| | Low | 133 (18) | 8 (2) | | |
| | Average | 241 (33) | 47 (6) | | |
| | High | 106 (15) | 522 (71) | | |
| | Very high | 29 (4) | 146 (20) | -0.0364 – -0.0076 | 0.0020 |
| Ability to prevent dog attack | Strongly disagree | 42 (6) | 1 (0) | | |
| | Disagree | 56 (8) | 3 (0) | | |
| | Can't tell | 133 (18) | 4 (1) | | |
| | Agree | 477 (65) | 481 (66) | | |
| | Strongly agree | 20 (3) | 239 (33) | -0.0584 – -0.0240 | 0.0001 |
| Ability to limit injury when attacked by dog | Strongly disagree | 49 (7) | 1 (0) | | |
| | Disagree | 74 (10) | 2 (0) | | |
| | Can't tell | 222 (30) | 10 (1) | | |
| | Agree | 370 (51) | 610 (84) | | |
| | Strongly agree | 13 (2) | 105 (15) | -0.0302 – -0.0055 | 0.0034 |

***Interviewer-rated and self-rated participants' knowledge of dog handling and safe interaction with dogs before and after engagement activities***

Interviewer-rating of respondents' knowledge of ways of restraining and calming dogs at home and during vaccination clinics showed significant changes after engagement activities (Table 3).

Respondents' self-rating of their level of confidence in their abilities to communicate with their dogs, to restrain a dog and to avoid dog attacks or limit injury when attacked showed significant improvements after engagement activities (Table 13).

### (iv) Reach of intervention media among follow up survey participants

During the follow up survey, respondents indicated through which medium of delivery of engagement activity they received information on dog behavior and handling. Posters were the most frequently cited, followed by leaflets and village-level meetings (Fig. 10). The distribution of posters and leaflets was targeted at participants in the survey while village-level

meetings and video screenings were targeted at the whole village. Respondents were further asked to indicate through which of the media did they acquire new information the most; 81% referred to posters. During the follow up survey, the majority of respondents were also observed to have the posters hanging on the wall in their sitting rooms.

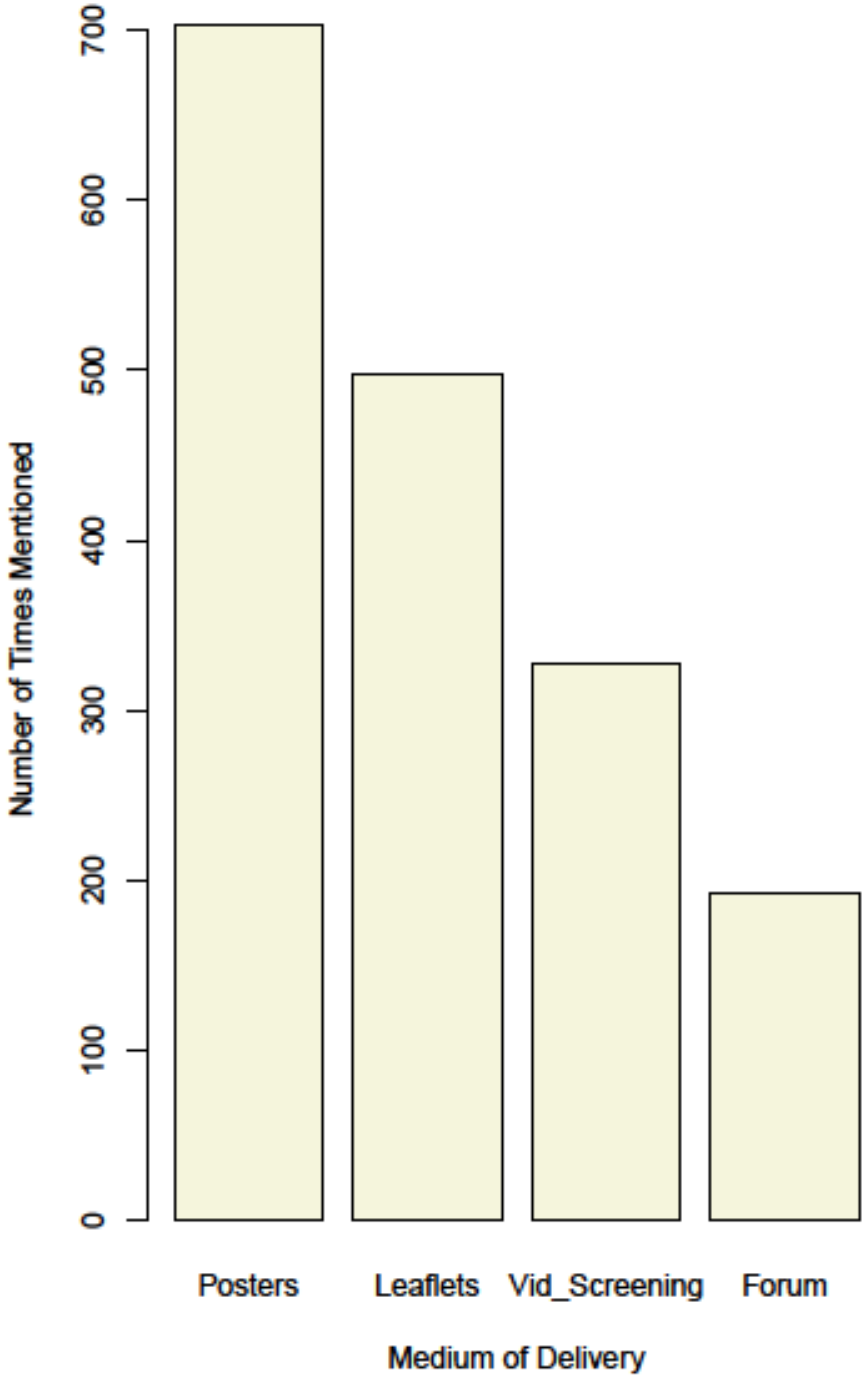


**Figure 10: Reach of intervention media among follow up survey participants**

### (v) Feasibility of including communities in delivering mass dog vaccination campaigns

To assess the feasibility of including community leadership in planning and implementing mass dog vaccination campaigns, an engagement meeting was held where the community engagement team, three district veterinary officers and 11 community leaders (one female), including the Ward Executive Officer, Village Executive Officers, Village and Subvillage Chairpersons participated. Their views on rabies in their communities were discussed and they identified what goes into organizing mass dog vaccination campaigns.

In all cases the district officers and community leaders agreed that rabies is a problem to their people and cited cases of dog bites and human deaths. The meeting then identified key mass dog vaccination activities and assigned them as roles to stakeholders (Table 14).

**Table 14: Outcomes of meeting to involve community leadership in planning and implementing of dog vaccination: roles performed and those not performed**

| Stakeholder Group | Assigned Roles | Performed Roles (Yes/No) |
|---|---|---|
| Research or Donor Organizations | Procure vaccine and vaccination materials (syringes, cards, register, transport, funds, megaphones) | Yes |
| | Recruitment and training of vaccinators | Yes |
| | Evaluation of outcome of vaccination clinics | Yes |
| Government or District Veterinary Office | Mobilizing stakeholders (researchers, donors, communities and ministry agencies) for sustained efforts | No |
| | Transport for vaccinators | No |
| | Provide cold boxes on the day of vaccination | Yes |
| | Issue directives in support of the vaccination campaign | Yes |
| | Ensure readiness of vaccinators | No |
| | Supervision of the vaccination clinics | No |
| Community Leadership | Advertising of the campaign | Yes |
| | Provision of food for vaccinators in their village/sub-village during campaign | No |
| | Provision of waste bins | No |
| | Provision of table and chairs for vaccinators | Yes |
| | Conduct census of all dogs and cats per household | Yes |
| | Sub-village chairmen to assist the vaccinators at the vaccination points as dog handlers | Yes |
| | Conduct community self-assessment after the vaccination to see what proportion of dogs in each sub-village are vaccinated | No |

Three months after the engagement meeting a vaccination campaign for the ward was undertaken to assess the feasibility of the stakeholders performing their respective roles. The community engagement team (representing research/ donor organizations) performed all of three assigned roles, the district veterinary office performed two out of six assigned roles and the community leadership performed four out seven assigned roles.

The district veterinary office cited lack of funds for supervision and to provide transportation for vaccinators. There was change in the community leadership of the ward between the engagement meeting and vaccination exercise, which affected performance of roles assigned to the community leaders (Table 12).

### (vi) Opportunities and barriers to community participation in planning and implementing mass dog vaccination campaigns

Our assessment of the meeting with the community leaders and observation of the demonstration vaccination exercise showed there were both opportunities and barriers to community participation in planning and implementing mass dog vaccination campaigns in the context of Tanzania. The opportunities included the availability of leaders at different levels (village, sub-village and ten-household units) of the community, and willingness of the community leaders to own and participate in planning and implementing of the dog vaccination campaign. On the other hand, even though the community leaders agreed to assist the campaign for free, some demanded payments afterwards. The village executive officers think that they need to pay the people they work with irrespective of the agreement that was had with them. There also was a general lack of enthusiasm for dog vaccination, which hampered the mobilization for the vaccination campaign.

### (vii) Outcomes of the demonstration vaccination exercise

The census data showed a relatively low dog ownership: total number of dogs for the ward was 566, ranged from 55-99 and averaged 81 dogs per sub-village. The vaccination coverage was good in most of the sub-villages: ranged 29-81% and averaged 59% (Table 15).

**Table 15: Number of dogs censused and vaccinated in Kyangasaga Ward during the demonstration vaccination exercise**

| Villages | Sub-villages | Number of Dogs | | Vaccination Coverage (%) |
|---|---|---|---|---|
| | | **Censused** | **Vaccinated** | |
| **Gabimori** | Ngurumi | 95 | 60 | 63 |
| | Mukiringo | 60 | 42 | 70 |
| | Buhare | 73 | 59 | 81 |
| | Esuka | 86 | 53 | 62 |
| **Kyangasaga** | Nsagaro | 99 | 48 | 48 |
| | Sonjo | 55 | 16 | 29 |
| | Kyangasaga | 98 | 61 | 62 |

### 4.1.3 Evaluating the likelihood of integrating and sustaining the community-based continuous mass dog vaccination approach in the context of Tanzania, using the normalization process theory – Specific Objective Three

#### (i) Summary of findings per the Normalization Process Theory constructs

Key findings for likelihood of integrating and sustaining CBC-MDV in practice are summarized under the 16 NPT constructs in Table 16.

**Table 16: Overall findings for routinization of the community-based continuous mass dog vaccination approach from on NPT constructs**

| Coherence (sense making work) | Cognitive Participation (relational work) | Collective Action (operational work) | Reflexive Monitoring (appraisal work) |
|---|---|---|---|
| **Differentiation** | **Enrollment** | **Skill set workability** | **Reconfiguration** |
| Communities and implementers perceived CBC-MDV to be different from the pulse approach. The differences were that CBC-MDV involved the community in planning, created more awareness, was flexible, continuous, more accessible and reached more dogs including new pups. | Community leaders and implementers were prepared to invest time and energy into CBC-MDV: they perceived it as part of their responsibilities; and made time by planning. | Community leaders and DLFOs believed implementers have the required skills to deliver CBC-MDV.<br><br>Non-participant observation noted implementers competently delivered most CBC-MDV components. | Implementers did not feel they had the power to vary the intervention in the course of implementation based on their experience. |
| **Communal Specification** | **Activation** | **Contextual integration** | **Communal appraisal** |
| Communities and implementers understood the aims, objectives and benefits of CBC-MDV as to achieve the vaccination of more dogs and prevention of rabies and its impacts. | Community leaders defined activities and work needed to sustain CBC-MDV as including: mobilization of community members, rabies education, advertisement of dog vaccination, creation of a community register of dogs for monitoring, preparing annual timetables for dog vaccination, enacting by-laws to enforce vaccination; and secure funding.<br><br>Implementers defined activities as: coordination of activities, creating awareness at village meetings and planning timetables | Community leaders believed some by-laws exist and should be enforced to support CBC-MDV: i.e., that people must vaccinate their dogs every year with fines imposed on those who fail and that owners must pay for post-exposure treatment if the unvaccinated dog bites someone.<br><br>They also believed if communities were involved in planning, CBC-MDV could be included in the community budget<br><br>Communities and implementers advocated for donor support for vaccines and equipment.<br><br>Fridge and office spaces were available for keeping vaccination materials at district offices, some village offices provided room space for passive cooling devices and others released tables and chairs for clinics. | Community leaders and implementers collectively assessed effectiveness and benefits of CBC-MDV as: less frequent rabies cases including in livestock; prevention of the costs of human vaccines when a biting dog is vaccinated; the dog vaccination service is more available now and more dogs are vaccinated.<br><br>However, providing feedback to communities and involving them in evaluating outcomes of vaccination campaigns was not done. |

| Coherence (sense making work) | Cognitive Participation (relational work) | Collective Action (operational work) | Reflexive Monitoring (appraisal work) |
|---|---|---|---|
| **Individual Specification**<br><br>Understanding of individual tasks and responsibilities:<br><br>Community Leaders understood their responsibilities included mobilization, education and inspiration of people on controlling rabies; to enact by-laws; to supervise, monitor and report vaccination activities DLFOs [..] to enforce government policies on animal diseases including rabies; to train and supervise implementers.<br><br>LFOs […] to provide education on rabies, organize and report on campaigns.<br><br>OHCs [...] to educate and mobilize communities, estimate or document the number of dogs needing vaccination, advertise campaigns, registration and certification of vaccinated dogs. | **Initiation**<br><br>Willingness and ability to involve others: community leaders and implementers appreciated the need to get community-level committees and members involved in CBC-MDV; they stated that they have authority to convene meetings.<br><br>For example, one DLFO involved the district commissioner and executive director; two wards (strategy 3) decided on their own delivery approach with communities and some OHCs helped with activities in other villages within their wards. | **Interactional workability**<br><br>Implementers observed they are able to continue with routine tasks because they know the timetable of CBC-MDV for the whole year.<br><br>CBC-MDV made dog vaccination easier to implement because: it involved communities in planning, vaccines and funds were available, the passive cooling devices ensured easy access to vaccines throughout the year because vaccines were stored in communities. | **Individual appraisal**<br><br>Community leaders and members said they now understood the advantages of dog vaccination; they don't have to take many injections (PEP) when bitten by a dog.<br><br>Implementers thought the community was convinced about the importance of dog vaccination and were satisfied with the outputs of CBC-MDV. |
| **Internalization**<br><br>Communities and implementers believed the value, benefits and importance of CBC-MDV included: reaching communities sustainably at reduced cost, allowing local input, involving community-based implementers to improve mobilization, protecting people and dogs from rabies and averting expensive treatment of dog bites. | **Legitimization**<br><br>Community leaders believed: their involvement helped to make dog owners responsive to the vaccination team and thought, if involved in planning and monitoring of CBC-MDV, implementation would improve<br><br>Implementers believed it is part of their responsibilities to control rabies, they also considered their involvement as serving their communities. | **Relational integration**<br><br>**Community leaders and members** said they trusted CBC-MDV and its implementers because of recognition by district veterinary offices, and they did not see any negative impact of the vaccine on dogs<br><br>**DFLOs** said communities trusted the program and its implementers because the OHCs were selected from the communities and communities had access to the vaccinators. | **Systematization**<br><br>Communities and implementers agreed that CBC-MDV should be used to deliver dog vaccination across Tanzania because: they believed it reached more dogs, it involved the community, fostered ownership of dog vaccination, it improved awareness of rabies, it was user friendly, available most of the time and sustainable. |

### (ii) Coherence – making sense of the community-based continuous mass dog vaccination approach

Coherence examines if those involved in a new intervention can differentiate it from existing or other interventions based the features, values and advantages of the new intervention, and their appreciation of the tasks and responsibilities they have to perform in delivering that intervention. Implementers, community leaders and members understood the aims, values and advantages of the CBC-MDV strategies: a) they perceived CBC-MDV as a more inclusive approach to mobilizing dog owners and they perceived CBC-MDV as providing better access to dog vaccination compared to the pulse; b) they clearly identified how the two approaches differed; and c) they understood the tasks ascribed to them. These are exemplified in the following quotes; a village leader highlighted the distinctive features of CBC-MDV as:

> *There is a big difference since the community-based strategy involved team work in making an action plan and also involved people from the particular community and so this made it much easier to reach more dogs* (Community Leader-3 IDI, District 1).

Another village leader described the roles ascribed to them on CBC-MDV as:

> *My responsibility is to mobilize the community in collaboration with the livestock field officers who are educating people, when they plan to vaccinate, I call the ward development committee to discuss and we give responsibilities to each other and emphasize to the community to bring their dogs* (Community Leader-1 IDI, District 2).

The veterinary officials also strongly linked their involvement in CBC-MDV to their overall roles in the prevention of livestock diseases:

> *My first role as a veterinary doctor is to prevent livestock diseases, so one of my responsibilities in rabies control is to use appropriate methods to prevent and protect the community and animals from contracting the disease. That is my responsibility and I perform it by providing rabies vaccine* (DLFO IDI, District 1).

These views illustrate that CBC-MDV made sense to those involved and thus has potential to be integrated into their routines.

***Cognitive Participation – investing in the community-based continuous mass dog vaccination approach***

Cognitive participation examines if those involved in a new intervention have reflected on the set of activities required to implement the intervention, whether or not they feel it is legitimate for them to be involved in the intervention and are willing to get others involved in the implementation process. Implementers and communities showed willingness to engage with CBC-MDV: a) they considered their involvement in CBC-MDV to be legitimate and that they should make time for it; b) they had clear understanding of what was required to enact and sustain CBC-MDV implementation and c) knew who should be involved to ensure success. One implementer said: "*I found it easy to make time for CBC-MDV because dog vaccination is among my responsibilities as a livestock field officer, so I was using my normal timetable*" (RC-2 IDI, District 1).

One community member clearly outlined what must be done to make mass dog vaccination via CBC-MDV successful:

> *I think that the community should be provided with adequate education about rabies, they should be educated on the benefits of vaccinating their dogs. Secondly, laws should be made to hold people accountable […] when this [vaccination] exercise is completed we should conduct an inspection from house to house to verify that all dogs have been vaccinated and those who did not vaccinate their dogs intentionally will be made to face the law* (P 3, Implementers FGD, District 3).

Another community member recognized that community mobilization is necessary for the success of CBC-MDV: "*The main issue is community mobilization so as to make them aware about the importance of vaccination*" (P 9, Adult Male FGD, District 3).

Communities and implementers also indicated how CBC-MDV can be improved further through extended community participation. One community leader said: "*We should engage all village levels from ward to village to sub villages … to have a vaccination timetable by putting it into our work plan*" (P 9, Community Leaders FGD, District 1).

Likewise, the implementers also agreed that one way CBC-MDV can be improved is the involvement of the various community leadership structures in the process: *"… also using different leaders such as Ward Executive Officers, Village Executive Officers, Village and Sub*

*village Chairpersons who can advertise easily to the community to bring their dogs for vaccination"* (P 7, Implementers FGD, District 3).

These propositions by the implementers are supported by observations of community members, that the involvement of community leaders in some cases helped the implementation process: "*It was the mobilization done by our community leaders in village meetings, so we had to take our dogs for vaccination*" (P 5, Adult Females FGD, District 2).

The implementers also observed that conflicting local political interests among community leaders and the OHCs was a barrier to strong community collaboration and participation in CBC-MDV delivery. One DLFO expressed his opinions as follows: "*The major thing is politics, sometimes people involve politics and different opinions but otherwise there is no problem if the community is directly involved*" (DLFO IDI, District 2).

This is also supported by the experience of one of the RCs:

> *What hindered me were political issues, my area is led by the opposition party. So, when we are mobilizing for this exercise others considered it as a strategy for the ruling party to campaign, that was one of the challenges we faced* (RC-2 IDI, District 2).

These views illustrate awareness of what was required and willingness to enact CBC-MDV into practice.

***Collective action – implementing the community-based continuous mass dog vaccination protocol***

Collective action examines the possibilities of operationalizing a new intervention by looking at whether or not there are adequate skill sets, resources and policies to support the implementation process, and hence the stakeholders trust the new approach and the implementers. The implementers found it relatively simple to operationalize the CBC-MDV protocol: a) district-level implementers managed logistics efficiently and ward/ village-level implementers delivered CBC-MDV components satisfactorily; b) infrastructure (fridge and room spaces to keep vaccination materials) and by-laws to support CBC-MDV were available; c) having an annual schedule for vaccination activities helped implementers in planning their routine tasks; d) availability of [research fund & local] resources made delivery of CBC-MDV

easier; and e) secondment of implementers by DLDOs and community leadership fostered trust in CBC-MDV and its implementers. The experience of one RC is as follows:

> *There are [resources to support CBC-MDV], it was in my village government office where I stored the reports and equipment for the vaccination exercise. The areas which I vaccinated, the chairs and tables I used belong to the respective village government offices* (RC-1 IDI, District 3).

The support was based on trust, the district veterinary officers believed the implementers were trusted because they were known: "*Yes, they (communities) have trust in them (vaccinators), because they come from the same communities*" [DLFO IDI, District 1).

The district veterinary officers also trusted in the abilities of vaccinators to deliver CBC-MDV because they have been adequately trained: "*They have skills because they have studied about these things but also received training from the project so apart from studying on their profession on working with livestock, the project continues to educate them*" (DLFO, IDI, District 1).

These experiences indicate that CBC-MDV had adequate infrastructure and local support and can be integrated in the context of Tanzania with relative ease.

***Reflexive monitoring – recommending the community-based continuous mass dog vaccination approach***

Reflexive monitoring examines how those involved in a new intervention judge its impact on their individual and collectively routine tasks, whether or not they have the agency to amend the intervention in the course of delivery based on success of implementation and outcomes. While both implementers and communities positively appraised CBC-MDV, sharing of feedback among the research team, implementers and communities was lacking and implementers were not aware upfront that they could vary the CBC-MDV protocol in the course of its implementation. A young participant clearly identified the benefits of CBC-MDV and recommends its adoption: "*Yes, and I would like this strategy [CBC-MDV] to be sustained because it reduces rabies, it brings vaccination centers close to even those who are living far*". (P 5, Mixed Young People FGD, District 1).

However, community leaders advised what needs to happen to maximize the outcome of CBC-MDV:

> *There must be an evaluation, for example in our zone we expected to vaccinate 1,000 dogs but after implementation, how many dogs have we vaccinated? And if we failed to reach our goal what are the causes? That will help to make strategies for the easiest way for the next implementation* (P 3, Community Leaders FGD, District 3).

From the point view of the implementers, they were not abreast with possibilities of amending the protocol in the course of implementation: "*No, we did not consider experience (to modify the protocol), but we considered the level of mobilization and how the community perceives the programme (dog vaccination) and then explained it to them*" (RC-1 IDI, District 2).

Communities also collectively appreciated the benefits of CBC-MDV: "*I just mention one, as a person gets bitten and rushed to hospital, you might find there are no post exposure vaccines. But after this program there will be no high risk, because the dogs were already vaccinated*" (Community Leader-3 IDI, District 2).

Community members suggested ways that implementers can be empowered and how to ensure continuity of dog vaccination including easy access of implementers to the villages, and that vaccination should continue to be free of charge. A leader said: "*By modification I mean vaccination teams should be empowered with transport facilities for easy and early access to vaccination centers. […] to motivate personnel so they can go around the village frequently*" (P 8, Community Leaders FGD, District 3).

Another community leader made a similar call: "*Also, government should provide vaccines in sustainable manner*" (P 5, Community Leaders FGD, District 3).

In these regards, both implementers and community members observed these have actually helped the vaccination campaigns in the context of this research project: "*Frankly, the major policy which causes the community members to bring their dogs is that the vaccination is free of charge*" (OHC-33 IDI, District 3).

> *As it has been sponsored up to now it is a good thing, for example vaccines are here and for free. That led to easy community mobilization for mass dog and cat vaccination.*

> *But if it would rely on community contribution, I think this would not be possible* (P 2, Community Leaders FGD, District 3).

These views of what is needed to mobilize communities, and suggestions regarding how CBC-MDV could be improved, were further expressed in the way that implementers think CBC-MDV should be monitored: "*If each village has a register of dogs, it will be easy to monitor who has brought their dogs for vaccination*" (OHC-23 IDI, District 2).

Some community leaders expressed similar views:

> *Also, they [the vaccinators] have to provide a register of vaccinated dogs to community leaders. For example, if it is per household, then it will be easy to identify unvaccinated dogs. They have never given us a register after that exercise of dog vaccination in our village although we participated in mobilization* (P 9, Community Leaders FGD, District 3).

Community views on CBC-MDV campaign strategies were that villages should be divided into zones, each with a vaccination point, and that each zone or sub-village or street should have an OHC: "*Setting vaccination centers near communities will help even lazy ones to bring their dogs*" (P 5, Community Leaders FGD, District 3).

> *Maybe I can say it is the large size of this ward, walking to every place to reach the community to educate them about this matter, and most of our people live far in the bush, that is a challenge* (Community Leader-1 IDI, District 3).

These views have contributed to considerations regarding how the normalization of CBC-MDV can be facilitated.

### ***Stakeholders' views on how the normalization of the community-based continuous mass dog vaccination approach can be facilitated***

Based on the views of implementers and communities presented in the NPT analysis we constructed a stakeholder mental model of approaches to designing, implementing and evaluating CBC-MDV to facilitate integrating and sustaining it in practice (Fig. 11).

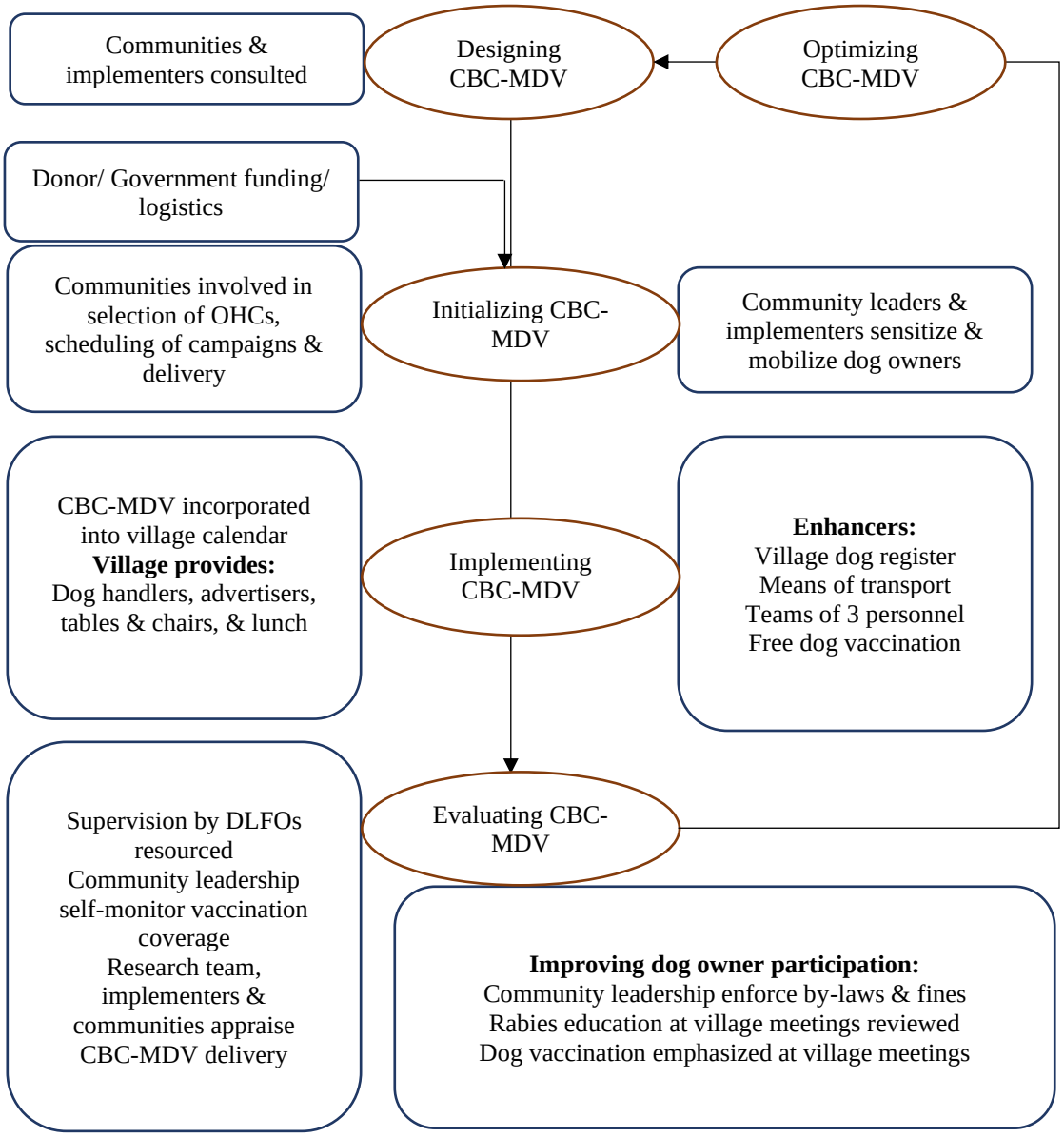


**Figure 11: Community and implementer mental model of the community-based continuous mass dog vaccination approach**

### 4.1.4 Assessing Ownership and Sustainability of Implementation Processes of the Community-Based Continuous Mass Dog Vaccination Approach – Specific Objective Four

#### (i) Ownership

Indicators of intention or likelihood of ownership of CBC-MDV were found at the veterinary system, implementer and community levels.

**System level:** the director of veterinary services of Tanzania declared the project as learning platform to inform national mass dog vaccination strategies of the country in a key stakeholder meeting and in a Mara regional meeting. The LGA of Mara region pledged $2,000 each in support dog vaccination each year; LFOs who will be involved in CBC-MDV will not take extra salary (only allowances). Intention of ownership was due to nine regional and national engagement meetings involving national veterinary and local government officials.

**Implementer level**: it was found that implementers believed dog vaccination is part of their responsibilities and CBC-MDV is a better approach to delivering mass dog vaccination as exemplified by their views (Table 16).

**Community level:** community leaders and members expressed community readiness to engage with and support CBC-MDV delivery. They think communities can a) contribute to mobilizing dog owners and b) evaluating the activities. Communities also called for collaboration with implementers to deliver CBC-MDV (Fig. 11). Some community leaders recommended that dog vaccination should be a main agenda at village meetings. Meeting reports and observations showed ownership by communities have not been strongly fostered due to lack involvement of communities in the design, planning and implementing of CBC-MDV so far. In the views of communities, CBC-MDV will be delivered with great success if the government should leave the implementation to the village and sub-village leaders.

### (ii) Sustainability

The indicators of sustainability explored included continued efforts by implementers to bring communities on-board initializing and delivering CBC-MDV components; continued efforts by implementers in terms of days spent at conducting vaccination campaigns; and if vaccination outputs of wards were being maintained.

#### *Efforts by implementers in bringing communities on-board initializing and delivering the community-based continuous mass dog vaccination approach components*

Table 17 shows the extent to which CBC-MDV components aimed at bringing communities on-board were implemented. None (0/5) of the components were implemented at the beginning of year 2 campaigns (12 months after roll-out).

**Table 17: Delivery of the community-based continuous mass dog vaccination approach components relating to bringing communities on-board from 0 – 12 months of roll-out**

| CBC-MDV components to engage communities | Number of times component was delivered | | |
|---|---|---|---|
| | Month 0 | Month 6 | Month 12 |
| Introduction of vaccination team (9) at village meeting | 9 | 3 | 0 |
| Teams (9) who discussed timetable with community leadership before campaign begin | 8 | 0 | 0 |
| Sensitization of communities about dog vaccination and their roles by 35 OHCs | 0 | 0 | 0 |
| Sensitization of communities about forthcoming clinics by 35 OHCs | 19 | 0 | 0 |
| Community self-monitoring campaigns | 0 | 0 | 0 |

***Number of days spent by wards at conducting vaccination in year 1 compared to year 2***

The vaccination teams (wards) spent same number of days conducting campaigns in year 2 (237 days) as in year 1 (237 days) (Fig. 12). The number campaign days spent in each year decreased sharply during subsequent rounds, with 80% and 78% of days spent on first two rounds in year 1 and year 2 respectively.

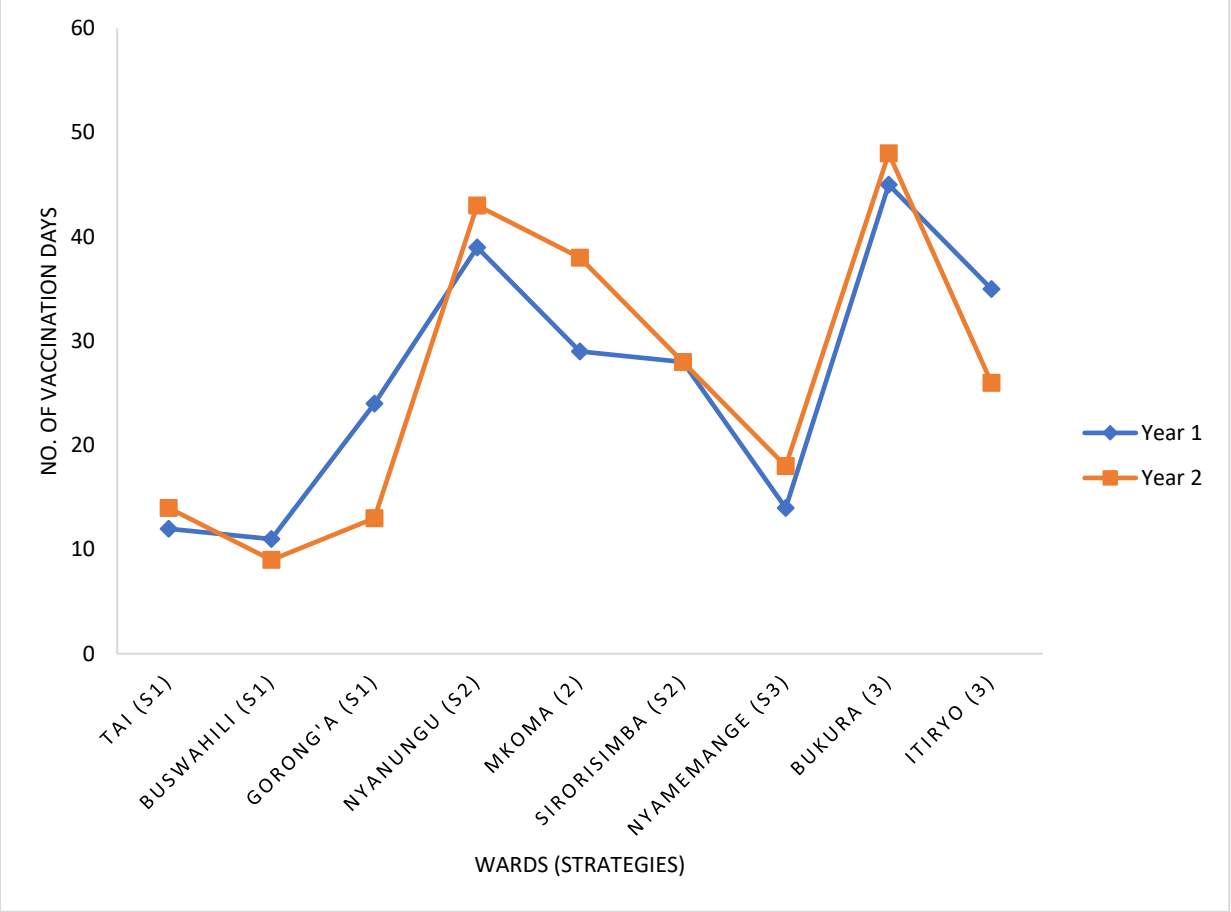


**Figure 12: Number of vaccination days by wards, year 1 vs year 2 compared**

***Vaccination outputs of wards in year 1 compared to year 2***

In spite of spending same number of days conducting campaigns, vaccination outputs in year 2 was overall 5503 (32%) lower compared to year 1: average percentage reduction was 32% (range 1 – 57%). The average percentage reduction differed across strategies: Strategy 1 (44%), Strategy 2 (26%) and Strategy 3 (15%) (Fig. 13). It emerged from review of year 2 campaigns that the population did not get the message that dogs have to be vaccinated each year. The advertising of year 2 beginning campaigns was evaluated by randomly speaking to 30 individuals, 18 of them sort clarification, "*what if my dog was vaccinated last year?*". Also, it was difficult to determine which dogs were due for the annual shot as many dog owners misplaced the vaccination cards. So, people were asking questions like: "I have vaccinated my dog recently, is there need for me to bring it again?". "My dog was vaccinated last year August, this is June, is it time for me to vaccinate again?".

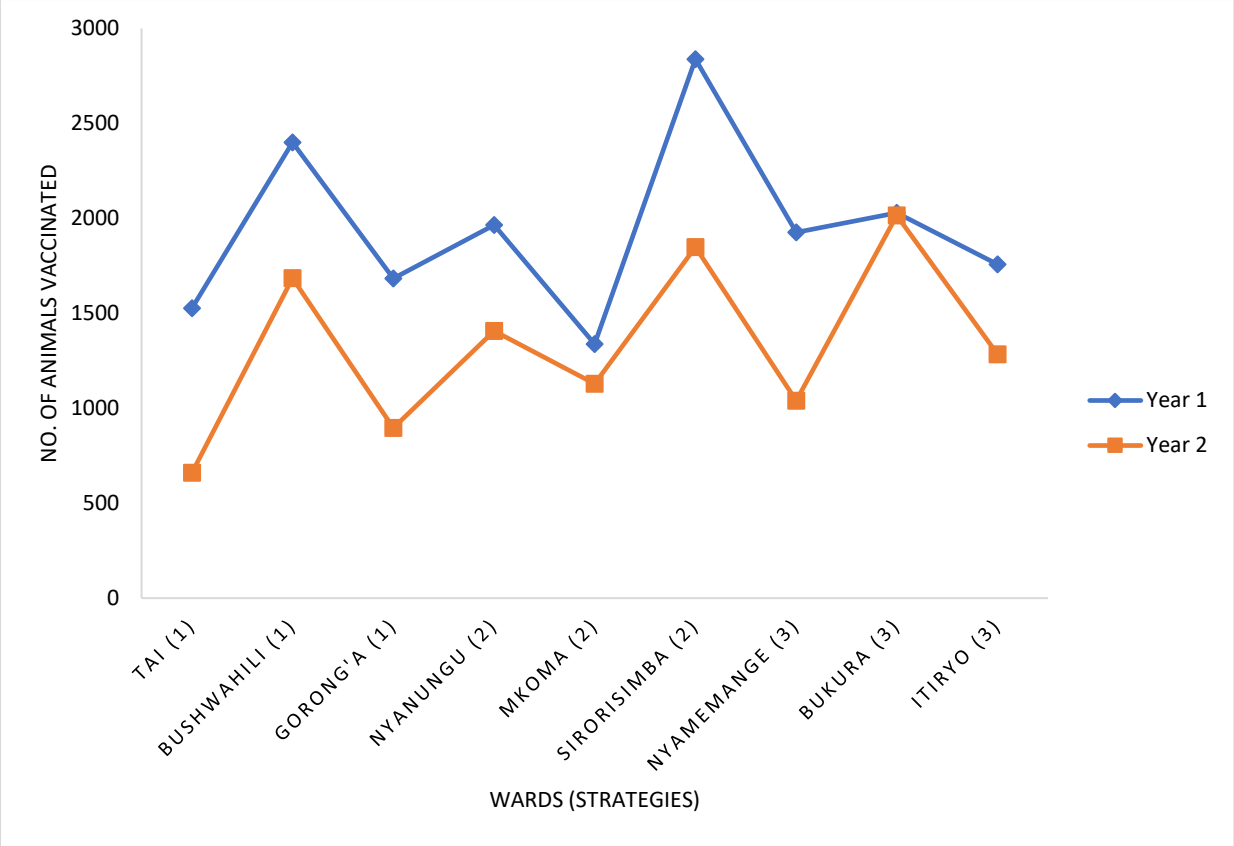


**Figure 13: Vaccination outputs by wards, year 1 vs year 2 compared**

Other issues bothering on sustainability were: out of 35 OHCs, only 1 dropped out (97% retention); all of them indicated they would like to continue working as OHCs as exemplified in this quote. Four out of the nine locally made passive cooling devices cracked within the first year so the cooling sand layer could not hold water. Also, in year 2, several teams experienced rampant shortages or delayed delivery of vaccination materials.

In summary, the use of mixed methods in this study have facilitated triangulation of the qualitative and quantitative data and potentially have reduced weaknesses such recall bias. A clear example is that through triangulation, it was deduced that people were not appreciating that dogs have to be vaccinated each year, which largely explain the reason why vaccination outcomes in year two declined, although the implementers maintained the same level of campaign activities over the two-year period.

In comparison: a) the CBC-MDV approach showed that it can be used to attain and sustain sufficient vaccination coverage in a more consistent and sustainable manner by providing more time point access to dog vaccination to communities; but as demonstrated by numerous studies, the pulse approach did not attain vaccination coverage even up to the minimum threshold; b)

however, because CBC-MDV is a more complex intervention, with several interacting components such as the involvement of local veterinary authorities and communities, local storage of dog rabies vaccines outside of the cold chain system, and a continuous approach to dog vaccine delivery, it requires more effort to set up and prepare all stakeholders to sufficiently perform their roles needed for successful implementation. Delivering mass dog vaccination using the pulse approach is simpler where adequate resources available.

## 4.2 Discussion

This study employed implementation science concepts including the UK-MRC guide on developing and testing complex intervention prior to full-scale evaluation, participatory community engagement processes and normalization process theory to explore how the development and implementation processes and contextual factors affected the effectiveness and routinization of a community-based, continuous approach for delivering mass dog vaccination campaigns. The findings demonstrated that: a) it was feasible to deliver CBC-MDV in the context of Tanzania and it performed better in terms of achieving the required vaccination coverage to interrupt transmission of rabies compared to the pulse, b) certain population-related factors influence knowledge of dog handling which has implications for owner participation in dog vaccination and these can be improved via community engagement activities, c) CBC-MDV was well understood, accepted, operationalized with relative ease and positively rated against the pulse, and can be easily integrated and sustained in practice in Tanzania, d) however, broad, especially community participation in design, delivery and evaluation of CBC-MDV could foster ownership and sustainability of outcomes.

The iterative and multisectoral nature of the development workshops of CBC-MDV followed the one health principle. However, lack of community representation at the design stage of CBC-MDV and weak community entry processes at roll-out likely explains why some village leaders perceived the project as an avenue for making money, questioned the identity of OHCs or did not fully cooperate. More effective community entry processes could have enhanced participation, and strengthened collaborations between implementers and community leaders in mobilizing towards vaccination campaigns. This, potentially, could have led to increased community support and contributions to the implementation of CBC-MDV (Amazigo, 1999; Duamor *et al.,* 2017; Msoffe *et al.,* 2010; The Cummuty-Directed Interventions Study Group, 2010; Yirga *et al.,* 2010).

Globally, community participation in intervention delivery has evolved from communities as passive recipients, through communities as active participants in delivery to communities as co-designers of interventions (The Cummuty-Directed Interventions Study Group, 2010; World Health Organization & African Program for Onchocerciasis Control, 2012). The performance of the community-based personnel in the delivery of CBC-MDV components and outcomes of community-led interventions elsewhere show that communities can implement interventions such as dog vaccination campaigns if effectively engaged and supplied with logistics (The Cummuty-Directed Interventions Study Group, 2010; World Health Organisation & African Program for Onchocercisis Control, 2010).

The delivery of CBC-MDV components was feasible in the context, with more than 50% fidelity to the implementation manual. However, whilst components relating to managing vaccination logistics, organizing clinics and information recording were carried out with high fidelity, components aimed at ensuring that vaccination clinics proceeded smoothly were mostly omitted or implemented with low fidelity. These included community engagement, supervision of campaigns, separation of registration and inoculation points to minimize dog aggression, finding dogs that missed previous campaigns and establishing telephone contact among vaccinators and dog owners. The factors that influenced variation in fidelity to the implementation manual are attributable to the implementer's appreciation of the strategy components, the design of strategies/ components or the socio-physical context. For example, finding dogs that missed previous rounds, establishing telephone contact among vaccinators and dog owners at centers and muzzling of potentially aggressive dogs appeared practically challenging to implement. Finding dogs that missed previous campaigns was found to be labor intensive and a kind of 'fishing expedition' without prior knowledge of where these dogs live. In this regard, use of a village dog register which links names of dogs and their households was recommended in one of our publications, and the rabies research team in Mara is currently implementing this in 112 villages, which potentially will inform its scalability. Also, implementers expressed fear about muzzling a dog, others indicated the muzzles were too small or could tear in the process. This is line with findings by other process evaluation studies, where implementers not having ample time to assimilate the value(s) of intervention components, not feeling competent enough to deliver certain components or having unusable equipment resulted in low fidelity (Draper *et al.*, 2019; Gray *et al.*, 2013). As demonstrated by this study, providing information through community engagement does improve knowledge of dog behaviour and

handling, incorporating this into the training of vaccinators could reduce dog aggression and its negative impact on vaccination campaign outputs.

Who takes the household's dog for vaccination has implications for dog aggression? In exploring determinants of dog aggression, our model predicted that when the owner was less than 15 years of age (the age bracket who are likely to be the persons who feed the dog), the dog was less likely to struggle compared to when the owner aged 15 years or more. Moreover, if a dog owner was able to restrain their dog during inoculation, the dog was usually vaccinated without any struggles and where they were unable, it becomes difficult for the vaccinators (strangers) to restrain the dogs. This signifies the importance of bonding between dogs and their owners.

Another area of variation in implementation is the amount of efforts invested by the strategy teams. The marked decline in the number of vaccination days with each passing round of vaccination may be an indication of implementation fatigue. RCs serve large populations (3-4 villages/ ward on average) by providing many different extension services such as dipping of large herds of domestic animals, meat inspection at several locations, animal levy collection at cattle auctions and other routine duties. Conducting four rounds of dog vaccination campaigns alone was likely a substantial additional workload. It is also possible that the RCs did not consider the *continuous* component of CBC-MDV very critical, and assumed that they had vaccinated sufficient dogs in Round 1 without much consideration of the arrival of new dogs and puppies in villages. This is consistent with the findings of other studies, which cited staff 'burn out' as a barrier to implementing community-based interventions as intended (Chillag *et al.,* 2002; MacLeod *et al.,* 2012). How much work CBC-MDV adds to routine duties of implementers would be a useful consideration during replication and scale up of the approach. In this regard, a good example is Mexico, which used twice annual campaigns to achieve rabies-free status in 2019 (Pan American Health Organisation, 2020; United Against Rabies, 2022). This is further supported by the fact that the vaccinators in our study used around 85% of the days on two out of four rounds of campaigns but still achieved the required coverage.

The variation in implementation in terms of work inputs across the different strategies was influenced primarily by the design of the respective strategies. Though this was not statistically tested due to the limited sample size, to show how the timing and amount of advertising, as well as number of days used in conducting campaigns differed across the strategies, it offers insights into the differences in the coverage achieved by each strategy.

Strategy 1 required a larger effort over a shorter period of time for the implementers. However, because the vaccination activity of Strategy 1 occurred at a central point of the village, for many owners this strategy likely posed a challenge of access as they will be required to travel further to reach the central point. Living far from the point of the clinic has been cited by other studies as a reason for nonparticipation in vaccination clinics (Castillo-Neyra *et al.*, 2017, 2019; Mazeri *et al.*, 2018; Yoak *et al.*, 2021).

In comparison, Strategy 2, being hosted at the subvillage level, came with a relatively lighter workload on each vaccination day for the implementers. However, with multiple subvillages for every village, it required multiple days to complete the campaign (reaching 35 consecutive days). However, subvillage level clinics are easier for the owners to attend because of their closeness. It is noteworthy, that when given the discretion to choose, all Strategy 3 teams adopted the subvillage (Strategy 2) approach even though they reported it required more time. Suggesting that, empowering the implementers to select approaches may have fostered a stronger sense of ownership and desire to work harder and achieve more. This notion is supported by previous research where social motivation was found to enhance community participation in community level development activities (Siregar & Sismudjito, 2016). The discretion also may have allowed Strategy 3 teams to be more flexible in their schedules around personal and local events.

Strategy 3 teams also recorded a higher number of times and hours advertised per village and number of vaccination days per village, and this possibly explains why the annual average vaccination coverage achieved by Strategy 3 was marginally higher (Lugelo *et al.*, 2022). It suffices to mention that work output did not quite vary with the general trend of vaccination coverage achieved by the three strategies, pointing to possible moderating effects of contextual factors but which need to be explored further. However, the ability to use their discretion may have caused Strategy 3 teams to relax after the first round of clinics as they accounted for 3 out of the 7 missed rounds by all strategies and could be why they recorded a lower coverage at month 11. Given the differences in the prescribed activities, it seems logical that Strategy 1 teams would need to work harder during subsequent rounds to attain similar outputs as strategies 2 and 3. Frequent supervision from district veterinary officials and oversight by community leaders could have helped to sustain levels of campaign activities during subsequent rounds.

The strategy for a vaccination clinic has implications for how much time dog owners had to spend at the centers and the possible of dog aggression during vaccination. This study showed that dog owners spent longer time when attending to village level clinics and this could have implication for future participation in clinics. Also, the generalized linear model showed dog are likely to struggle when the total number of dogs vaccinated on the day was higher than 100, suggesting one possible benefit of using sub-village level approach, where there is less crowding of dogs and hence less likely to be aggressive. This in turn will help the clinic to proceed smoothly and swiftly.

Several local environmental, economic and sociocultural events also affected the feasibility of delivering the CBC-MDV components. These included school cycles, farming/ raining seasons, cattle auction markets, national elections/ mass cattle vaccinations, cultural festivities and funerals. Structural community participation in initializing and implementing the intervention could help take these events and issues into account during planning and delivery. Consequently, replication of CBC-MDV across wider contexts would benefit from tailoring campaign schedules to local environmental and social events or calendars (Castillo-Neyra *et al.,* 2017; Costa *et al.,* 2020; Welburn *et al.,* 2017). In this regard, the CBC-MDV strategy would be less impacted by local events compared to the pulse strategy. For instance, whilst both strategies can be affected by the timing of local events, the impact of disruption on a single day of a pulsed campaign would likely be more significant than the impact on several days of CBC-MDV campaigns as this latter strategy provides more timepoint access than the pulse strategy.

Though mass dog vaccination has been proven to control canine-mediated rabies, endemic countries have to battle with low dog owner participation and high operational costs of current approaches. It is widely documented that owner participation in dog vaccination campaigns is dependent upon their ability to restrain and take their dogs to the centers (Beyene *et al.,* 2018; Castillo-Neyra *et al.,* 2017; Robinson *et al.,* 1996; Thomas *et al.,* 2013; Wera *et al.,* 2015). Through community engagement, it was found that participant's ability to interpret dog body language and their knowledge of techniques for restraining and holding dogs at home and during vaccination was very low among our study population. This phenomenon is also reported by studies conducted in the Flores Island of Indonesia, in Peru, in Tanzania and in Ethiopia, where the inability to restrain dogs was a common reason why owners failed to send their dogs for vaccination (Beyene *et al.,* 2018; Castillo-Neyra *et al.,* 2017; Lugelo *et al.,* 2022;

Wera *et al.,* 2015). Also, poor knowledge of dog behavior and safe ways to interact with aggressive or stray dogs could be a precursor for dog bites, and could in turn discourage good relationships between people and dogs. Participants' knowledge of dog behaviour (body language interpretation), knowledge of ways of averting dog attack and of ways of limiting injury when attacked by a dog significantly improved after the engagement activities. This suggests that if the population is regularly engaged and provided with information on these topics, its knowledge will improve and potentially improve its ability to take their dogs for vaccination as these have been reported to influence owners' intention to participate in dog vaccination campaigns (Wera *et al.,* 2016).

In this regard, opportunities exist at village levels for regular delivery of talks on dog behavior and dog vaccination to communities. This can either be assigned to the ward-level livestock field officers (in the context of Tanzania) as part of their animal health extension duties or to duly selected community-based people with some knowledge of animal husbandry practices who can be trained to deliver these talks at community meetings. These lay people have previously been used in Tanzania to deliver Newcastle Disease vaccinations (Bessell *et al.,* 2017; De-Bruyn *et al.,* 2017; Msoffe *et al.,* 2010) and rabies (Kaare *et al.,* 2009). Similarly, community structures or people also have been used in communicating programme objectives and benefits to communities (Msoffe *et al.,* 2010). This study showed that people are likely to benefit from information prepared in the forms of posters and leaflets which they potentially could keep for long periods. The majority of respondents in this study were found to still have the posters neatly pasted in their living rooms 3 months after they were given out.

However, sustaining the interests of communities in discussing dog vaccination can be challenging. In the fishing communities of this study for example, dogs are usually seen as a nuisance by non-dog owners because they eat their sardines (dried in the open). There also was the impression from livestock keepers that getting treatment for livestock diseases is of higher priority than dog vaccination. Integrating approaches for local disease control programmes could help foster interest. For instance, discussing dog vaccination alongside vaccination for other livestock, enforcement of local dog vaccination laws and recognition or rewarding of community leaders where high vaccination coverage is achieved could foster prioritization of dog vaccination. Also, media platforms such as national television and radio stations can deliver regular segments as part of national mass dog vaccination mobilization strategies to inform the population on dog behavior and dog handling techniques. The means of

communication (posters, leaflets, flip charts, video screenings and village level forums) used in the context of our community engagement were extensive and intensive, and likely explains why they had a significant impact on knowledge. Therefore, it will require much commitment to scale up and sustain these means of engagement at national levels due to cost. The pictorial illustrations of posters also may have aided learning even by those who could not read.

It is also noteworthy that participants' baseline knowledge of dog behavior and handling, and safe ways to interact with dogs, was not significantly associated with level of education. This makes sense as in a rural setting in Tanzania, older residents are less likely to have high level of education (32% had no formal education): but as shown by the model, older people will tend to have higher knowledge level, possibly due to longer experience with dogs. Similarly, participating in a recent vaccination campaign was associated with decreased odds of scoring high on knowledge level. This could be explained by the observation that knowledge level increased with age but it is younger people who usually take the households' dog(s) for vaccination (Sambo *et al.,* 2014; Sikana *et al.,* 2021).

Understanding population-related factors that predicted knowledge level on dog behavior, dog handling and safe ways to interact with dogs can be useful in defining the target group for interventions aimed at mobilizing the population for mass dog vaccination campaigns. An individual's knowledge on dog behavior and handling techniques have been cited as influencers of owner participation in mass dog vaccination campaigns in Peru, the Philippines, Indonesia and Grenada (Castillo-Neyra *et al.,* 2017; Robinson *et al.,* 1996; Thomas *et al.,* 2013; Wera *et al.,* 2015).

Another potential barrier to owner participation is negative perception of the impact of vaccines on dogs: these include 'dogs will develop skin rashes', 'become infertile', 'docile or die' when vaccinated (Beyene *et al.,* 2018). Although these negative perceptions were not widely held among our study population, they could have a significant influence on owner participation if held by a socially important figure. Also, the perceptions were significantly influenced by the engagement activities, possibly due to the fact that they were held by very few people and for a very long time, and could not be improved through engagement only. It might take people actually vaccinating their dogs and observing the outcomes in order to change their perceptions, as owners intention to vaccinate their dogs was also found to be positively associated with perceived benefits and trust in the vaccine (Beyene *et al.,* 2018). However, it would be useful to systematically investigate and document adverse events after dog vaccination to inform

community engagement toward dog vaccination. As people may associate the high mortality rates in puppies with vaccination and could reinforce belief that the vaccine causes death. It is also possible that some forms of adverse events occur on a small scale in vaccinated dogs but these may be insignificant compared to the benefits of the vaccine. A study conducted in the Philippines actually reported that owners of 20% of vaccinated dogs said they observed some form of adverse reactions in their pets (Robinson *et al.,* 1996). The limited prevalence of these perceptions also suggests the need to focus on dealing with other known barriers to owner participation such as the ability to restrain dogs and charging of vaccination fees.

An effective way to encourage dog owner participation in vaccination campaigns could be to involve communities in the design, implementation and evaluation of mass dog vaccination campaign strategies (World Health Organization & African Program for Onchocerciasis Control, 2012). This was demonstrated during the community engagement: outlining activity components of mass dog vaccination campaigns and assigning roles to communities with participation of community leaders showed it is feasible for communities to participate fully in the planning and execution of mass dog vaccination campaigns. This may also result communities contributing both simple material and human resources with the potential to reduce campaign costs. For instance, community-based people were involved in the development of the low-tech, passive cooling clay devices (Lugelo *et al.,* 2020). Arguably, communities can contribute locally made waste bins, in addition to tables and chairs, registers, and advertising of campaigns. This was demonstrated by mass dog vaccination campaign cost components description studies in Chad and Kenya (Ferguson *et al.,* 2020; Kayali *et al.,* 2006; Mindekem *et al.,* 2017). A review also found that community participation in planning and delivery of interventions was the most frequently cited facilitating factor in the success of the community-based, lay animal vaccinator programmes. The community leaders actually performed most of the roles assigned to them during the demonstration vaccination in this engagement, lending credence to the feasibility of their participation.

A key step rabies endemic countries must take to reach the zero human by 2030 agenda will be to create the human resource capacity to vaccinate adequate number of dogs (Wallace *et al.,* 2017). Evaluating the processes of CBC-MDV showed that communities can play key roles such as announcing the vaccination campaigns, assisting as dog handlers and certification of vaccinated dogs, and to conduct vaccination coverage estimation. Also, vaccinators can be drawn from a wide range of sectors of society to complement the veterinary staff, with the

examples of Brazil and Mexico, this can include: students, community volunteers, health workers, environmental health officers, emergency/ disaster/ rescue/ security forces (Pan American Health Organisation, 2020; United Against Rabies, 2022). Recruiting lay animal vaccinators from professional workforces could cure the potential pitfall of them going ahead to provide animal health services beyond their training as these people already have sources of income. The case of Mexico was made possible through the One Health approach involving state agencies, academia and NGOs.

Another example of local contribution is community self-monitoring of locally delivered intervention. Including communities in evaluating outcomes of CBC-MDV is likely to foster ownership and sustained efforts at delivering components. Community participation in evaluating local interventions has been gaining traction and, for example, was a key component of the community-directed treatment with ivermectin (CDTI) model introduced by the African Programme for Onchocerciasis Control (The Cummuty-Directed Interventions Study Group, 2010; World Health Organization & African Program for Onchocerciasis Control, 2012). In the CDTI model, a 3-member committee selected by each village carried out community self-monitoring of mass distribution of ivermectin, thereby checking the performance of distributors and compliance of community members. In the process, challenges were identified and resolved with participation of community leaders. Lessons and strategies such as those outlined above and those generated from this study could be incorporated into CBC-MDV to ensure its successful replication.

Whilst the community structure of Tanzania is suitable for inclusion in planning, organizing and monitoring of dog vaccination campaigns, certain barriers such as lack of traction for volunteerism and lack of prioritization of welfare of dogs exist and may hamper strong representation of dog vaccination on the agenda of communities. For example, community people asking for incentives was cited to have derailed implementation of community self-monitoring in the community-directed treatment with ivermectin programme (Duamor *et al.*, 2017). However, these barriers could be removed with comprehensive community entry processes or with incentives (such as enlisting of organizing of mass dog vaccination as part the key performance index for community leaders and linking of rabies outcomes to their promotion) to fully bring communities on board with mass dog vaccination campaigns. Again, deepening consensus on community roles and possibly crafting local government legislation or by-laws to back them up can be helpful.

The average coverage of the demonstration vaccination led by the community leaders was about 19 percentage points above the critical minimum threshold (40%), and conducting the campaigns two or three times annually could sustained coverage above this threshold. However, given the low dog population of the sub-villages, it can be expected that almost all of the dogs should have been vaccinated. The mobilization likely was affected by the facts that these communities were new to mass dog vaccination, the mobilization being volunteer-based and also there was a change in the community leadership between the time of planning and execution of the vaccination exercise. This lends credence that a community-led mass dog vaccination campaigns can achieve and sustain adequate vaccination coverage.

Consequently, factors that will determine whether CBC-MDV will be integrated and sustained in practice within the context of Tanzania were explored using the normalization process theory (NPT). Exploring these factors through the lens of the NPT constructs revealed CBC-MDV was well understood, accepted, operationalized with relative ease and positively appraised by implementers and communities.

The coherent sense making of CBC-MDV by implementers and communities appeared to be due to the training of implementers before rollout and more than 12 months of interaction with the intervention. Having clear understanding of how CBC-MDV was designed to function helped value judgments of the process-outcome chains and led to clear differentiation of CBC-MDV from the pulse approach. As noted previously, having a good knowledge of CBC-MDV could have fostered acceptance on the part of implementers and communities (Leydon & Dahl, 2008; Merrell *et al.,* 2012). A broader participation in design of CBC-MDV could further enhanced common understanding of its purpose and elicited stronger willingness to implement (Tapanainen *et al.,* 2016).

Implementers and communities perceived their roles in CBC-MDV as part of their jobs, that fit well into their routines and made it simpler for them to deliver it. How much time implementers have to understand a new practice; regarding how it might impact existing routines, operational tasks and regulations required, and its advantages, influences how an intervention is enacted into practice (Elf *et al.,* 2018). These reflections are also important for legitimization and buy-in to a new intervention and are key to successful implementation (Finch *et al.,* 2012; Lewis *et al.,* 2012; Mair *et al.,* 2012). Despite the acceptance of CBC-MDV by those involved, respondents also considered how its design, implementation and evaluation could be improved with many suggesting it was important for communities to be more directly

involved in these processes. Co-design is cited to afford implementers and communities opportunities to contribute towards building understanding of how a new intervention could work (Ross *et al.,* 2018; Rostami *et al.,* 2018), with subsequent increased tendency for adoption and ownership (Fobi *et al.,* 2015; World Health Organization & African Program for Onchocerciasis Control, 2012). Local politics, cited as a barrier to collaboration between community leaders and implementers in CBC-MDV demonstrates how people with vested political interests might derail or capture collaborative efforts to their advantage (Walker & Hurley, 2004). Evidence of this was described in a report of a community-based programme delivering Newcastle Disease vaccine where it was reported that the question of who controlled the resources and power that came with the project strained relationships among community leaders and vaccinators (Bagnol, 2012).

The implementation of CBC-MDV was operationalized with relative ease because sufficient resources were provided for effective training of implementers and it fit well into their routines. Additionally, ease of delivery of CBC-MDV was ensured through availability of resources such as space in district and village offices for fridges and storage of vaccination materials and passive cooling devices, respectively, the availability of tables and chairs from village offices for use during clinics and funds from the research project. This suggests that, outside of this project, if funding is secured and the strong community leadership support for CBC-MDV is harnessed, CBC-MDV can be integrated (Holtrop *et al.,* 2016) and sustained in practice (Fobi *et al.,* 2015; World Health Organization & African Program for Onchocerciasis Control, 2012) in Tanzania. In contrast to findings of other studies, where implementers resisted new interventions because operational tasks and the realities of the new intervention added complexities or required additional efforts or time to deliver (Asiedu *et al.,* 2019; Foster *et al.,* 2016; Moulin *et al.,* 2011), CBC-MDV was accepted by implementers as it fitted well into their routines and matched their skills. Similarly, in a bone fracture prevention study, it was noted that putting in place designated services coordinators freed up healthcare professionals and enhanced their capacity to enact components of the intervention (Drew *et al.,* 2015). The training CBC-MDV implementers received also facilitated its operationalization. As noted by another study, the amount of training implementers are given influenced enactment and routine use of a new intervention (Holtrop *et al.,* 2016).

The CBC-MDV implementation manual prescribed that the district veterinary office and the research team will provide feedback on vaccination coverage to communities after each round,

and communities to monitor delivery of CBC-MDV; these were not implemented. The spread of COVID-19 during the time of the study likely contributed to this lack of engagement from the research team. But also, feedback activities imposed extra work, which may have deterred implementers from carrying them out. This is similar to findings from an implementation study of a digital patient feedback intervention where the health staff perceived feedback activities as an added burden (Ong *et al.*, 2020). The elaborate community leadership structure of Tanzania (a significant administrative connection among ward, village, sub-village, hamlet and household leaderships) provides a good platform to establish village-level monitoring of CBC-MDV delivery. Reflexive monitoring also permits value judgements of an intervention and whether it should be sustained in practice (Bamford *et al.*, 2012). In this regard, both communities and implementers recommended CBC-MDV to be adopted as the standard approach for delivering MDV across the country. This suggests CBC-MDV could be integrated and sustained in practice should large-scale evaluation results support its dissemination nation-wide.

However, sustaining the effectiveness of CBC-MDV at reaching more dogs hinges largely on sustained dog owner awareness of the need to vaccinate their dogs annually. The campaign outputs shown implementers spent the same number of days on vaccination clinics in year 2 as year 1, an indication that the momentum of campaign activities was sustained, however, number of animals vaccinated in year 2 was about one-third lesser. The qualitative review of this finding revealed many dog owners were not aware that dogs have to be vaccinated every year. Consequently, implementation of CBC-MDV component aimed at getting communities involved must be maintained to ensure sustainability of CBC-MDV outcomes and ownership of its implementation processes. Clearly, achieving sustained adequate dog-owner participation in MDV campaigns in current endemic countries hinges to a large extent on effective rabies education. The Global Alliance for Rabies Control asserts that the benefits of rabies education include improved human-dog relationship, increased participation in dog vaccination, decreased dog bites and increased adherence to post-exposure prophylaxis use (Global Alliance for Rabies Control, 2016).

# CHAPTER FIVE

# CONCLUSION AND RECOMMENDATIONS

## 5.1 Conclusion

The development of CBC-MDV employed an iterative, One Health approach and incorporated extensive stakeholder views, leading to stakeholder acceptance of the approach. However, including community-level decision makers/ leaders in the process could have fostered stronger ownership at community levels as well. It was feasible to deliver CBC-MDB in the context of Tanzania. Intervention-, implementer- and context-related factors influenced delivery of CBC-MDV components and the effectiveness of the strategies in reaching more dogs. The CBC-MDV strategies sustained vaccination coverage well above the minimum critical threshold (approximately 40%) throughout the year whilst the pulse strategy failed to achieve the required vaccination coverage of ≥70%.

There was low level of knowledge on effective and safe dog handling techniques among the study population (dog owners and vaccinators), which could make people uncertain in their ability to restrain and take their dogs to vaccination centers or cause dog aggression during inoculation. Interacting with the communities on rabies and dog vaccination improved their knowledge of dog behavior and handling and their perceptions of the benefits of dog vaccination. Identified barriers (such as low dog owner participation and prohibitive campaign operational costs) to mass dog vaccination campaigns can be addressed through community engagement. As the results showed community members can deliver components of mass dog vaccination campaigns, including planning and delivery processes, with potential for cost savings.

This work also suggests that CBC-MDV has the potential to be integrated and sustained in the context of Tanzania. However, enabling broad community (all members – including non-dog owners) participation in the design, implementation, evaluation and sharing of feedback on CBC-MDV activities among stakeholder, especially with communities; as well as close supervision and monitoring of implementation processes, could improve tailoring of the intervention to local contexts, strengthen community interest in and contributions towards delivery of CBC-MDV strategies resulting in high fidelity and vaccination outcomes in a more sustainable manner.

## 5.2 Recommendations

We make the following recommendations, situated within the confines of the findings of this study:

(i) The national rabies control task force should adopt CBC-MDV for the delivery of mass dog vaccination across Tanzania. We also recommend CBC-MDV to all rabies endemic countries. However, the approach should always be adapted in response to differing contextual factors.

(ii) During introduction and initializing of CBC-MDV, implementing institutions should employ due community entry processes should be employed to consult, sensitize and involve communities, especially in planning when vaccination activities should take place and possible activities that communities can perform during the campaigns. This has the potential to benefit the process in the following ways: a) community input will help to better tailor activities around local socioeconomic and physical events to minimize disruption of vaccination schedules; b) communities can contribute material and human resources toward campaigns, potentially reducing up to 30% of cost to government; and c) CBC-MDV could become embedded into local schedules for animal health activities such as dipping, with the potential for better adherence by dog owners.

(iii) We recommend that endemic countries should create community dog registries, with names of dogs linked to their households, and will be ticked during vaccination clinics as dogs are vaccinated. Thus, dogs that missed a round of vaccination and where they live can easily be identified and targeted. This also potentially will facilitate effective logistics planning, and accurate, timely and less costly coverage estimation after campaigns.

(iv) We recommend that endemic countries should adopt campaign schedules composed of 2 rounds of vaccination (at the village / sub-village level) per year, with robust arrangements for on-demand to target new dogs and puppies that arrive in the village and dogs that missed previous vaccination rounds, could be sufficient and more manageable for RCs given their other animal health duties. This is supported by the elimination scenario of Mexico.

(v) To encourage frequent supervision and higher number of days spent vaccinating dogs, implementing institutions should adopt a remuneration system that is based on performance: a portion of implementers' salaries can be paid as bonuses/ allowances upon delivery of certain indicators: e.g., for RCs - carrying out all rounds of campaigns of the year, complete & timely monthly reporting, achieving coverage above a minimum threshold at month 11, no animal rabies cases recorded in the ward; for district veterinary officers – number of verifiable supervision days, number of feedback provided to research team and or communities

(vi) We recommend to the veterinary authorities of Tanzania consider use of lay vaccinators to support veterinary in vaccinating dogs (drowned from students, security personnel, teachers, nurses, environmental health officers etc): with clearly outlined selection and recruitment process; standardized training curriculum (duration and content); and mechanism for monitoring and appraisal.

Based on the findings and limitations of this study, we also propose further studies by individuals and research organizations in the following areas to further support the generatability of the findings and to support scale up and replication of the CBC-MDV strategies in similar socioeconomic settings:

(i) Need for further studies to explore moderating effects of contextual factors on the impact pathways of the CBC-MDV strategies.

(ii) A larger study is needed to establish the feasibility and sustainability of community participation in mass dog vaccination.

(iii) Process evaluation studies of the delivery of CBC-MDV in a broader and in varying settings such urban and nomadic communities

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# APPENDICES

## Appendix 1: Delivery of 45 components the community-based continuous mass dog vaccination approach Compared to what was Planned

| CBC-MDV COMPONENTS | LEVEL OF FIDELITY TO IMPLEMENTATION PROTOCOL | | | |
|---|---|---|---|---|
| | Delivered as planned (44%) | Not delivered as planned (31%) | Modified/ partly delivered (20%) | Delivered in excess of what was planned (5%) |
| **(i) Local delivery of CBC-MDV to be led by district level veterinary authorities** | | | | |
| District veterinary office to receive and manage stocks of vaccination materials | ✓ | | | |
| District veterinary office will coordinate transport of materials to wards and ensure unused vaccines after six months are returned and properly labeled for storage | | ✓ | | |
| District veterinary office to be responsible for monitoring implementation of CBC-MDV components | | ✓ | | |
| District veterinary office to introduce village-based One Health Champions (OHCs) to village leadership with letter before campaign starts | ✓ | | | |
| **(ii) Involvement of village level leadership in roll out of CBC-MDV** | | | | |
| The OHCs to introduce themselves to village leaders using a letter from District veterinary office | | | ✓ | |
| OHC to sensitize leadership of villages, schools, churches, mosques, neighborhood groups, NGOs/firms (if any) on: burden of rabies, benefits of mass dog vaccination, the campaign and their expected roles; 7-10 days before campaigns begin | | | ✓ | |
| OHCs and RCs to draw timetable and communicate plans to village chairman/executive officers, get permission to advertise campaigns | | | ✓ | |
| OHCs and RCs to ask village officers to encourage/mobilize villagers to bring their dogs for vaccination | | | ✓ | |
| OHC to request estimate of dogs in ten-cell compartments of village from 'mabalozi' (leaders of) and send total for the village to RC before campaign | | ✓ | | |

| CBC-MDV COMPONENTS | LEVEL OF FIDELITY TO IMPLEMENTATION PROTOCOL | | | |
|---|---|---|---|---|
| | Delivered as planned (44%) | Not delivered as planned (31%) | Delivered as planned (44%) | Delivered in excess of what was planned (5%) |
| **(iii) Use of trained village-based One Health Champions to support ward-level rabies coordinators to carry out vaccination activities** | | | | |
| OHCs will estimate dog population of their respective villages | ✓ | | | |
| OHC to sensitize villagers about forthcoming vaccination clinics at village meetings | | | ✓ | |
| OHCs to visit houses after each round and compile a list of dogs that missed vaccination and plan with RC to vaccinate them, also document pregnant dogs | | ✓ | | |
| OHCs to give their telephone number out to villagers (during sensitization meetings, advertising and clinic days) to call them anytime if they have concerns about rabies or if they have new dogs or puppies that need to be vaccinated in between campaigns | | ✓ | | |
| OHCs to advertise vaccination clinic using posters, loud speaker or word of mouth | ✓ | | | |
| On day of vaccination OHC will assist RC by entering dog data into register, issue vaccination certificates, restraining of dogs and putting on of collar where necessary | | | | ✓ |
| **(iv) Widespread communication at village level about CBC-MDV and advertising of campaigns using multiple forms of communication and venues** | | | | |
| Advertising of campaigns to be done a day before | | | | ✓ |
| Advertising of vaccination clinics to made at popular places like schools, market squares, churches and mosques, and village meetings | ✓ | | | |
| OHCs and RCs to inform targeted households for house-to-house campaigns through ‘mabalozi’ (leaders of cluster of ten houses) | | | ✓ | |

| CBC-MDV COMPONENTS | LEVEL OF FIDELITY TO IMPLEMENTATION PROTOCOL | | | |
|---|---|---|---|---|
| | Delivered as planned (44%) | Not delivered as planned (31%) | Delivered as planned (44%) | Delivered in excess of what was planned (5%) |
| **(v) Use of locally designed cooling clay pots to store rabies vaccine in wards** | | | | |
| Rabies Coordinators (RCs) to send request for materials, accompanied with dog population estimate for ward, via sms, then call district veterinarian to schedule a day for pick up | ✓ | | | |
| RCs to liaise with DLFO to coordinate transport of new batches of vaccines from district office to ward | ✓ | | | |
| Equipment and vaccines will be requested based on dog population of ward | ✓ | | | |
| RCs to store batches of vaccines in cooling pots on six monthly bases to ensure vaccines that have stayed outside of the cold chain for more than six months are not used | ✓ | | | |
| RCs to return unused vaccines at the end of the sixth month period to DLFDO's office to be labelled 'X' with a black marker pen and stored | | ✓ | | |
| RCs to return used needles and microchip units to DLFDO's office or health center for proper disposal | | | ✓ | |
| RCs to place cooling pot in the appropriate place at home, add water regularly | ✓ | | | |
| RCs to monitor and record temperature of pot daily | ✓ | | | |
| **(vi) A continuous approach to MDV activities; quarterly basis and available on demand by dog owners all year round** | | | | |
| Vaccinators were to organize quarterly vaccination campaigns: Central point campaign strategy by all arms during month 1 vaccination | | | ✓ | |
| During subsequent rounds, vaccinators can adopt house-to-House approach to reach more dogs | ✓ | | | |
| Throughout the year, teams will provide vaccination services to owners on-demand: vaccinators can either visit owner or ask owner to bring dog upon call from owner | ✓ | | | |
| Subsequent to each round, OHCs will go around their villages to document dogs the missed the previous round to be targeted for vaccination | | ✓ | | |
| The vaccinators were to ensure villagers have continuous access to vaccination by giving out their telephone contacts | | ✓ | | |

| CBC-MDV COMPONENTS | LEVEL OF FIDELITY TO IMPLEMENTATION PROTOCOL | | | |
|---|---|---|---|---|
| | Delivered as planned (44%) | Not delivered as planned (31%) | Delivered as planned (44%) | Delivered in excess of what was planned (5%) |
| **(vii) Delivery of free dog vaccination clinics using suitable approaches** | | | | |
| Vaccination clinics were to start from 08 HOURS and end 14 HOURS | | | ✓ | |
| Registration center set approximately 20 meters apart from the inoculation and microchipping center | | ✓ | | |
| Team to use muzzles on potentially aggressive dogs | | ✓ | | |
| Dog owners to stand in queues to ensure first-come first-served and to reduced fighting among dogs | ✓ | | | |
| Dog owners to leave immediately with their dogs after vaccination to avoid crowding of dogs | ✓ | | | |
| All animals vaccinated will have their biodata entered into a local register (to be kept at ward level) and an online database, certified, microchipped and collared | ✓ | | | |
| Vaccination of dogs will be delivered free of charge | ✓ | | | |
| Vaccination team to deliver subsequent campaigns using approaches they deemed appropriate | ✓ | | | |
| **(viii) Monitoring and feedback on vaccination coverage among research team, district veterinary authorities, vaccinators and communities** | | | | |
| District veterinary office to supervise and monitor implementation of campaigns | | ✓ | | |
| OHCs to prepare weekly reports on dogs needing vaccination and other issues to be discussed with RC in weekly report | | ✓ | | |
| Research team to give feedback to communities after first round of data collection | | ✓ | | |
| A 3-member committee selected by the village executive to conduct community self-monitoring to see if RCs, OHCs and villagers are working together to ensure all dogs are vaccinated | | ✓ | | |
| OHCs to conduct transect after the day's clinic to access vaccination coverage | ✓ | | | |
| RCs to provide summary reports on number of animals vaccinated, temperature of cooling pot and rabies events to DLFDO's office/research team via WhatsApp | ✓ | | | |

*OHCs: One Health Champions, *MDV: Mass Dog Vaccination, *RCs: Rabies Coordinators

## Appendix 2: Comparison of fidelity and reasons for variations in delivery of components of the community-based continuous mass dog vaccination approach by strategy arms

| CBC-MDV COMPONENTS | Strategy 1 | Strategy 2 | Strategy 3 | Total No. of teams (*N*=9)/ One Health Champions (*N*=35) who delivered component |
|---|---|---|---|---|
| | No. of teams (*N*=3)/ One Health Champions (*N*=12) who delivered component | No. of teams (*N*=3)/ One Health Champions (*N*=13) who delivered component | No. of teams (*N*=3)/ One Health Champions (*N*=10) who delivered component | |
| **Involvement of village level leadership in roll out of CBC-MDV** | | | | |
| The OHCs who introduced themselves to village leaders using a letter from District veterinary office | 8 | 13 | 10 | 31 |
| OHC who sensitized leadership of villages, schools, churches, mosques, neighborhood groups, NGOs/firms (if any) on: burden of rabies, benefits of mass dog vaccination, the campaign and their expected roles; 7-10 days before campaigns begin | | | | |
| RCs who discussed their timetable with village chairman/ executive officers, get permission to advertise campaigns | 0 | 2 | 2 | 4 |
| OHCs who asked village officers to encourage/ mobilize villagers to bring their dogs for vaccination | 2 | 8 | 9 | 19 |
| OHCs who requested estimate of dogs in ten-cell compartments of village from 'mabalozi' (leaders of cluster of ten houses) and send total for the village to RC before campaign | 3 | 0 | 0 | 3 |
| **Use of trained village-based One Health Champions to support ward-level rabies coordinators** | | | | |
| OHCs who estimated dog population of their respective villages | 12 | 13 | 10 | 35 |
| OHCs who sensitized villagers about forthcoming vaccination clinics at village meetings | 2 | 8 | 9 | 19 |
| OHCs who advertised vaccination clinic using posters, loud speaker or word of mouth | 12 | 13 | 10 | 35 |
| OHCs who assisted RCs on day of vaccination entering dog data into register, issue vaccination certificates, restraining of dogs and putting on of collar where necessary | 12 | 13 | 10 | 35 |
| **Advertising of campaigns** | | | | |
| OHCs who advertised vaccination campaigns a day before | 12 | 13 | 10 | 35 |
| OHCs who advertised vaccination clinics at popular places like schools, market squares, churches and mosques | 12 | 13 | 10 | 35 |
| Teams who informed targeted households for house-to-house campaigns through 'mabalozi' (leaders of cluster of ten houses) | - | - | - | - |

| **CBC-MDV COMPONENTS** | **Strategy 1** | **Strategy 2** | **Strategy 3** | Total No. of teams (*N*=9)/ One Health Champions (*N*=35) who delivered component |
|---|---|---|---|---|
| **Use of locally designed cooling clay pots to store rabies vaccine in wards** | | | | |
| RCs who sent request for materials, accompanied with dog population estimate for ward, via sms, then call district veterinarian to schedule a day for pick up | 3 | 3 | 3 | 9 |
| RCs who liaised with DLFO to coordinate transport of new batches of vaccines from district office to ward | 3 | 3 | 3 | 9 |
| RCs who requested equipment and vaccines based on 80% of dog population of ward | 3 | 3 | 3 | 9 |
| RCs who stored batches of vaccines in cooling pots on six monthly bases to ensure vaccines that have stayed outside of the cold chain for more than six months are not used | 3 | 3 | 3 | 9 |
| RCs who returned unused vaccines at the end of the sixth month period to DLFDO's office to be labelled 'X' with a black marker pen and stored | 1 | 1 | 0 | 2 |
| RCs who returned used needles and microchip units to DLFDO's office or health center for proper disposal | 2 | 2 | 1 | 5 |
| RCs who placed cooling pot in the appropriate place at home, added water regularly | 3 | 3 | 3 | 9 |
| RCs who monitored and recorded temperature of pot daily | 3 | 3 | 3 | 9 |
| **Providing continuous access to dog vaccination** | | | | |
| Teams who organized quarterly vaccination campaigns: Central point campaign strategy by all arms during month 1 vaccination | 9 out of 12 | 11 out of 12 | 9 out of 12 | 29 out of 36 |
| Number of days vaccinators adopted House-to-House approach to reach more dogs during subsequent rounds | 3 days of HTH | 10 days of HTH | 15 days of HTH | - |
| Number of days throughout the year that teams provided vaccination services to owners on-demand: either visited owner or asked owner to bring dog upon call from owner | 7 days of on-demand | 8 days of on-demand | 5 days of on-demand | - |
| OHCs who visited houses after each round and compiled lists of dogs that missed vaccination and planned with RC to vaccinate them, also documented pregnant dogs | Not done | Not done | Not done | - |
| OHCs who gave their telephone number out to villagers (during sensitization meetings, advertising and clinic days) to call them anytime if they have concerns about rabies or if they have new dogs or puppies that need to be vaccinated in between campaigns | Not done | Not done | Not done | - |

| **CBC-MDV COMPONENTS** | **Strategy 1** | **Strategy 2** | **Strategy 3** | Total No. of teams (*N*=9)/ One Health Champions (*N*=35) who delivered component |
|---|---|---|---|---|
| **Delivery of free dog vaccination clinics using suitable approaches** | | | | |
| Vaccination clinics were to start from 08 HOURS and end 14 HOURS | Varied tart and closing time | Varied start and closing time | Varied start and closing time | - |
| Teams who set registration center approximately 20 meters apart from the inoculation and microchipping center | Not done | Not done | Not done | - |
| Teams who muzzled on potentially aggressive dogs | Not done | Not done | Not done | - |
| Dog owners to stand in queues to ensure first-come first-served and to reduce fighting among dogs | Delivered as planned | Delivered as planned | Delivered as planned | - |
| Dog owners to leave immediately with their dogs after vaccination to avoid crowding of dogs | Delivered as planned | Delivered as planned | Delivered as planned | - |
| All animals vaccinated will have their biodata entered into a local register (to be kept at ward level) and an online database, certified, microchipped and collared | Delivered as planned | Delivered as planned | Delivered as planned | - |
| Vaccination of dogs will be delivered free of charge | Delivered as planned | Delivered as planned | Delivered as planned | - |
| Vaccination team to deliver subsequent campaigns using approaches they deemed appropriate | Delivered as planned | Delivered as planned | Delivered as planned | - |
| **Monitoring and feedback on vaccination coverage among stakeholders** | | | | |
| RCs who reported district veterinary office supervised and monitored implementation of campaigns | Not done | Not done | Not done | - |
| OHCs who prepared weekly reports on dogs needing vaccination and other issues to be discussed with RC in weekly report | Not done | Not done | Not done | - |
| Research team to give feedback to communities after first round of data collection | Not done | Not done | Not done | - |
| A 3-member committee selected by the village executive to conduct community self-monitoring to see if RCs, OHCs and villagers are working together to ensure all dogs are vaccinated | Not done | Not done | Not done | - |
| OHCs to conduct transect after the day's clinic to access vaccination coverage | 12 | 13 | 10 | 35 |
| RCs to provide summary reports on number of animals vaccinated, temperature of cooling pot and rabies events to DLFDO's office/research team via WhatsApp | 3 | 3 | 3 | 9 |

## Appendix 3: Utility of approaches and number of rounds of vaccination clinics organized by strategy arms

| Strategy Arms | How vaccination clinics were organized by strategy arms during rounds of campaigns | | | |
|---|---|---|---|---|
| | **Round-1: Month-1** | **Round-2: Month-3** | **Round-3: Month-6** | **Round-4: Month-9** |
| **Strategy One Buswahili** | A-day village level temporal static point clinics for 4 villages | A-day village level temporal static point clinics for 3 villages: 2 days for 1 village with many dogs | A-day village level temporal static point clinics for 3 out of 4 villages + 3 on-demand | No campaign activity |
| **Strategy One Tai Ward** | A-day village level temporal static point clinics for 4 villages | 7, a-day temporal static point clinics for selected subvillages | No campaign activity | 1day temporal static point clinics for 2 subvillages + 2 on-demand |
| **Strategy One Gorong'a Ward** | A-day village level temporal static point clinics for 3 villages: 2 days for 1 village with many dogs<br>Team then followed with 9, a-day temporal static point clinics for single or combined subvillages after 3 weeks | 7, a-day temporal static point clinics for selected subvillages | 3 days house-to-house for scattered houses + temporal static point clinics for clustered houses + 2 on-demand | No campaign activity |
| **Strategy Two Sirorisimba Ward** | 14, a-day Subvillage level temporal static point clinics | 7, a-day temporal static point clinics for single or combined subvillages | 6, a-day temporal static point clinics for single or combined subvillages | 2, a-day temporal static point clinics for single or combined subvillages + 3 on-demand |
| **Strategy Two Mkoma Ward** | 20, a-day Subvillage level temporal static point clinics | 6 village level temporal static point clinics | 2-day house-to-house campaigns + 3 on-demand | No campaign activity |
| **Strategy Two Nyanungu Ward** | 27, a-day Subvillage level temporal static point clinics | 6 days mixed village, subvillage level temporal static point, house-to-house clinics + 2 on-demand | 4-day house-to-house campaigns | A-day house-to-house campaign |
| **Strategy Three Nyamemange Ward** | 8, 2 combined subvillages level temporal static point clinics per day | 6, 2 combined subvillages level temporal static point clinics per day | No campaign activity | No campaign activity |
| **Strategy Three Bukura Ward** | 35, a-day subvillage level temporal static point clinics | 5 village level temporal static point clinics | 5-day house-to-house campaigns + 4 on-demand | No campaign activity |
| **Strategy Three Itiryo Ward** | 15, a-day subvillage level temporal static point clinics | 12 days mixed subvillage level temporal static point & house-to-house clinics | 7 days mixed subvillage level temporal static point & house-to-house clinics | A-day house-to-house campaign + 1 on-demand |

## Appendix 4: The CPE interventions, number of people reached and how they were evaluated

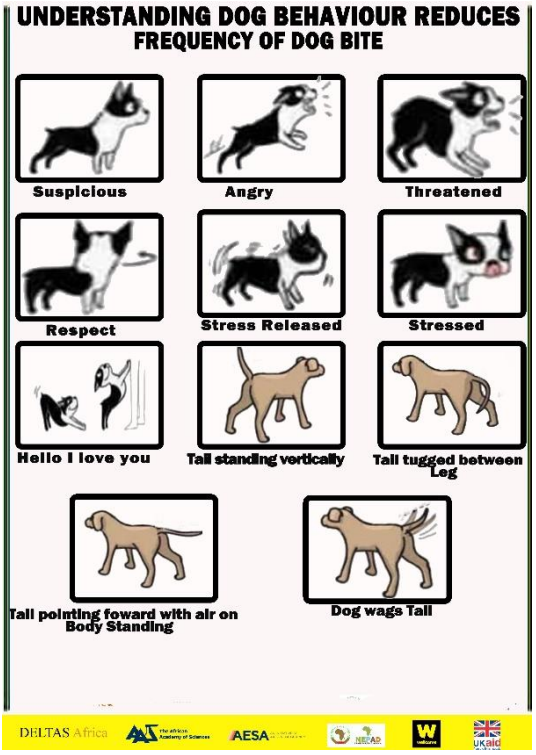
| Intervention | Number of people reached | | Duration of delivery | How outcomes were evaluated |
|---|---|---|---|---|
| | Kwihancha | Kyangasaga | | |
| Information via posters illustrations and leaflets | 472 | 354 | Distributed at baseline, found pasted in sitting rooms at follow (3 months later) | Measurement of knowledge gained through questionnaires |
| Sub-village-level (7) and school-based (3) fora (conversations) with flipcharts and videos | 1,062 | 950 | 7 days, 2 hours for a forum and 2 hours for video screening, separately in afternoon and evening respectively. | Meetings reports and observation field notes |
| Dog handling demonstration by dog owners and vaccinators | 8 CPE team members<br>9 dog handlers during vaccination | 8 CPE team members<br>16 dog owners | 4 days, 3-4 hours each | Observation field notes |
| Mass dog vaccination planning meeting with community leaders and district veterinary officials | 8 CPE team members<br>11 community leaders | 8 CPE team members<br>3 district veterinary officials<br>13 community leaders | 2 days, 3 hours 45mins each | Meetings reports, observation field notes and documenting participation in a vaccination exercise |

**Appendix 5: Pictorial aid for recommended dog body language interpretation**


Available at: https://bowwowinsurance.com.au/pet-community/pet-talk/dog-communication-body-language/

**Appendix 6:** **Posters for short-medium term learning about recommended ways to avoid being attacked and limiting injury when attacked (a-b); recommended ways to hold dog during vaccination (c) and uses of dogs (d)**


a)




b)

Avoid being attacked and limiting injury when attacked Available at: https://www.google.com/search?q=avoiding+attack+by+dogs&tbm=isch&ved=2ahUKEwiI76ac2t73AhX8QfEDHY5rCVgQ2-cCegQIABAA&oq=avoiding+attack+by+dogs&gs_lcp=CgNpbWcQAzoHCAAQsQMQQzoECAAQQzoFCAAQgAQ6BggAEAgQHlDyHFiRcWC2dWgAcAB4AIABsAGIAaIVkgEEMjkuNJgBAKABAaoBC2d3cy13aXotaW1nwAEB&sclient=img&ei=A3p_YsjhJfyDxc8Pjtelw AU#imgrc=7rTV7rzz5IJiKM


c)


d)

Recommended ways of holding dogs during vaccination, available at: https://www.google.com/search?q=how+to+hold+dog+during+vacciantion&tbm=isch&ved=2ahUKEwj87OH1_d73AhXI0oUKHd6OAEQQ2-cCegQIABAA&oq=how+to+hold+dog+during+vacciantion&gs_lcp=CgNpbWcQAzoECCMQJzoECAAQQzoFCAAQgAQ6CwgAEIAEELEDEIMBOggIABCABBCxAzoICAAQsQMQgwE6BwgAELEDEEM6BAgAEB46BggAEAgQHjoECAAQGFCGK1jqnAFggJ8BaAFwAHgAgAGiAYgBwReSAQQzMC42mAEAoAEBqgELZ3dzLXdpei1pbWfAAQE&sclient=img&ei=cp9_YvzrHMillwTenYKgBA

Common uses of dogs, available at: https://www.google.com/search?q=uses+of+dogs&tbm=isch&ved=2ahUKEwi-xp6A_t73AhUC04UKHd1pBWsQ2-cCegQIABAA&oq=uses+of+dogs&gs_lcp=CgNpbWcQAzIFCAAQgAQyBQgAEIAEMgQIABAYMgQIABAYMgQIABAYMgQIABAYMgQIABAYOgQIIxAnOggIABCABBCxAzoLCAAQgAQQsQMQgwE6BAgAEEM6CggAELEDEIMBEEM6CAgAELEDEIMBUNmmBliAugZglr8GaABwAHgAgAFxiAG6CJIBBDEzLjGYAQCgAQGqAQtnd3Mtd2l6LWltZ8ABAQ&sclient=img&ei=iJ9_Yr7iGoKmlwTd05XYBg

## Appendix 7: Leaflets for short-medium term learning about dogs and rabies

**Hatari!** Mbwa mwenye kichaa hung'ata bila kuonyesha viashiria vyovyote hivyo kufanya yaliyoelekezwa hapo juu yanaweza yasiwe na msaada.

**Unaweza vipi kumkamata mbwa wako nyumbani au kumshikilia ila apate chanjo bila kung'ata mtu.**
Kama utatakiwa kumkamata mbwa wako ili kupata huduma au chanjo, hizi ni mbinu za kuepuka mbwa asikung'ate:-

Tumia zawadi ya chakula kumfanya mbwa afurahi au asogee karibu yako na hapo utaweza kutumia mikono au kamba kumkamata.

Onyesha upole kwa kuita jina lake kwa sauti ya chini na ya upole, cheza nae kwa kumpapasa kifuani, mabegani, masikio na kichwani au tengeneza kitanzi kwa kamba na uiweke kwenye fimbo na tumia kumnasa mbwa ambaye sio rafiki.

Wakati wa kuchanja, hizi ni njia za kumkamata mbwa wako kwa usalama ili asijeruhi mtu yeyote.

Kwa mbwa wadogo wenye umri chini ya miezi mitatu, weka shingo yake katikati ya kidole gumba na kidole cha shahada cha mkono wako mmoja na utumie mkono mwingine kuinua maeneo ya kiuno. Kama mbwa ana umri wa miezi sita, acha shingo yake ilale sawia na mkono wako mmoja na mkono wako mwingine uinue sehemu ya kiuno ya mbwa.

Kwa mbwa wakubwa:-
Muweke mbwa katikati ya miguu yako na katika hali ya mchezo inua miguu yake ya mbele mpaka usawa wa kiuno chako. Mbwa pia atajua ni mchezo, kama hata umizwa na ukamataji wako na ataonyesha furaha yake kwa kulamba midomo au kuchezesha mkia wake. Mkao huu huitwa 'horse-back' na humfanya mbwa asitikisike sana au chuchumaa pembeni ya mbwa wako na uzungushe mkono wako shingoni kwake kupitia kwa chini, huku kiganja cha mkono wako kikifika kichwani kwake ili kuzuia asichezeshe kichwa. Weka mkono wako mwingine maeneo ya kiuno ili kumkamata mbwa asitikisike.

Katika njia zote, kama ukiona mbwa anaonyesha utofauti, haraka mtulize kwa kumpapasa kichwani, masikioni, mabegani au kifuani au ita jina lake kwa sauti ya chini na ya utulivu.

**Baadhi ya dhana potofu kuhusu chanjo ya kichaa cha mbwa.**
Mbwa hatabweka usiku kama akichanjwa.

Mbwa hataweza kuzaa/kuzalisha kama akichanjwa.

Mbwa hatawinda tena kama akichanjwa.

Mbwa hutokewa na magonjwa ya ngozi baada ya kuchanjwa.

Mbwa hufa baada ya kuchanjwa.

Haya yote sio Kweli. Chanjo ni salama na hufanya kazi kwa usahihi, haiwezi kumdhuru mbwa.

**Hitimisho:** Mtu akionyesha dalili za ugonjwa wa kichaa cha mbwa, kifo ni asilimia 100%. Hata hivyo, kichaa cha mbwa kinaweza kuzuilika kwa asilimia 100%. Tafiti zinaonyesha njia ya gharama nafuu ya kuzuia ugonjwa wa kichaa cha mbwa ni kuchanja mbwa na paka wote kwenye jamii yetu kila mwaka. Dunia nzima inalenga kufuta kabisa vifo vya binadamu vinavyotokana na ugonjwa wa kichaa cha mbwa kufika 2030. Tunaweza kufikia lengo hilo kwa kuwajali mbwa wetu ambao pia wanalinda mashamba yetu, mifugo na nyumba zetu; tutafaidika na mbwa kwa mawindo yao, michezo na urafiki.

Chanja mbwa wako kila mwaka, kwa Tanzania bila kichaa cha mbwa.

**KUELEKEA TANZANIA ISIYO NA UGONJWA WA KICHAA CHA MBWA**

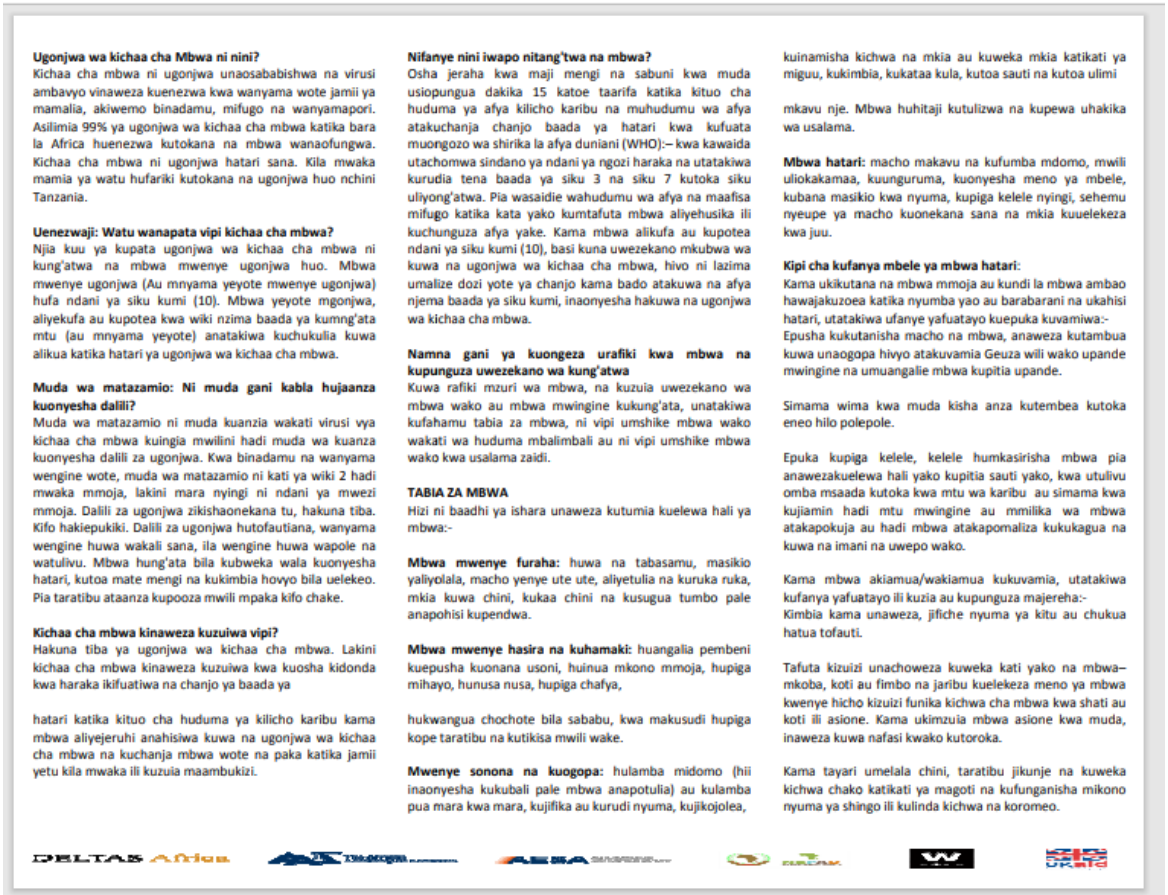
**MAPENDEKEZO YA TAARIFA KATIKA KIPEPERUSHI**

- **Ugonjwa wa mbwa**
- **Uenezaji**
- **Tiba**
- **Jinsi ya kuzuia**

***Kwa maelezo zaidi wasiliana na***

***Samson Masalu Nyamagalla***

***Simu:- +255 789 298 652/+255 627 171 035***



**Ugonjwa wa kichaa cha Mbwa ni nini?**
Kichaa cha mbwa ni ugonjwa unaosababishwa na virusi ambavyo vinaweza kuenezwa kwa wanyama wote jamii ya mamalia, akiwemo binadamu, mifugo na wanyamapori. Asilimia 99% ya ugonjwa wa kichaa cha mbwa katika bara la Africa huenezwa kutokana na mbwa wanaofungwa. Kichaa cha mbwa ni ugonjwa hatari sana. Kila mwaka mamia ya watu hufariki kutokana na ugonjwa huo nchini Tanzania.

**Uenezwaji: Watu wanapata vipi kichaa cha mbwa?**
Njia kuu ya kupata ugonjwa wa kichaa cha mbwa ni kung'atwa na mbwa mwenye ugonjwa huo. Mbwa mwenye ugonjwa (Au mnyama yeyote mwenye ugonjwa) hufa ndani ya siku kumi (10). Mbwa yeyote mgonjwa, aliyekufa au kupotea kwa wiki nzima baada ya kumng'ata mtu (au mnyama yeyote) anatakiwa kuchukulia kuwa alikua katika hatari ya ugonjwa wa kichaa cha mbwa.

**Muda wa matazamio: Ni muda gani kabla hujaanza kuonyesha dalili?**
Muda wa matazamio ni muda kuanzia wakati virusi vya kichaa cha mbwa kuingia mwilini hadi muda wa kuanza kuonyesha dalili za ugonjwa. Kwa binadamu na wanyama wengine wote, muda wa matazamio ni kati ya wiki 2 hadi mwaka mmoja, lakini mara nyingi ni ndani ya mwezi mmoja. Dalili za ugonjwa zikishaonekana tu, hakuna tiba. Kifo hakiepukiki. Dalili za ugonjwa hutofautiana, wanyama wengine huwa wakali sana, ila wengine huwa wapole na watulivu. Mbwa hung'ata bila kubweka wala kuonyesha hatari, kutoa mate mengi na kukimbia hovyo bila uelekeo. Pia taratibu ataanza kupooza mwili mpaka kifo chake.

**Kichaa cha mbwa kinaweza kuzuiwa vipi?**
Hakuna tiba ya ugonjwa wa kichaa cha mbwa. Lakini kichaa cha mbwa kinaweza kuzuiwa kwa kuosha kidonda kwa haraka ikifuatiwa na chanjo ya baada ya

hatari katika kituo cha huduma ya kilicho karibu kama mbwa aliyejeruhi anahisiwa kuwa na ugonjwa wa kichaa cha mbwa na kuchanja mbwa wote na paka katika jamii yetu kila mwaka ili kuzuia maambukizi.

**Nifanye nini iwapo nitang'twa na mbwa?**
Osha jeraha kwa maji mengi na sabuni kwa muda usiopungua dakika 15 katoe taarifa katika kituo cha huduma ya afya kilicho karibu na muhudumu wa afya atakuchanja chanjo baada ya hatari kwa kufuata muongozo wa shirika la afya duniani (WHO):– kwa kawaida utachomwa sindano ya ndani ya ngozi haraka na utatakiwa kurudia tena baada ya siku 3 na siku 7 kutoka siku uliyong'atwa. Pia wasaidie wahudumu wa afya na maafisa mifugo katika kata yako kumtafuta mbwa aliyehusika ili kuchunguza afya yake. Kama mbwa alikufa au kupotea ndani ya siku kumi (10), basi kuna uwezekano mkubwa wa kuwa na ugonjwa wa kichaa cha mbwa, hivo ni lazima umalize dozi yote ya chanjo kama bado atakuwa na afya njema baada ya siku kumi, inaonyesha hakuwa na ugonjwa wa kichaa cha mbwa.

**Namna gani ya kuongeza urafiki kwa mbwa na kupunguza uwezekano wa kung'atwa**
Kuwa rafiki mzuri wa mbwa, na kuzuia uwezekano wa mbwa wako au mbwa mwingine kukung'ata, unatakiwa kufahamu tabia za mbwa, ni vipi umshike mbwa wako wakati wa huduma mbalimbali au ni vipi umshike mbwa wako kwa usalama zaidi.

**TABIA ZA MBWA**
Hizi ni baadhi ya ishara unaweza kutumia kuelewa hali ya mbwa:-

**Mbwa mwenye furaha:** huwa na tabasamu, masikio yaliyolala, macho yenye ute ute, aliyetulia na kuruka ruka, mkia kuwa chini, kukaa chini na kusugua tumbo pale anapohisi kupendwa.

**Mbwa mwenye hasira na kuhamaki:** huangalia pembeni kuepusha kuonana usoni, huinua mkono mmoja, hupiga mihayo, hunusa nusa, hupiga chafya,

hukwangua chochote bila sababu, kwa makusudi hupiga kope taratibu na kutikisa mwili wake.

**Mwenye sonona na kuogopa:** hulamba midomo (hii inaonyesha kukubali pale mbwa anapotulia) au kulamba pua mara kwa mara, kujifika au kurudi nyuma, kujikojolea,

kuinamisha kichwa na mkia au kuweka mkia katikati ya miguu, kukimbia, kukataa kula, kutoa sauti na kutoa ulimi

mkavu nje. Mbwa huhitaji kutulizwa na kupewa uhakika wa usalama.

**Mbwa hatari:** macho makavu na kufumba mdomo, mwili uliokakamaa, kuunguruma, kuonyesha meno ya mbele, kubana masikio kwa nyuma, kupiga kelele nyingi, sehemu nyeupe ya macho kuonekana sana na mkia kuuelekeza kwa juu.

**Kipi cha kufanya mbele ya mbwa hatari:**
Kama ukikutana na mbwa mmoja au kundi la mbwa ambao hawajakuzoea katika nyumba yao au barabarani na ukahisi hatari, utatakiwa ufanye yafuatayo kuepuka kuvamiwa:-
Epusha kukutanisha macho na mbwa, anaweza kutambua kuwa unaogopa hivyo atakuvamia Geuza wili wako upande mwingine na umuangalie mbwa kupitia upande.

Simama wima kwa muda kisha anza kutembea kutoka eneo hilo polepole.

Epuka kupiga kelele, kelele humkasirisha mbwa pia anawezakuelewa hali yako kupitia sauti yako, kwa utulivu omba msaada kutoka kwa mtu wa karibu au simama kwa kujiamin hadi mtu mwingine au mmilika wa mbwa atakapokuja au hadi mbwa atakapomaliza kukukagua na kuwa na imani na uwepo wako.

Kama mbwa akiamua/wakiamua kukuvamia, utatakiwa kufanya yafuatayo ili kuzia au kupunguza majereha:-
Kimbia kama unaweza, jifiche nyuma ya kitu au chukua hatua tofauti.

Tafuta kizuizi unachoweza kuweka kati yako na mbwa– mkoba, koti au fimbo na jaribu kuelekeza meno ya mbwa kwenye hicho kizuizi funika kichwa cha mbwa kwa shati au koti ili asione. Kama ukimzuia mbwa asione kwa muda, inaweza kuwa nafasi kwako kutoroka.

Kama tayari umelala chini, taratibu jikunje na kuweka kichwa chako katikati ya magoti na kufunganisha mikono nyuma ya shingo ili kulinda kichwa na koromeo.

**Links to videos:**

Recommending ways to void dog attack, available at: https://www.youtube.com/watch?v=OrkvjdlWWG0

Recommending ways to survive dog attacks, available at: https://www.youtube.com/watch?v=kaA2urO2vCA and https://www.youtube.com/watch?v=vX-OOfbnD9w

Recommended ways to restrain a dog during vaccination, available at: https://www.youtube.com/watch?v=ULFwjoZoRt8

**International guides**

We referred to the International Companion Animal Management Coalition guide, available at: https://www.icam-coalition.org/wp-content/uploads/2019/09/2019-ICAM-DPM-guidance-Interactive-updated-15-Oct-2019.pdf

And World Society for the Protection of Animals, available at: https://www.icam-coalition.org/wp-content/uploads/2017/03/Identification-methods-for-dogs-and-cats.pdf

**Appendix 8: Proforma for observing community leadership involvement in the vaccination exercise**

| TOPICS | NAMES OF SUB-VILLAGES | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Esuka** | **Mkiringo** | **Buhare** | **Sonjo** | **Kyangasaga** | **Esegere** | **Ngurumi** | **Nyasagaro** |
| Set up and commencement of vaccination | | | | | | | | |
| Sub-village chairs went round houses to conduct census of all dogs and cats per households? | | | | | | | | |
| Advertising of the campaign | | | | | | | | |
| Provision of table and chairs for vaccinators | | | | | | | | |
| Provision of waste bins | | | | | | | | |
| Provision of meals to vaccinators or the respective leaders should cook for vaccinators working in their village/sub-village during campaign | | | | | | | | |
| Sub-village chairmen to assist the vaccinators at the vaccination points as dog handlers | | | | | | | | |
| | | | | | | | | |

| TOPICS | NAMES OF SUB-VILLAGES | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Esuka** | **Mkiringo** | **Buhare** | **Sonjo** | **Kyangasaga** | **Esegere** | **Ngurumi** | **Nyasagaro** |
| Conduct community self-assessment after the vaccination to see what proportion of dogs in each sub-village are vaccinated | | | | | | | | |
| General observation of:<br>-People's attitudes<br>-Turn outs<br>-Events | | | | | | | | |

## Appendix 9: Information given to participants

**Aim of study:** Before participants were enrolled into the study or interviewed, the aim of the study was explained to them.

**Study protocol and duration:** Participants were told how they will be involved in the study: what they will be interviewed on and how long it will take. A detailed participants' information sheet on the research aims and procedure were provided to respondents to read and given time to ask questions where necessary. Respondents were then permitted to sign a consent form. The household heads consented for participants in household survey who aged less than 18 years. The participants information sheet and consent forms were written in Kiswahili.

**Risks and discomforts:** Participants were assured that the lines of questions were not intrusive but it would take some amount of their time.

**Benefits:** Participants were made aware that they were not going to be paid for responding to questions, however, contributing their insights to the study could lead to a better design of CBC-MDV which has potential benefits to the larger society in terms of rabies prevention.

**Autonomy and confidentially:** Participants were assured that their participation is voluntary and they can decide to discontinue the whole interview process or elect not to answer a particular question, any information they give will only be used for the purposes of this research and cannot be used against them in anyway. Participants' names were designated with codes to enable us organize the information and hence participants will not be identified whenever the results of this study is used anywhere. The data is secured in password protected databases and only authorized people will be allowed access.

**Sharing the results:** Participants were informed that findings from this study will be available in a form of thesis in the library of The Nelson Mandela African Institution of Science and Technology, published in online journals and also shared with community leaders and district, regional and national veterinary authorities in order to help make policies to improve mass dog vaccination campaigns in the country.

**Who to contact in case of need:** Participants were provided with email address and telephone number of Christian Tetteh Duamor, principal investigator of this research study, and they can contact him if necessary.

## Appendix 10: Research permit from NIMR

**THE UNITED REPUBLIC OF TANZANIA**

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University of Dodoma, Faculty of Arts and Social Sciences
Building No. 11
P.O. Box 743
40478 Dodoma

NIMR/HQ/R.8a/Vol. IX/2788

22nd May 2018

Kennedy Lushasi
C/o Godfrey Mbaruku
Ifakara Health Institute
P.O. Box 78373
Dar es Salaam

**RE: ETHICAL CLEARANCE CERTIFICATE FOR CONDUCTING MEDICAL RESEARCH IN TANZANIA**

This is to certify that the research entitled: The science of rabies elimination in Tanzania (Lushasi K. *et al.*) whose supervisor is Dr. Godfrey Mbaruku of Ifakara Health Institute has been granted ethical clearance to be conducted in Tanzania.

The Principal Investigator of the study must ensure that the following conditions are fulfilled:

1. Progress report is submitted to the Ministry of Health, Community Development, Gender, Elderly & Children and the National Institute for Medical Research, Regional and District Medical Officers after every six months.
2. Permission to publish the results is obtained from National Institute for Medical Research.
3. Copies of final publications are made available to the Ministry of Health, Community Development, Gender, Elderly & Children and the National Institute for Medical Research.
4. Any researcher, who contravenes or fails to comply with these conditions, shall be guilty of an offence and shall be liable on conviction to a fine as per NIMR Act No. 23 of 1979, PART III Section 10(2).
5. Site: Lindi, Mtwara, Morogoro, Dar es Salaam, Arusha and Mara.

Approval is valid for one year: 22nd May 2018 to 21st May 2019.

**Name: Prof. Yunus Daud Mgaya**

**Signature**
**CHAIRPERSON**
**MEDICAL RESEARCH**
**COORDINATING COMMITTEE**

**Name: Prof. Muhammad Bakari Kambi**

**Signature**
**CHIEF MEDICAL OFFICER**
**MINISTRY OF HEALTH, COMMUNITY DEVELOPMENT, GENDER, ELDERLY & CHILDREN**

CC: RMOs of Lindi, Mtwara, Morogoro, Dar es Salaam, Arusha and Mara.
DMOs/DEDs of selected districts.

**Appendix 11: Research permit from TAMISEMI**

JAMHURI YA MUUNGANO WA TANZANIA
OFISI YA RAIS

Telegrams "TAMISEMI" DODOMA
Simu Na: (026) 2322848, 2321607,
2322833, 2322420
Nukushi: (026) 2322116, 2322146
2321013
Barua pepe : ps@tamisemi.go.tz

Tawala za Mikoa na
Serikali za Mitaa,
Jengo la Mikapa,
2 Barabara ya Hospitali,
S. L. P. 1923,
41185 DODOMA.

Unapojibu tafadhali taja:

Kumb. Na. AH. 213/420/01

23/07/2018

Katibu Tawala Mkoa,
Ofisi ya Mkuu wa Mkoa,
S. L. P. 299,
**MARA.**

**YAH: UCHANJAJI MBWA NA PAKA DHIDI YA UGONJWA WA KICHAA**

Rejea kichwa cha habari hapo juu.

OR – TAMISEMI imepokea barua Kumb. Na. CAN 82/248/01 ya tarehe 20 Julai, 2018 kutoka kwa Katibu Mkuu – Mifugo kuhusu somo tajwa hapo juu. Katika barua hiyo imeelezwa kwamba zoezi hili ni sehemu ya utekelezaji wa Waraka wa Waziri wa Mifugo wa Mwaka 2017, unaozielekeza Halmashauri zote nchini zichanje mifugo dhidi ya magonjwa yanayozuilika kwa njia ya chanjo.

Aidha, imeelekeza kuwa, uzuiaji wa magonjwa hayo, unaratibiwa kupitia mpango wa **Afya Moja** chini ya uratibu wa Ofisi ya Waziri Mkuu, Kitengo cha Maafa. Wadau hawa wamechangia chanjo husika pamoja na vifaa vya kuhifadhia chanjo. Washiriki wa Kampeni hii ni wataalamu wa Afya na Mifugo wa Halmashauri zote za mkoa wako na hapatakuwepo na malipo yeyote yatakayotozwa kwa wenye mbwa au paka.

Kwa barua hii, unaombwa kuzielekeza Halmashauri zilizoko katika mkoa wako zitoe ushirikiano utakaohitajika wakati wa zoezi hili muhimu. Ushirikiaano unaopendekezwa ni pamoja na kutoa elimu kwa umma, kuhamasisha ushiriki wa wafugaji na utoaji wa vyombo vya usafiri pale panapohitajika kufanya hivyo.

Nakushukuru kwa ushirikiano wako.

Dkt. Andrew Komba
Kny: **KATIBU MKUU**

## Appendix 12: Research Permit from IHI

IFAKARA HEALTH INSTITUTE
research | training | services

INSTITUTIONAL REVIEW BOARD
P O BOX 78373 DAR ES SALAAM, TANZANIA
Tel +255 (0) 22 2774714, Fax: + 255 (0) 22 2771714 Email: irb@ihi.or.tz

7th August 2014

National Institute for Medical Research
P O Box 9653
Dar Es Salaam
Email:

Kennedy Lushasi
Ifakara Health Institute
P O Box78373
Dar es Salaam

**IHI/IRB/No: 22-2014**

**INSTITUTIONAL CLEARANCE CERTIFICATE FOR CONDUCTING HEALTH RESEARCH**

On 2nd August 2014, the Ifakara Health Institute Review Board (IHI-IRB) reviewed from study titled: ***"Rabies persistence and elimination in Tanzania"*** submitted by Principal Investigator Kennedy Lushasi.

The following documents were reviewed:

1. Protocol
2. Informed Consent Forms
3. Budget
4. Tools
5. CVs

The study has been approved for implementation after IRB concerns. This certificate thus indicates that the above-mentioned study has been granted an Institutional Ethics Clearance to conduct the above named study in Pemba Island, Serengeti, Ngorongoro, Ulanga and Kilombero districts.

The Principal Investigator of the study must ensure that, the following conditions are fulfilled during or after the implementation of the study:

1. PI should submit a six month progress report and the final report at the end of the project
2. Any amendment, which will be done after the approval of the protocol, must be communicated as soon as possible to the IRB for another approval
3. All research must stop after the project expiration date, unless there is prior information and justification to the IRB.
4. There should be plans to give feedback to the community on the findings
5. Any publication needs to pass through the IRB
6. The approval is valid until 2nd August 2015

***The IRB reserves the right to undertake field inspections to check on the protocol compliance***

*Chairperson*
*Dr Abdallah Ramadhan Nasr*

*Deputy IRB Secretary*
*Dr Hosiyadni Mvungi*

Dar es Salaam: PO Box 78373, Tel: 022 2774756
Ifakara: PO Box 53, Tel: 0232 620168
Bagamoyo: PO Box 74, Tel: 0232 440660
Rufiji: PO Box 40, Kibiti, Tel: 0787 384521
Mtwara: PO Box 1946, Tel: 0232 333487
Kigoma: PO Box 1077, Tel: 0352 600855

## RESEARCH OUTPUTS

Duamor, C. T., Hampson, K., Lankester, F., Sambo, M., Kreppel, K., Wyke, S., & Cleaveland, S. (2021). Use of lay vaccinators in animal vaccination programmes: A scoping review. *PLoS Neglected Tropical Diseases*, *15*(8), e0009691.

Duamor, C. T., Hampson, K., Lankester, F., Lugelo, A., Mpolya, E., Kreppel, K., & Wyke, S. (2022). Development, feasibility and potential effectiveness of community-based continuous mass dog vaccination delivery strategies: Lessons for optimization and replication. *PLoS Neglected Tropical Diseases, 16*(9), e0010318.

Duamor, C. T., Lankester, F., Mpolya, E., Ferguson, E. A., Johnson, P. C., Wyke, S., & Kreppel, K. (2022). Participation in mass dog vaccination campaigns in Tanzania: Benefits of community engagement. *Frontiers in Public Health*, *10*(971967), 1-16.

Duamor, C. T., Hampson, K., Lankester, F., Lugelo, A., Changalucha, J., Lushasi, K. S., ... & Wyke, S. (2023). Integrating a community-based continuous mass dog vaccination delivery strategy into the veterinary system of Tanzania: A process evaluation using normalization process theory. *One Health*, 100575.

## Appendix 13: Conferences, workshops and seminars

| Conferences | | | |
|---|---|---|---|
| **Participation** | **Event** | **Date** | **Place** |
| Oral presenter | Tanzania Veterinary Association Scientific Conference | 6th – 8th December, 2022 | Dodoma – Tanzania |
| Oral presenter | The 7th World One Health Congress | November 7-11th, 2022 | Singapore |
| Oral presenter | Afrique One-ASPIRE Scientific Meeting | June 27-29th, 2022 | Yamoussoukrou, Cote d'Ivoire. |
| Oral presenter | Tanzania Veterinary Association Conference | November 24-26th, 2021 | via zoom. |
| Oral presenter | Rabies in the Americas Conference | October 26-29th, 2021 | via zoom. |
| Oral presenter | Afrique One-ASPIRE Scientific Meeting | 27-29th Jan, 2021 | via zoom. |
| Poster presentation | Afrique One-ASPIRE Management Board Meeting and Scientific Conference | 23rd – 27th September, 2019 | Grand Bassam – Cote d'Ivoire from |
| Oral presenter | Afrique One-ASPIRE Scientific Meeting | 17th – 22nd September, 2017 | Arusha – Tanzania |
| workshops | | | |
| Participant | Facilitation of public engagement, delivered to the Rabies Lab Group | January 18-20th, 2022 | Via zoom |
| Participant | Afrique One-ASPIRE Summer School: Impact Pathways and Hackaton Training | 1st – 4th February 2021 | Via zoom |
| Participant | The Afrique One-ASPIRE Summer School: Grant and article writing, career strategy, disseminating scientific findings via digital media, mentoring and work-life balance | 18th – 22nd September 2019 | Grand Bassam, Cote d'Ivoire |
| Participant | Scalable Rabies Elimination Strategies for Kenya, Namibia and Tanzania Workshop | 18th – 20th December, 2018 | WHO HQ, Geneva – Switzerland. |
| **Conferences** | | | |

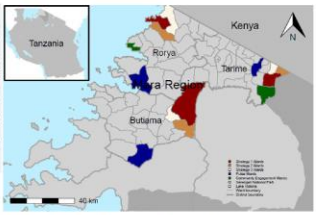
| **Participation** | **Event** | **Date** | **Place** |
|---|---|---|---|
| Participant | Afrique One-ASPIRE Summer School on Public Engagement and Science Communication | September, 2018 | Nairobi – Kenya |
| Participant | Afrique One-ASPIRE Summer School on Research Methods and Data Management | September, 2017 | Arusha – Tanzania |
| Professional Development | | | |
| Participation | Training | Date | Institution |
| Student | A semester course on evaluation of complex health interventions | January to March, 2018 | University of Glasgow |
| Student | Certificate, Public Health Response in Humanitarian Emergencies, | August – September 2021 | Coursera |
| Student | Certificate in One Health: Connecting humans, animals and the environment in disease control | | University of Basel |
| Student | Certificate, Implementation Research | June – July, 2018 | WHO/TDR MOOC |
| Seminars | | | |
| Presenter | 10 PhD research progress presentations at the Department of Global Health | 2018 - 2023 | NM-AIST, Arusha - Tanzania |
| Presenter | Student seminar talk at University of Glasgow; delivered to the Health and Behavioral Group | June 1st, 2022 | University of Glasgow |
| Presenter | Student seminar talk at University of Glasgow; delivered to the MRC/CSO/IHW Group | May 30th, 2022 | University of Glasgow |
| Presenter | Student seminar talk at University of Glasgow; delivered to the Rabies Lab Group | May 23th, 2022 | University of Glasgow |

## Appendix 14: Poster Presentation

# Process evaluation of community-based mass dog vaccination delivery strategies in the Mara Region of Tanzania

**Background:** Rabies can be eliminated if coverage of domestic dog vaccination is sustained above 40% all year round for five-seven consecutive years. Current approaches usually fail to achieve this required vaccination coverage and an alternative, a community-based continuous mass dog vaccination (CBC-MDV) approach, was designed and piloted in the Mara region of Tanzania. This thesis used mixed, qualitative, quantitative and participatory methods to evaluate the development and delivery of the CBC-MDV approach over two years to generate evidence to inform the optimization of the design prior to its evaluation in a full-scale randomized control trial.

**Key Message: A** community-based, continuous approach has the potential to accelerate rabies elimination by overcoming the operational challenges of the current centralized, once-yearly approach, relating to cost and inconsistent implementation of mass dog vaccination.




Map of the study area, showing Mara region, study districts and wards.

### Supervisors

- Emmanuel Mpolya, NM-AIST - Tanzania.
- Katharina Kreppel – ITM, Belgium
- Katie Hampson, UoG - UK.
- Sarah Cleaveland, UoG - UK.
- Sally Wyke, UoG - UK.
- Felix Lankester, WSU – USA.


### Acknowledgement

The authors acknowledge support from the DELTAS Africa Initiative [Afrique One-ASPIRE /DEL-15-008].

Afrique One-ASPIRE is funded by a consortium of donors including the African Academy (AAS) Alliance for Accelerating Excellence in Science in Africa (AESA), the new Partnership for Africa's Development Planning and coordinating (NEPAD) Agency, the Wellcome Trust [107753/A/15/Z] and the UK government.


### Research Objectives

a) To document the development, feasibility and potential effectiveness of the community-based continuous approach to mass dog vaccination
b) To develop and evaluate approaches through community and public engagement to address barriers to participation in mass dog vaccination campaigns
c) To identify factors that will influence the normalization of a community-based continuous approach in the context of Tanzania using the normalization process theory
d) To assess ownership and sustainability of implementation processes of the CBC-MDV approach

### Methodology

**Study Design**
A prospective and cross-sectional process evaluation embedded in a pilot randomized controlled trial. The trial evaluated the effectiveness of the current once-yearly and new CBC-MDV approaches in achieving and sustaining adequate vaccination coverage.

The process evaluation aimed to generate a formative understanding of how to optimize the design of the CBC-MDV.

**Data Collection**
◇ **Non-Participant Observations *(n = 197 Observation hours)*** of the development and implementation processes.
◇ **Audits *(n = 141)*** of the implementation process.
◇ **Focus Group Discussions *(n = 24)*** with village members and leaders
◇ **In-depth Interviews *(n = 16)*** with village, ward, and district-level implementers and leaders.
◇ **Household surveys (*n* = 3,434 dog owners)** to assess vaccination coverage impact of community engagement.

**Data Analysis**
◇ Qualitative data were analyzed using thematic analysis, both inductive and deductive. Descriptive statistics, regression, two-proportion Z-tests, and Mann-Whitney U test were employed in the analysis of the quantitative data

### Results/Outcomes

**Results**
◇ The findings showed that the development process of CBC-MDV was iterative and involved cross-sectoral participation but without the direct involvement of communities.

◇ In relation to feasibility, fidelity and potential effectiveness, CBC-MDV was delivered with 69% fidelity and performed better in terms of sustaining high vaccination coverage compared to the centralized approach. Design-, implementer- and context-related factors influenced the delivery and effectiveness of the CBC-MDV strategies.

◇ We found that the community engagement activities positively influenced factors that underpin participation in MDV campaigns.

◇ In relation to integrating and sustaining the new approach in practice, CBC-MDV was well understood, accepted, operationalized with relative ease and positively appraised compared to the centralized approach.

**Outcomes**
a) Informed optimization of CBC-MDV, b) Delivered one community engagement grant, c) 4 publications; 1 draft

### Conclusion

The conclusions were reached that it was feasible to deliver CBC-MDV in the context of Tanzania, it can be sustained in practice, and barriers to participation in mass dog vaccination can be addressed through community engagement processes. However, community participation in the design, delivery and evaluation of CBC-MDV is needed to foster ownership and sustainability of the intervention.

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