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Status on use and delivery of foot and mouth and newcastle vaccines in Kenya

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Abstract

The contribution of the livestock sector to food and nutritional security is challenged by high prevalence of diseases that limit productivity, trade and profitability within various livestock value chains in Kenya. Climate change has contributed to increased stress for the animals, higher disease prevalence, misuse of antibiotics and consequent antimicrobial resistance (AMR). Mass vaccination has been recommended by the Kenya AMR Policy and action plan 2017 as a sustainable disease control option to counter development of AMR. However, challenges in accessing quality vaccines constrain vaccination programs for important livestock diseases. A cross-sectional study was undertaken in Uasin Gishu and Nyandarua Counties to appraise use of New Castle disease (NCD) and Foot and Mouth disease (FMD) vaccines that are widely used in indigenous poultry and dairy value chains respectively and suggest improvements in delivery. Seventy-one (71%) of respondents reported to have experienced FMD outbreak in the recent past in both counties. Whereas up to 74% and 92% of farmers used NCD and FMD vaccines respectively, the schedule used did not lead to effective control of both diseases. Agro veterinary shops were the leading source of vaccines at 94% with the rest sourced from the manufacturers, distributors, county government, NGOs and extension service providers. Challenges hindering effective vaccine use included large pack size beyond the needs for small scale farmers (50%), unreliable supply (47%) and presumed presence of counterfeit products (15%) among others. The vaccines delivery infrastructure was found inadequate to authenticate vaccines at point of use and also in terms of compliance with cold chain requirements. The study recommends innovative vaccine delivery processes including product authentication and traceability along the supply chain.

Keywords: *Vaccine delivery; FMD; NCD; endemic diseases*

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Introduction

Livestock industry in Kenya constitute an important sector estimated to contribute 12% of the Gross Domestic Product (GDP), 42% of the agricultural GDP and employs 50% of

agricultural labor force. However, the industry faces challenges, among them, high prevalence of diseases which lead to trade restrictions (Magiri *et al.,* 2021). The high prevalence of diseases lowers productivity and profitability of livestock enterprises, which have been escalated by climate change. It is estimated that small-scale livestock farmers lose up to 70% of their livestock population due to diseases. During climate extremes, animals become immunocompromised, increasing susceptibility to endemic diseases, thus lowering productivity and profitability of livestock enterprises (Lacetera, 2019). Increasing global temperatures result in heat stress, affecting immunity by altering physiology and chemical balance in farm animals such as chicken that tolerate narrow temperature ranges of 18-25^{O}C (Gupta *et al.,* 2022; Johnson *et al.,* 2019; Kpomasse *et al.,* 2021).

Diseases showing increased prevalence and are of economic and trade implications include Foot and mouth disease (FMD), rift valley fever, Newcastle Disease (NCD), Gumboro (Infectious Bursal Disease - IBD) and fowl pox (FP) that were previously controlled using existing management practices but have undergone considerable epidemiological changes resulting in more frequent outbreaks (Karesh *et al.,* 2021). The outbreaks are associated with emergence of virulent disease strains or variants, occasioned by climate change, adoption of more productive but vulnerable breeds and intensification of production systems. Heat stress drives antimicrobial use (AMU) not only by causing immunosuppression and leaving animals more susceptible to infections, but also by causing symptoms of non-bacterial diseases that might be mistaken by smallholder farmers as infections that can be treated with antibiotics (Pokharel and Adhikari, 2020; Kemp *et al.,* 2021). This has led to an increase in over-the-counter purchase of antimicrobials and their subsequent usage without prescription, a practice that aids development of antimicrobial resistance (AMR) (Magnusson *et al.,* 2021).

To mitigate antimicrobial misuse, routine vaccination is recommended primarily to improve production efficiency in food animals (Ayukekbong *et al.,* 2017). Vaccines have been significantly used in veterinary practice as they are vital in prevention and control of animal infectious diseases. Vaccination is a cost-effective way of reducing risk of disease outbreaks including zoonoses and food borne pathogens. It reduces animal suffering and antibiotic use, thus improving animal welfare and health. Vaccination can save up to 60% of farm animals (Schat, 2014). However, vaccination uptake is low among smallholder farmers due to poor accessibility and perceived vaccine failures associated with disease outbreaks in vaccinated populations (Donadeu *et al.,* 2019). Reasons for vaccine failure are many and include ineffective vaccines, outdated vaccination schedules, inadequate dosing, vaccinating immunocompromised animals, carrier status, non-compliance with cold chain requirements, errors in reconstitution and administration, wrong timing, variations in individual animal responses and sale of counterfeit products among others (Kollaritsch & Rendi-Wagner, 2013; Tizard, 2021). The poultry industry is particularly affected where Newcastle Disease (ND) outbreaks occur throughout the year with losses of 80-100% in naïve flocks (Amoia *et al.,* 2021).

While vaccine manufacturers have established internal and external quality assurance (QA) systems, few of them do post-market performance testing, to guard against counterfeits and deterioration at point of use. The objective of this work was to assess the level of adherence to quality management practices and cold chain maintenance in vaccine delivery from the manufacturer to the point of use, and including awareness on presence of counterfeit products. This activity was conducted in the context of dairy and poultry value chains in Nyandarua and Uasin Gishu counties of Kenya. The purpose was to highlight challenges encountered in vaccine delivery that would inform appropriate interventions to enhance vaccine adoption.

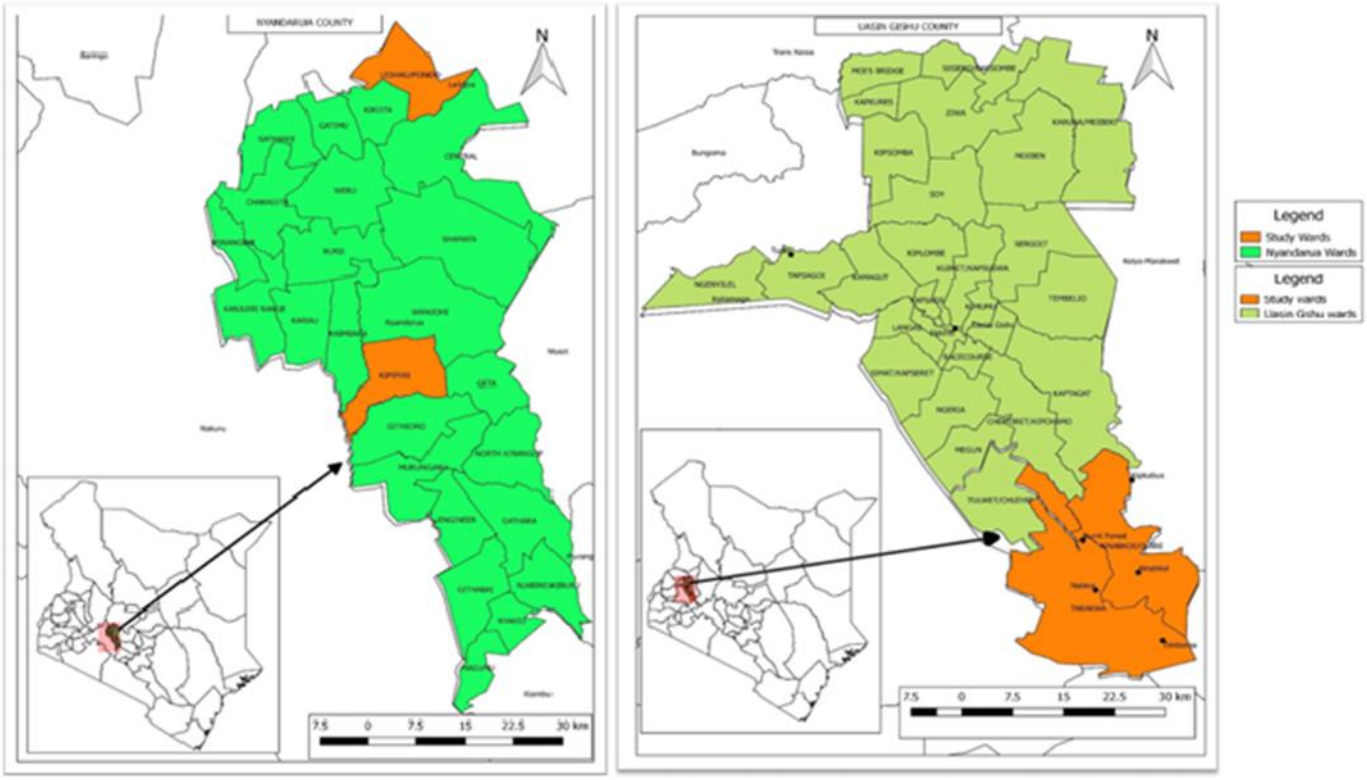
Materials and Methods

Study design

A cross-sectional study design was employed with mixed methods approaches and purposive sampling of study subjects. Study participants were drawn from animal health service providers (AHSPs) and farmers. AHSPs were recruited from the sampling frame of qualified practitioners, some of whom serve as input providers, that was provided by the area veterinary office within the Kenya Climate Smart Agriculture Project (KCSAP) wards. In each study area, all agro veterinary suppliers were recruited as respondents while farmers were recruited using snowballing method. All participants in the study provided consent to participate by affirming their agreement as outlined in the digital questionnaire. Quantitative data was collected from livestock farmers and agro veterinary retailers, while qualitative data was collected by conducting Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) with vaccine manufacturers, distributors and animal health service providers. Quantitative data collected targeted smallholder livestock keepers preferably belonging to a local farmer's association and or cooperative. All the vaccine outlets that served the targeted livestock keepers in the study areas were included for retailer's interviews. Key informants were selected based on their knowledge of the local chicken and dairy value chain dynamics and the role they played along the value chains. They ranged from County Agricultural officers, public and private veterinary practitioners, vaccine manufacturers and distributors. The survey was designed to evaluate practices used in NCD and FMD disease prevention. Information was collected on household and socio-demographic characteristics, knowledge, attitude, and practices (KAPs) on vaccination, source, accessibility, packaging, and use of cold chain.

Figure 1

Study sites in Nyandarua and Uasin Gishu Counties



***Selection** of study areas*

The study was carried out in Uasin Gishu and Nyandarua counties, which were purposively selected due to their strengths in both poultry and dairy value chains. The counties also have good infrastructure of well-established public and private animal health service providers that include farm inputs suppliers and marketers. Nyandarua County covers an area of 3,245.2 km^2, lying between latitude 0°8′ and 0°50′ and longitude 35°13′ and 36°42′. Its population is 638,289 persons. Farming is the main economic activity involving cultivation of pyrethrum, potato, vegetables as well as dairy farming. The county also boasts tourist attraction sites like the Aberdare National Park, Lake Ol Bolossat, Mount Kipipiri and Kinangop Plateau. Uasin Gishu County is situated in the mid-west of the Rift Valley covering an area of 3,345.2 square kilometers and lies between longitude $34^{0}50'$ east and $35^{0}37'$ west and latitudes 0°03′ and 0°55′. Its altitude ranges from 1,500 - 2,700 meters above sea level with a temperate and cool climate and has a human population of 1,163,186. The county's main economic activity is large scale maize and wheat farming, dairy farming and some elements of aquaculture and horticulture.

Study wards (Figure 1) were selected based on the livestock population and existence of cooperatives for dairy cattle and poultry production under the Kenya Climate Smart Agricultural Productivity Project.

Baseline survey to audit existing vaccine delivery systems and identify gaps

The baseline survey targeted NCD and FMD, the two most devastating diseases in the poultry and dairy value chains respectively (Apopo *et al.*, 2020). Existing vaccine delivery processes from the manufacturer to the end user (farmers) were audited jointly with the stakeholders to observe current practices, challenges in implementation of recommended best practice, and opportunities for effective delivery of vaccines. The research commenced with desktop study, which involved gathering and analyzing existing information from publicly available sources. The study objective and relevant keywords were set to include: vaccine, new castle, foot and Mouth, delivery and livestock were set. This was followed by a search for relevant literature in academic databases and online repositories to enrich the study.

Workshops were conducted with key stakeholders in each county to assess the accessibility and delivery processes of vaccines. Stakeholders comprised managers from vaccine manufacturers, poultry and dairy farmers, public and private animal health service providers, dairy cooperative managers, and owners of agro veterinary shops (Table 1). All respondents possessed substantial knowledge and institutional memory regarding vaccine use and distribution, which ranged from a minimum of two years. Semi-structured questionnaires concerning the delivery practices and infrastructure of NCD and FMD vaccines were formulated through a consultative approach. Prior to field deployment, the questionnaires were pre-tested, involving purposively selected urban agro veterinary shops and nearby farmers within the study regions. Data collected was transmitted using the Open Data Kit (ODK) mobile application. Only those participants that consented by affirming their agreement as outlined in the digital questionnaire participated in the study. The data collection tool provided steps for the interviewer to ensure that respondents understood the purpose of the questionnaire, how their data will be used, and their rights regarding participation. Lessons learnt provided crucial inputs into finalizing the digitized questionnaires. The survey tools were adjusted and re-uploaded into the Kobo Toolbox application (https://www.kobotoolbox.org/).

The target sample comprised of farmers and vaccine supply chain actors such as those involved in trade and farm vaccination service delivery. Using the Kenya Climate Smart Agriculture Project (KCSAP) ward as the unit of study, Animal Health Service Providers (AHSPs) were purposively selected from a sampling frame provided by the Veterinary Office within the KCSAP ward. Additionally, the snowball

sampling technique was employed to engage farmers, guided by knowledgeable field guides. The purposive sampling methodology ensured representation of responses from women. Data collected included information on vaccine access, distribution, and usage from resident AHSPs (n=78), who also served in roles such as agro-veterinary shop attendants or managers.

The sample size for AHSPs per study site was calculated using the formula:

$$\text{Sample size} = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1 + \left(\frac{z^2 \times p(1-p)}{e^2 N}\right)}$$

N = AHSP population in the region in the Kenya Veterinary Board databases • e = Margin of error (percentage in decimal form) • z = z-score

Table 1

Respondents in the baseline survey

	Number of respondents per County		
	Nyandarua	**Uasin Gishu**	**Total**
Manufacturers	3		3
Distributors	3	6	9
Retailers/AHSPs	20	58	78
End-users/farmers	118	240	358
Total			**454**

Table 2

Distribution of AHSPs participants in the baseline survey

County	**KCSAP wards**	**Sample**
Uasin Gishu	Tarakwa	18
	Ainabkoi/Olare	40
Nyandarua	Leshau Pondo	8
	Kipipiri	12
	Total	***78***

Key informant interviews (KII) were conducted with subject matter specialists drawn from county livestock and veterinary offices, vaccine supply chain players and private extension agents. Focused group discussions (FGDs) were conducted to gain an understanding of the current status of animal health services and to triangulate information collected through questionnaires and KIIs. Discussions were conducted using a participatory approach where 14 informants participated in the group discussion. Selected lead actors were identified and used as case studies to obtain information on experiences related to animal health and provide a framework for quantitative and qualitative data analysis, identify issues for discussion in focused groups and to undertake "spot checks" of reported information. Data was directly entered into data sheets and uploaded into the server and data quality checks done on a daily basis.

Data analysis

Field surveys data collected were exported from Open Data Kit (ODK) mobile application and imported into Stata 15.0 for cleaning and analysis. Quantitative data was analyzed using Stata 15.0 to generate descriptive statistics presented in frequency tables, charts, and percentages while qualitative data generated through KIIs was analyzed using thematic analysis and subjected to MS Excel for visualisation and to depict the differences between the two study counties. This analysis generated gaps in technology, information and management practices that negatively affect quality vaccine delivery and use by farmers.

Results

Observations on dairy and indigenous poultry farming and status of vaccine usage

Livestock numbers in the study counties derived during desktop survey from the 2021 census estimates are shown in Table 3 (KNBS, 2021). Both counties are strong in dairy value chain having a national dairy cattle population of 700,957 (14%), and also have a significant poultry population 1,428,424 (2.5% of the national total) and thus were well suited for the study objectives.

Three hundred and fifty-eight (358) farmers were interviewed; 118 (33%) and 240 (67%) from Nyandarua and Uasin Gishu counties, respectively. Out of these, 96% and 82% in Nyandarua and Uasin Gishu counties, respectively engaged in dairy farming, while 58% in both counties kept indigenous poultry. Fifty-four (54%) and 41% of farmers engaged in both dairy and poultry farming in Nyandarua and Uasin Gishu counties, respectively (Figure 2).

Table 3

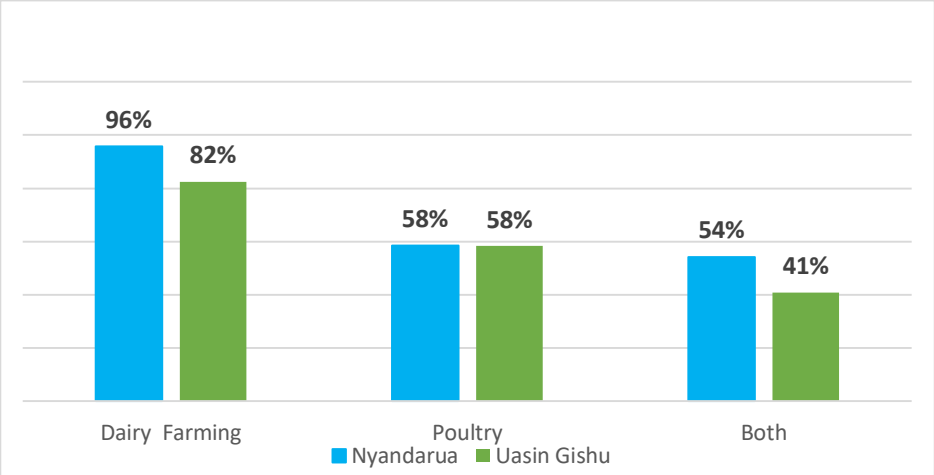
Chicken and Cattle populations in Nyandarua and Uasin Gishu Counties

	Nyandarua	Uasin Gishu	**Totals**
Poultry	**633,200(1.1%)**	**795,224(1.4%)**	**1,428,424(2.5%)**
Indigenous chicken	558,200	706,702	**1,264,902**
Hybrid layers	28,500	44,261	**72,761**
Broilers	46,500	44,261	**90,761**
Dairy Cattle	**358,100(7.1%)**	**342,857(6.8%)**	**700,957(14%)**
Indigenous cattle	35,800	43,174	**78,974**

Source: KNBS 2021

Figure 2

Respondents keeping indigenous poultry and dairy in the study counties (n=358)



Sixty-three (63%) and 79% of farmers reported to have experienced FMD outbreak in the past one year in Nyandarua and Uasin Gishu counties respectively. In both counties, 82% of dairy farmers reported single annual outbreaks of FMD while 13% reported the outbreaks twice a year. In Nyandarua County, 92% of farmers used vaccination, 29% quarantine measure and 39% isolation to protect their cattle from FMD. Uasin Gishu County had 83% of farmers vaccinate their cattle, with additional measures of quarantine (30%) and isolation of sick animals (21%).

In Uasin Gishu County, 92% of farmers used NCD vaccines (42% after every three months, 17% after six months and 33% after twelve months). Agro veterinary shops were the main sources of NCD vaccines in both counties, at 94%. Other sources included manufacturers, distributors, county government, NGOs and extension service providers. Seventy-four percent (74%) of farmers in both counties used vaccination as a way of controlling NCD. In case of NCD outbreaks, farmers in Nyandarua county incinerated/burnt (49%), slaughtered (62%), and buried (67%) carcasses as a way of managing the disease. In Uasin Gishu, farmers employed similar management practices to contain NCD outbreaks but to differing degrees; 18% utilized incineration/burning, 15% resorted to slaughtering, and 18% opted for burial. The study revealed that the highest utilization of NCD vaccine in Uasin Gishu county, where there's a significant poultry population, coincided with the dry season, reaching 67%, compared to 33% during other times.

Practices on vaccine delivery system

Retailer/Animal health Service Providers

Sixty-eight percent (68%) of retailers in Nyandarua stocked NCD and 82% in Uasin Gishu. Fifty-eight percent (58%) of the same retailers in Nyandarua stocked FMD vaccines and 21% in Uasin Gishu counties respectively. FMD vaccine was mainly stocked by the County director of veterinary services (CDVS) in both counties with some exceptions of donor aided FMD vaccine in private retail outlets in Nyandarua County.

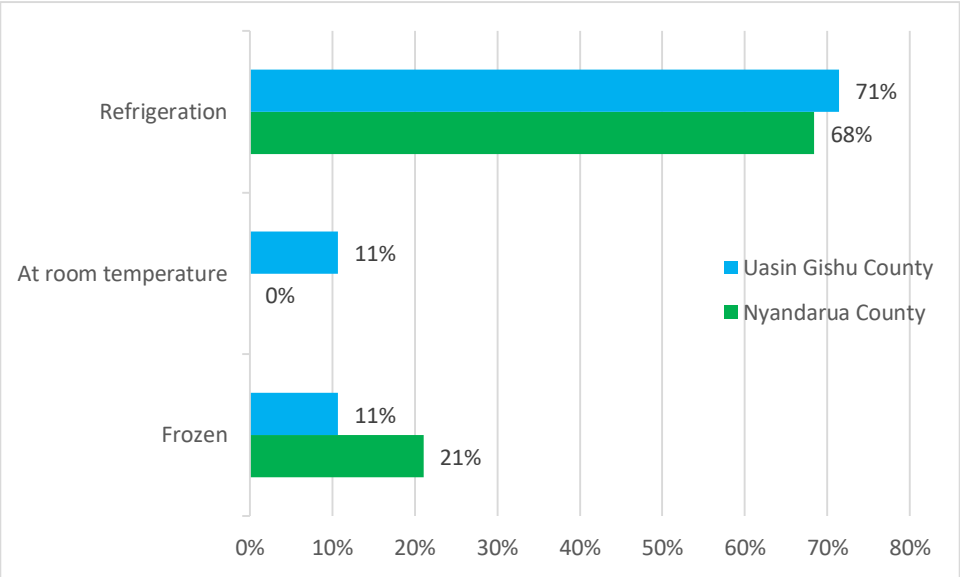
Information from Key Informant Interviews (KIIs) indicated that seventy-seven percent (77%) of retailers stocked a single brand of NCD vaccine while 23% stocked more than one brand in Nyandarua County. In Uasin Gishu, this was 70% and 30% respectively. In Uasin Gishu county, smaller pack sizes (100-1000 doses) of NCD vaccine were selling rapidly, accounting for 44% of sales, while larger packs containing more than 1000 doses constituted 14% of sales. However, in Nyandarua County, both smaller (100-1000 doses) and larger (more than 1000 doses) pack sizes were sold in equal proportions at 33% in a duration of one month. All retail outlets in Uasin Gishu sold vaccines directly to farmers and only 4% sold to institutions. In Nyandarua, 84% sold vaccines directly to farmers, 53% sold to animal health service providers and 5% to other retailers. All retail outlets gave instructions on handling, reconstitution and administration of vaccines. Twenty-one percent (21%) of retail outlets in Nyandarua and 4% in Uasin Gishu counties sold reconstituted NCD vaccines. Demand for FMD vaccines was seasonal and was highest from January to April in Uasin Gishu and from July to December in Nyandarua County. Retailers noted that the demand for NCD vaccines reached its peak from October to February, accounting for 34% of total vaccine sales across both counties, compared to an annual average of 25%.

Cold chain maintenance

Over the past year, sixty-two percent (62%) of retailers underwent training on vaccine handling and administration, ranging from durations of 1 to 6 months. These trained retailers subsequently imparted knowledge on good vaccine handling practices to farmers. On average, 86% of all retailers had functional cold storage facilities including refrigerators and freezers. In Uasin Gishu County, specifically, 71% and 11% of retailers had refrigeration and freezer storage facilities respectively. Similarly, in Nyandarua County, these figures were 68% for refrigeration and 11% for freezer storage facilities (Figure 3). Additionally, eleven per cent (11%) of vaccine-stocking outlets operated without refrigeration.

Figure 3

Storage conditions for vaccines in retail outlets

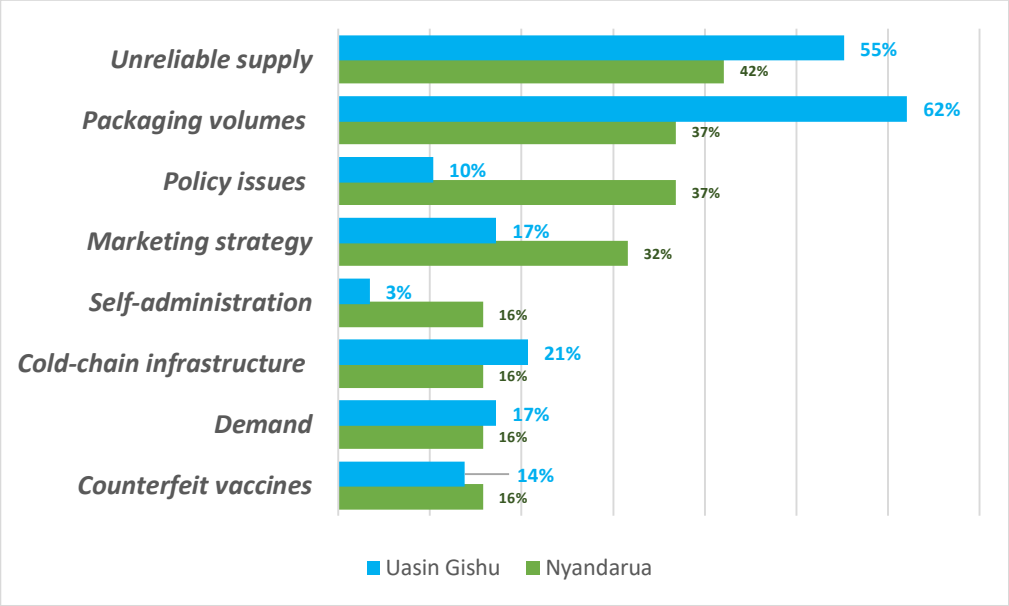


Gaps observed in vaccine delivery

It was established that manufacturers adhere to cold storage regulations up to the point of product dispatch. However, there is lack of data suggesting that they follow up on their products up to the point of use. The challenges faced by vaccine retailers (Figure 4) are unreliable supply/stock out (52%), mismatch of available package with market requirements (56%), lack of sensitization on vaccine usage leading to low uptake (21%). Other challenges include inadequate pricing strategy by manufacturers that does not consider the costs of vaccine distribution and delivery such as cold chain infrastructure to the point of use. Manufacturers encountered more significant constraints related to policy issues (75%), marketing strategy (50%), and infrastructure (100%), which impacted higher levels of vaccine distribution. In contrast, farmers' primary challenge was unreliable supply (35%), large pack size (24%) and counterfeit products (21%). Specific challenge in accessing FMD vaccine, which is controlled by the County Veterinary Directorate, by farmers and AHSPs was common in both Counties. While poor vaccine efficacy for different reasons discourages consumers, excessive regulatory requirements discourage retailers from stocking and selling vaccines.

Figure 4

Challenges encountered in vaccine distribution

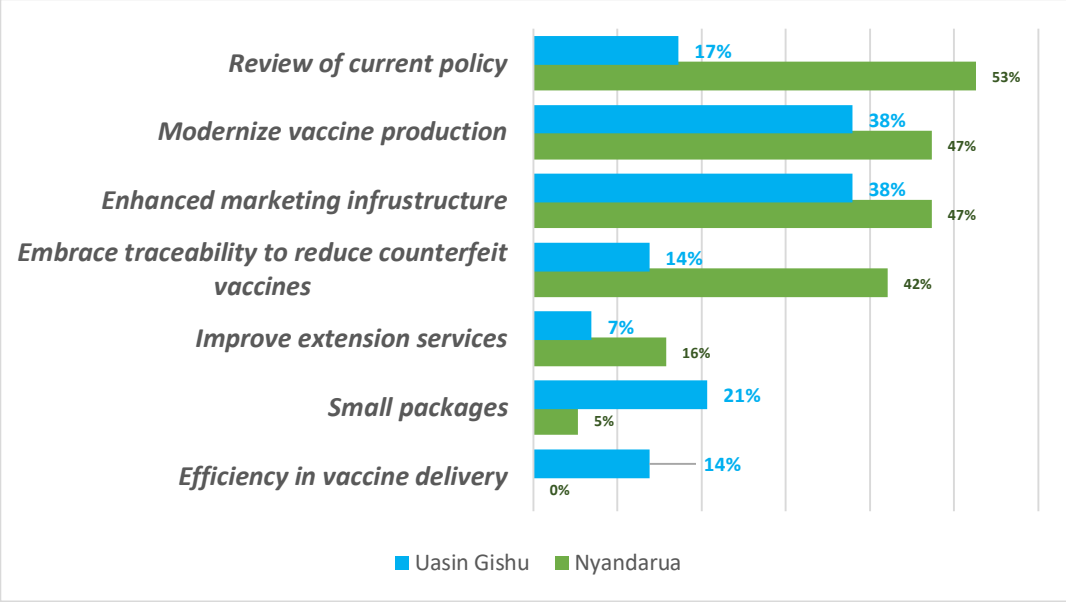


Proposed solutions

These are perceived opportunities and included: i) developing innovative vaccine products including thermotolerance ii) combined and easy to administer vaccines iii) establish robust quality control systems such as traceability indicators and tamper proof process of authentication to control counterfeits iv) performance testing of vaccines that are in the market v) enforce quality controls such as use of temperature monitors/loggers as package inserts, color sensitive pH indicators that changes color upon deviation from prescribed temperature, and SMS alerts to authenticate product source through scratch to reveal codes vi) smaller packages commensurate to the flock sizes vii) improving extension services by easing access to qualified professionals real time viii) enhancing marketing infrastructure to sensitize farmers and create demand.

Figure 5

Proposed solutions to vaccine use challenges



Discussion

Like many African countries, agricultural sector is still the backbone of Kenya's economy, supporting rural livelihoods and therefore critical to attaining food security and poverty reduction (Benonia, 2023). The livestock sub sector has huge potential for growth which the devolved governance structure in Kenya is set to fully exploit at the county level. This study focused on Nyandarua and Uasin Gishu counties which are rich in dairy, having the 2nd and 3rd largest dairy cattle population respectively in the country (KNBS, 2021). As such, the counties have a rich presence of animal health service providers (AHSPs), including distributors, suppliers and retailers for vaccines and other animal health inputs to support the livestock enterprises. This observation is in agreement with that of Higham *et al.,* (2016) who characterized animal health service outlets and the services they provide in the Rift Valley of Kenya. Muia et al. (2011) in his assessment of small holder dairy production in Nyandarua County highlighted high input and service costs as a hindrance to its optimization in supporting rural livelihoods. Therefore, the potential to increase milk production and establish good market linkages represent exciting challenges in line with devolution.

The volume of livestock vaccines manufactured and or imported is informed by demand and projected disease outbreak as well as strategic-market objectives. Three out of every four (75%) farmers in both counties reported vaccinating their cattle or chicken, implying that vaccination is a commonly used disease control option and that there is high demand for vaccines. This is in agreement with findings by Williams et al. (2022) who summarized the importance of vaccination in controlling endemic livestock diseases to enhance food security. Scheduled vaccination has also been advocated for to reduce antimicrobial use and associated resistance, both directly and indirectly (GOK, 2017; Micoli *et al.,* 2021). While end users (both farmers and AHSPs) could easily access New Castle Disease (NCD) vaccine over the counter in both counties, Foot and Mouth Disease (FMD) vaccine was controlled and only available from the county veterinary office (CDVS) for distribution in Uasin Gishu, while in Nyandarua County, some NGOs and private retailers could access the FMD vaccine. Stringent control of FMD vaccine was necessitated by the unexpected outcomes of vaccination failure,

supposedly using a proven product from the national manufacturer, and the cost implication of losing premium dairy animals. Lyons *et al.,* (2015) documented evidence of poor FMD vaccine (SAT2) effectiveness against clinical disease in Kenya, Nakuru County, where an outbreak occurred despite regular vaccination as recommended, three times in a year. Woolhouse *et al.,* (1996) also reported persistence of FMD outbreaks in Saudi Arabia despite revaccination at recommended intervals of 4-6 months. AHSPs observed that due to the challenges in accessing FMD vaccine promptly, outbreaks of FMD were common, occasionally occurring even after vaccinating as recommended post-strain typing. This underscores the need for further investigation into the role of strategic reserves managed by vaccine manufacturers and the modality of delivery to counties to mitigate FMD-related mortalities. These observations also emphasize the complex epidemiology of FMD, which is attributed to its high morbidity, diverse host-range, and genetic diversity.

The Government of Kenya recommends the use of vaccination to contain antimicrobial resistance in food-producing animals (GOK, 2017). Routine vaccination, as prescribed, serves to prevent disease outbreaks, establish herd immunity, and constitutes an important strategy for mitigating livestock diseases in the context of climate change. Findings in this study that 42% of farmers vaccinate poultry against NCD every 3 months, 17% every 6 months and 33% every 12 months depicts poor understanding on the rationale for vaccine use to control NCD. Shortcomings observed include use of outdated vaccination schedules, inadequate dosing due to lack of access, poor adherence to cold chain during vaccine storage and handling, all of which negatively impact vaccine adoption. In line with this survey, there are reports of NCD outbreak in vaccinated flocks. Sharif and Ahmad (2018) reported high rates of 53.5% of NCD vaccination failures in poultry flocks in Pakistan, and included failures for infectious bursal disease (Gumboro) (25.6%) and fowl pox (2.5%), probably due to breaches in vaccine transportation, handling, storage and administration which is common in developing countries. Therefore, there is need to train users on protocols for effective vaccination to reduce NCD outbreaks, as alluded by Williams *et al.,* (2022) in Tanzania. Although the number of farmers reporting use of vaccines was high, poor adherence to vaccination schedules require attention, in relation to the flock age composition of indigenous chicken in particular. The same narrative applies to FMD vaccine which is controlled by the County Veterinary authorities due to encountered outbreaks threatening the dairy herds. The downside of poor vaccine adoption is increasing antimicrobial use (AMU) and consequently antimicrobial resistance (AMR). This fact is well described by Holm *et al.,* (2022) supporting the importance of vaccines in combatting AMR.

Agro-veterinary dispensers served as significant vaccine outlets in this survey and are thus key in the last mile delivery to consumers. In Kenya the regulatory requirements enforce operations of agro-veterinary shops by qualified veterinary professionals who are in good standing and retained in the Kenya Veterinary Board (KVB) register. This requirement ensures there is competence to deliver vaccines in potent state as well as offer extension services to the farmers. Professional competence is most critical considering that over 90% of NCD vaccines stocked by the retailers were sold directly to farmers since it is easily administered in water following the instructions given on handling, reconstitution and dispensing of the vaccine. While the regulator was upbeat to uphold veterinary ethics and align with international standards, some retail shops were still manned by unqualified staff deficient in knowledge to give guidance on vaccine dispensing. Kariuki et al. (2023) reported that self-prescription and easy access to antibiotics were drivers of potential overuse in Kiambu County. Elelu (2017) reported same challenge in Nigeria where Veterinary retail shops are important players in the provision of animal health services, yet dosage and dispensing of recommended drug quantities based on animal body weight was the greatest challenge in the sale of veterinary drugs. This survey observed that 21% of agro-veterinary outlets in Nyandarua and 4% in Uasin Gishu counties sold reconstituted NCD vaccines. However, the impact of this malpractices such as reconstitution for sharing out at point of sale of NCD vaccine, thus dispensing smaller doses for

convenience as well as freezing of reconstituted vaccines contrary to standard protocols could not be measured. It was also difficult to measure the impact of vaccine counterfeits which were perceived as a challenge by users, especially in the absence of data on field vaccine efficacy and causes of vaccine failure. More than 80% of retail shops had a functional cold storage facility including refrigerators and freezers. This was a result of training by vaccine distributors. However, the 11% who operated without a cold storage facility formed the weak link in vaccine use.

Proposed solutions to the prevailing challenges include the need to develop innovative vaccine products in terms of appropriate dose packages to address small scale farmers, and preferably thermotolerant vaccines to circumvent stringent cold chain requirements. In addition, combined and easy to administer vaccines addressing different diseases at once would minimize the need for multiple visits by professionals to administer different products. To control fake and counterfeit vaccines, there is need to establish robust quality control systems along the supply chain, including a combination of product traceability indicators that present a tamper proof process of authentication. Suggested performance testing processes include i) use of temperature monitors/loggers as package inserts ii) color sensitive pH indicators that change color upon deviation from prescribed temperature, and iii) SMS alerts to authenticate product source through scratch to reveal codes.

Conclusion

FMD and NCD are important diseases that impact livestock productivity and farmer's livelihoods. Although there is significant use of vaccines to control these diseases, FMD vaccine is viewed with mixed reactions due to common vaccination failures. It is essential to make efforts towards achieving optimal adoption of both vaccines. Innovative vaccine delivery processes are required, including product authentication and traceability along the supply chain. While vaccine manufactures indicated adherence to cold chain requirements, a weakness was noted where some retailers tampered with the packaging. This resulted in delivery to end-users without consideration of cold chain maintenance from this point of transportation to the farm. Animal health service providers confirmed this observation since compliance with cold-chain requirements along the supply chain was questionable, with no system to self-monitor adherence. Agro-veterinary shops distributing vaccines, especially those reconstituting before sale should be encouraged to sell to only those farmers who can maintain a certain degree of cold chain. Eleven per cent (11%) of outlets stocking vaccines without refrigeration violated regulations and therefore require closer supervision and where compliance is difficult, closure of the outlets.

The Veterinary Medicine Directorate and vaccine manufactures have the responsibility to ensure product performance testing post marketing. The findings herein recommend enhanced pharmacovigilance to ensure that FMD and NCD vaccines delivery is in line with recommended best practices from source to the point of use by farmers.

Acknowledgement

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